Cardiac rehabilitation and socioeconomic variation: Bibliometric, systematic, and registry analyses across multiple contexts

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STATEMENT OF ORIGINALITY

This is to certify that the content of this these is my own work. This thesis has not been submitted for any other degree or purpose.

I certify that the intellectual content of this thesis is the product of my own work, and that all assistance received in preparing this thesis and all sources have been acknowledged.

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AUTHORSHIP ATTRIBUTION STATEMENT

Chapter 2 of this thesis has been published as:

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I led the conceptualisation (formulation of the overarching research goals and aims), methodology (development and design of the methodology), formal analysis (application of statistical techniques to analyse or synthesise study data), and writing – original draft (preparation and creation of the published work, specifically writing the initial draft). The roles of co-authors are as follows: KH and JR were involved in the conceptualisation and formal analysis. KH, DC, MH, QT, SG, AO, GKC, LZ, TB, SLG, RG, and JR were involved in the methodology and writing – reviewing & editing.

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I led the conceptualisation, methodology, formal analysis, and writing – original draft. The roles of co-authors are as follows: JR and KH were involved in the conceptualisation. JR, QT, and KH were involved in the methodology. QT, AJYC, NH, DC, and KH were involved in the formal analysis. JR, QT, AJYC, NH, DC, and KH were involved in the writing – reviewing & editing.

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I led the conceptualisation, methodology, formal analysis, and writing – original draft. The roles of co-authors are as follows: DB, JR, and KH were involved in the conceptualisation. DB, JR, QT, TB, and KH were involved in the methodology. DB and KH were involved in the formal analysis. DB, JR, QT, TB, NH, and KH were involved in the writing – reviewing & editing.

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I led the conceptualisation, methodology, formal analysis, and writing – original draft. The roles of co-authors are as follows: KT, DC, JR, and KH were involved in the conceptualisation and methodology. KH was involved in the formal analysis. KT, DC, AZ, MJ, MMK, SYC, LC, QT, NH, JR, and KH were involved in the writing – reviewing & editing.

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I led the conceptualisation, formal analysis, and writing – original draft. The roles of co-authors are as follows: MH, RZ, and KH were involved in the conceptualisation. MH, JR, RZ, and KH were involved in the methodology. KH was involved in the formal analysis. MH, JR, QT, NH, and RZ were involved in the writing – reviewing & editing.

In addition to the authorship attribution statements above, in cases where I am not the corresponding author of a published item, permission to include the published material has been granted by the corresponding author.

Student: Deborah Manandi

29 September 2025

As supervisor for the candidature upon which this thesis is based, I can confirm that the authorship contribution statements above are correct.

Lead Supervisor: Julie Redfern

29 September 2025

GENERATIVE AI USE STATEMENT

During the preparation of this thesis, the author used GPT-4 and GPT-5 (OpenAI) to assist with copyediting, debugging R error messages, and statistical modelling (see Appendix 1 for details). The author confirms that where text was modified by generative AI, the content was reviewed for possible errors, inaccuracies, and bias. The author takes full responsibility for the submitted thesis, confirms the work is their own, and has used generative AI in accordance with University of Sydney guidelines and policies (refer to the University of Sydney Generative AI Guide for Researchers).

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THESIS ABSTRACT

Background: Cardiac rehabilitation is a core model of secondary prevention that supports recovery after cardiac and vascular events through structured exercise, education, and psychosocial support. Despite well-established clinical efficacy, cardiac rehabilitation remains underutilised and inequitably accessed. Socioeconomic disparities influence participation across the care pathway, from referral and enrolment to completion and outcomes, yet the extent to which these disparities influence outcomes has been less consistently explored.

This thesis examined how socioeconomic characteristics were associated with cardiac rehabilitation participation and outcomes across international, national, and local contexts. Five interrelated aims were addressed: first, to describe the global publication history of cardiac rehabilitation research, including publication trends, geographic authorship by country income level, assigned keywords, and citation patterns; second, to systematically review studies on participation and outcomes across socioeconomic subgroups; third, to assess whether the association between participation and clinical outcomes varied by area-level socioeconomic status in an Australian cohort; fourth, to assess whether individual-level socioeconomic characteristics were associated with completion and psychosocial outcomes in lower-resourced settings globally; and fifth, to assess whether individual-level socioeconomic characteristics were associated with psychosocial outcomes in a multicultural cohort in Western Sydney.

Methods and results: These aims were addressed using a multi-methods approach spanning five studies, presented in Chapters 2 through 6. Chapter 2 presents a bibliometric review of 8,729 publications, showing growth in research output, predominantly from high-income countries, with socioeconomic characteristics and equity considerations underrepresented. Chapter 3 reports a systematic review of six observational studies, showing that participation was associated with lower mortality and hospital readmission, with some evidence of lower return to work among disadvantaged groups. Chapter 4 reports analysis of the CONCORDANCE national registry, finding that participation was associated with a lower risk of major adverse cardiovascular events and mortality, with no variation by area-level

socioeconomic status. Chapter 5 reports analysis of the International Cardiac Rehab Registry, finding that depressive symptoms improved overall, with greater improvements among those reporting financial strain and smaller improvements among those employed, while no socioeconomic differences were observed in quality of life. Chapter 6 reports analysis of the Westmead Hospital program, finding that health-related quality of life improved overall, although improvements were more modest among individuals who were unemployed or retired, those born overseas, and those residing in regional areas.

Conclusion: While cardiac rehabilitation delivers consistent clinical benefits across socioeconomic groups, participation and psychosocial recovery remain unequally distributed. Addressing these inequities may require routine inclusion of socioeconomic characteristics in research, the use of culturally adapted materials and workforce training in practice, and policies that engage stakeholders such as international and national organisations to strengthen global alignment.

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LIST OF ABBREVIATIONS

ACEi	Angiotensin-converting enzyme inhibitor
ACS	Acute coronary syndrome
ASCVD	Atherosclerotic cardiovascular disease
ARB	Angiotensin II receptor blocker
BIBLIO	Bibliometric reviews of the biomedical literature
BMI	Body mass index
CABG	Coronary artery bypass graft
CCB	Calcium channel blocker
CI	Confidence interval
CONCORDANCE	Cooperative National Registry of Acute Coronary Care, Guideline Adherence and Clinical Events
CR	Cardiac rehabilitation
CVD	Cardiovascular disease
DVT	Deep vein thrombosis
FDR	False discovery rate
FWCI	Field-weighted citation impact
HADS	Hospital Anxiety and Depression Scale
HF	Heart failure
H-index	Hirsch index
HR	Hazard ratio
HRQoL	Health-related quality of life
ICCPR	International Council of Cardiovascular Prevention and Rehabilitation
ICRR	International Cardiac Rehabilitation Registry
IRSAD	Index of Relative Socio-economic Advantage and Disadvantage
IRSD	Index of Relative Socio-economic Disadvantage
IQI	Interquartile interval
IQR	Interquartile range
MACE	Major adverse cardiovascular event
METs	Metabolic equivalents
MI	Myocardial infarction

mmHg	Millimetres of mercury
NA	Not applicable
NSTEMI	Non-ST-elevation myocardial infarction
OR	Odds ratio
PAD	Peripheral arterial disease
PCI	Percutaneous coronary intervention
PE	Pulmonary embolism
PHQ-2	Patient Health Questionnaire-2
PHQ-9	Patient Health Questionnaire-9
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PROSPERO	International Prospective Register of Systematic Reviews
RR	Risk ratio
SD	Standard deviation
SE	Standard error
SEIFA	Socio-Economic Indexes for Areas
SF-12	12-Item Short Form Health Survey
SF-36	36-Item Short Form Health Survey
STEMI	ST-elevation myocardial infarction
TIA	Transient ischaemic attack
UA	Unstable angina
WHO	World Health Organization
WHF	World Heart Federation

OUTPUTS FROM THE THESIS

Manuscripts published in peer-reviewed journals

1. **Manandi D**, Hyun K, Candelaria D, Hollings M, Tu Q, Gauci S, O'Neil A, Chaseling G, Zhang L, Briffa T, Grace SL, Gallagher R, Redfern J. A century of cardiac rehabilitation research: Bibliometric review of publication history, keyword trends, and citations. *npj Cardiovascular Health*. 2025;2(1):26. doi:10.1038/s44325-025-00062-w
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Manuscripts submitted to a peer-reviewed journal

1. **Manandi D**, Redfern J, Tu Q, Chang AYJ, Hafiz N, Candelaria D, Hyun K. Socioeconomic variation in the relationship between cardiac rehabilitation participation and clinical outcomes: A systematic review and meta-analysis. *Open Heart*. (under review).
2. **Manandi D**, Turk-Adawi K, Candelaria D, Zende A, Jiandani M, Ka MM, Chen SY, Cuenza L, Redfern J*, Hyun K*, on behalf of the ICRR collaborators. Association between socioeconomic characteristics among individuals who completed cardiac rehabilitation in low-resource settings with their depressive symptoms and quality of life: Analysis from the International Cardiac Rehabilitation Registry. *Journal of the American Heart Association*. (under review).
3. **Manandi D**, Hollings M, Redfern J, Tu Q, Hafiz N, Zecchin R*, Hyun K*. Differences in post-cardiac rehabilitation quality of life in Western Sydney by country of birth, employment status, socioeconomic status of area of residence, and remoteness of area of residence. *Heart, Lung and Circulation*. (under review).

Published abstracts

1. **Manandi D**, Hyun K, Candelaria D, Hollings M, Tu Q, Gauci S, O'Neil A, Chaseling, G., Zhang, L., Briffa, T., Grace, S. L., Gallagher, R., & Redfern, J. A century of cardiac

rehabilitation research: A bibliometric review of global publication, citation history, and trends in keywords from 1927 to 2024. *Heart Lung and Circulation*. 2025;34(Suppl 4):S225. doi:10.1016/j.hlc.2025.06.210

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Conference presentations – Oral

1. **Manandi D**, Hyun K, Candelaria D, Hollings M, Tu Q, Gauci S, O'Neil A, Chaseling G, Zhang, L., Briffa, T., Grace, S. L., Gallagher, R., & Redfern, J. A century of cardiac rehabilitation research: A bibliometric review of global publication, citation history, and trends in keywords from 1927 to 2024. Presented at: 73rd Annual Scientific Meeting (ASM) of the Cardiac Society of Australia and New Zealand (CSANZ): 2025 August 14-17; Brisbane, Australia.
2. **Manandi D,** Hyun K, Candelaria D, Hollings M, Tu Q, Gauci S, O'Neil A, Chaseling G, Zhang L, Briffa T, Grace SL, Gallagher R, Redfern J. A century of cardiac rehabilitation research: A bibliometric review of global publication history, trends in publication keyword, and citations from 1927 to 2024. Presented at: Faculty of Medicine and Health Higher Degree Research Conference; 2025 Jul 24; Susan Wakil Health Building, Sydney, Australia.
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5. **Manandi D**, Brieger D, Redfern J, Tu Q, Hafiz N, Hyun K. Participation in cardiac rehabilitation and association between participation and major adverse cardiovascular events among Australian patients with acute coronary syndrome alive at six-month follow-up. Presented at: 32nd Australian Cardiovascular Health & Rehabilitation Association Annual Scientific Meeting; 2023 Aug 3; University of Western Australia Club, Perth, Western Australia, Australia.
6. **Manandi D**, Brieger D, Redfern J, Tu Q, Hafiz N, Hyun K. Participation in cardiac rehabilitation and association between participation and major adverse cardiovascular events among Australian patients with acute coronary syndrome. Presented at: Faculty of Medicine and Health Higher Degree Research Conference; 2023 Jul 19; Westmead Education and Conference Centre, Westmead Hospital, Sydney, Australia.
7. **Manandi D**, Brieger D, Redfern J, Tu Q, Hafiz N, Hyun K. Participation in cardiac rehabilitation and association between participation and major adverse cardiovascular events among Australian patients with acute coronary syndrome. Presented at: Australian Society for Medical Research Medical Research Week New South Wales Annual Scientific Meeting; 2023 Jun 2; Aerial, University of Technology Sydney Function Centre, Sydney, Australia.

Conference presentations – Poster

1. **Manandi D**, Hyun K, Turk-Adawi K, Candelaria D, Zende A, Jiandani M, Ka M, Lin MJ, Cuenza L, Redfern J, on behalf of the ICRR collaborators. Socioeconomic factors and their association with depressive symptoms and quality of life following cardiac rehabilitation in low-income countries and low-resourced settings. Presented at: European Society of Cardiology (ESC) Congress; 2025 Aug 29-Sep 1; Madrid, Spain.
2. **Manandi D**, Hyun K, Candelaria D, Hollings M, Tu Q, Gauci S, O'Neil A, Chaseling G, Zhang L, Briffa T, Grace SL, Gallagher R, Redfern J. From efficacy to digital technology in cardiac rehabilitation research: A bibliometric analysis from 1956 to 2024. Presented at: Westmead Research & Innovation Conference; 2024 Sep 18-19; Westmead Innovation Centre, Sydney, Australia.
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Scholarship

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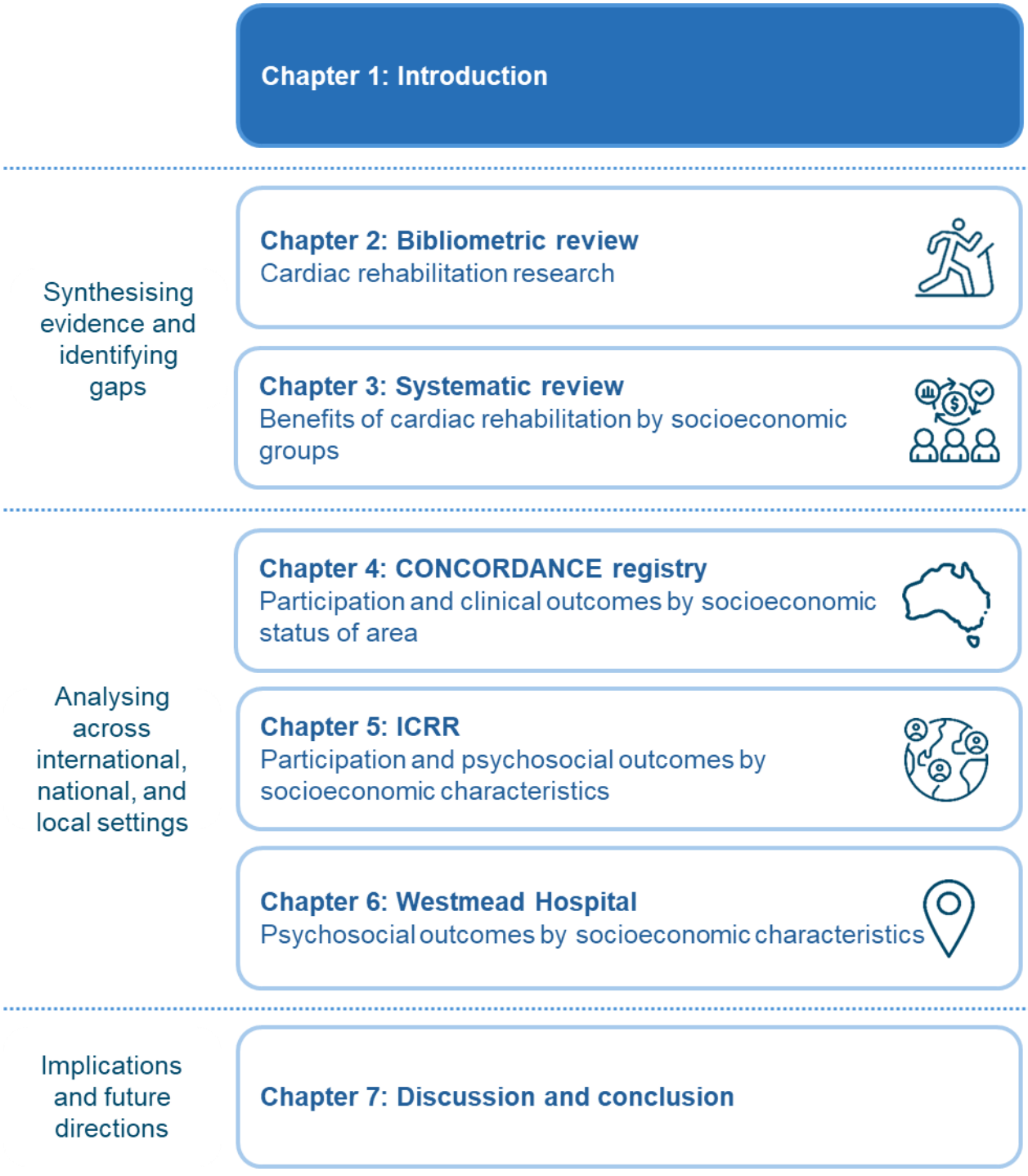
CHAPTER 1

Introduction: Cardiac rehabilitation and socioeconomic variation in participation and outcomes



Cardiovascular disease (CVD) remains a major contributor to global morbidity, mortality, and healthcare expenditure.[1,2] CVD is predominantly driven by atherosclerosis, a chronic process that affects arteries throughout the body, and gives rise to clinical events such as myocardial infarction and stroke. To address these risks and support recovery, cardiac rehabilitation has become a core secondary prevention strategy for individuals with cardiac and vascular diagnoses such as coronary heart disease, heart failure, peripheral artery disease, and aortic atherosclerosis, arrythmia requiring interventions, and post procedural recovery following percutaneous coronary intervention, coronary artery bypass graft, or valve surgery.[3-6] Many programs also extend to vascular conditions such as peripheral artery disease, aortic dissection and aneurysm, and to some extent, cerebrovascular disease. Although guidelines recommend this broad cardiac and vascular scope, referrals remain concentrated among post-cardiac cases, reflecting discharge-based referral pathways, clinician-level heuristics, electronic medical record default prompts, and challenges in identifying eligible patients.[7-16] Despite the obvious benefits of cardiac rehabilitation such as supporting recovery and reducing the risk of recurrent events, improving quality of life and reducing healthcare expenditure, participation in and outcomes from cardiac rehabilitation remain inconsistent.[17-24]

CVD and the global burden

Within CVD, atherosclerotic cardiovascular disease (ASCVD) comprises coronary artery disease, ischaemic cerebrovascular disease, peripheral artery disease, and atherosclerotic aortic disease.[25] These conditions are driven by atherosclerosis, a chronic process in the arterial intima characterised by deposition of lipids, by-products from damaged cells, calcium, and clotting materials such as fibrin, which forms plaques that progressively narrow or block blood flow.[25-28] The clinical manifestations depend on the arteries and organs involved. Coronary heart disease occurs when atherosclerosis narrows or blocks blood flow through the coronary arteries supplying the heart muscle, causing angina, myocardial infarction if a plaque ruptures, or ischaemic cardiomyopathy and heart failure if the heart muscle weakens over time.[29-31] Ischaemic cerebrovascular disease occurs when atherosclerosis affects the arteries supplying the brain, causing transient ischaemic attack or stroke.[29,30] Peripheral artery disease occurs when atherosclerosis affects the arteries supplying the limbs, which may cause claudication (pain, cramping, or fatigue in the legs during physical activity), and in severe cases, tissue death[29,30] Atherosclerotic aortic disease occurs

when progressive plaque forms in the aorta, which may cause aneurysm or systemic embolism when plaques break off and travel to other organs.[26] While these conditions differ in presentation, they share the same pathologic process, and collectively remain major contributors to global morbidity and mortality.[26,29-31] Cardiac rehabilitation focuses on secondary prevention across this spectrum and evaluate outcomes that span both cardiac and vascular diagnoses.[3-6]

The Global Burden of Disease Study, encompassing 204 countries and territories, confirmed CVD as the leading cause of death in 2021, with 19.4 million deaths–approximately 32% of all global mortality–and 66.8 million new cases.[1,2] Between 1990 and 2021, prevalence nearly doubled from 271 million to 523 million, illustrating the growing number of individuals living with CVD and the associated burden of secondary events such as recurrent cardiac events, rehospitalisation, depressive symptoms, and poorer quality of life, which are analysed in this thesis.[32,33] In high-income countries, mortality from CVD has declined, while prevalence has increased as populations age and more individuals survive acute events.[32,33] In many low- and middle-income countries, both mortality and prevalence continue to increase due to urbanisation, delayed diagnosis, limited access to secondary prevention, and health system constraints.[15,34] These differences highlight the persistent inequities and reinforce the need for structured secondary prevention, a focus of this thesis.

CVD burden in Australia

In Australia, CVD is responsible for over 500,000 hospital admissions each year and costs an estimated AUD $11.8 billion annually, or 8.7% of total healthcare expenditure.[35-37] Hospital readmission rates vary widely, reaching up to 27% for all-cause readmissions and may range between 6.3% and 13% for CVD-related readmission within 30 days. Up to 41% of individuals experience hospital readmission or premature death within five years.[37,38] This national burden supports consistent application of secondary prevention.

Psychosocial outcomes and quality of life

CVD carries a substantial psychosocial burden beyond clinical outcomes. Individuals live with residual symptoms, functional limitations, lifestyle adjustments and prognostic

uncertainty, which can contribute to anxiety, depressive symptoms and worsening quality of life.[39-42] Addressing psychosocial stressors improves adherence to recommendations for lifestyle modifications and medications, supports return to work, and is therefore integral to recovery.[43,44] Because recovery includes mental health, function, and return to work, comprehensive programs are required.

Secondary prevention of CVD

Historically, the management of CVD focused on curative interventions.[7,8] Coronary angiography and coronary artery bypass surgery emerged in the 1960s, followed by percutaneous angioplasty in the 1970s and coronary stents (mesh-like tubes) in the 1990s.[9-12] These technological advances expanded care and greatly improved survival after acute events. At the same time, the Framingham Heart Study in the 1950s marked the rise of prevention. As the first large-scale longitudinal cohort, it identified modifiable risk factors, including physical inactivity, obesity, smoking, hypertension, dyslipidaemia, and diabetes, each contributing to atherosclerosis through distinct pathological pathways.[45-47] Recognition of these risk factors shifted CVD care from acute management to long-term prevention and led to the establishment of structured secondary prevention strategies, including cardiac rehabilitation.

After hospital discharge, secondary prevention supports long-term recovery by reducing the risk of recurrent events. Core strategies include pharmacological risk factor management (such as antiplatelet therapy, lipid and blood pressure control, and diabetes management), structured exercise, dietary modification, smoking cessation, and psychosocial support.[48-50] These measures are the foundation of secondary prevention and are consistently endorsed as Class 1A evidence in international clinical guidelines, including those from the European Association of Preventive Cardiology (2020), the American College of Cardiology/American Heart Association (2022), the British Association for Cardiovascular Prevention and Rehabilitation (2023), the World Health Organization (2024), and the National Heart Foundation of Australia/Cardiac Society of Australia and New Zealand (2025).[3-6,51,52]

Cardiac rehabilitation

Cardiac rehabilitation delivers secondary prevention in a coordinated, multidisciplinary program, commonly structured across three phases. Phase I begins during inpatient care, supporting early mobilisation, providing foundational education, and preparing individuals for ongoing management.[3-6] Phase II commences at pre-cardiac rehabilitation program assessment, where demographic and clinical characteristics are recorded to inform risk stratification and program prescription.[3-6] The core 6-12 week program comprises: (1) structured, supervised exercise; (2) education on lifestyle modification targeting key risk factors such as physical inactivity, poor diet, tobacco use, hypertension, or dyslipidaemia; and (3) psychosocial support to assist with anxiety, depression, or return to work.[3-6] The roles of cardiologists, nurses, physiotherapists, exercise physiologists, dietitians, pharmacists, and social workers vary by guideline, country, and resource setting. Phase III involves structured follow-up to maintain behavioural change and clinical improvements.[53]

While ideally tailored to each individual, programs that follow these core guideline principles, adapted to available resources and workforce, are expected to deliver substantial clinical benefits. These include reducing the likelihood of premature death by up to 26%, lowering hospital readmission by up to 23%, decreasing recurrent CVD events, and improving functional capacity, depressive symptoms, and quality of life.[17-22] These reductions have also been consistently supported in systematic reviews, including Cochrane meta-analyses, and confirmed through registry data across diverse populations. [22,54-56] Cardiac rehabilitation is clinically effective and is associated with 99.9% probability of being cost-effective, with evidence that increased provision and utilisation can reduce hospital readmissions and prevent healthy life years lost.[23,24]

Cardiac rehabilitation quality improvement and innovations

Cardiac rehabilitation continues to be structured around exercise, education, and psychosocial support, although quality improvement and innovations have occurred within each cardiac rehabilitation component. Exercise prescription now incorporates cardiopulmonary exercise testing using treadmill or cycle ergometry, ventilatory threshold testing from six-minute walk tests or the talk test, and pragmatic alternatives suitable for low-resource settings. [57,58] Programs recommend 20-60 minutes of aerobic training three times weekly at moderate to

vigorous intensity, with optional high-intensity interval training in stable coronary disease, and resistance training two to three times weekly. [3-6,59] Education has expanded from general advice on risk factors to structured self-management strategies that emphasise goal setting, secondary prevention, and in some cases family-centred care planning.[60-62] Dietary recommendations have shifted from nutrient restriction to whole-diet patterns such as Mediterranean, Dietary Approaches to Stop Hypertension (DASH) diets, or plant-based diets, which are more sustainable and adaptable according to cultural context.[3-6,63,64] Psychosocial assessment has also become more robust, with validated tools such as Patient Health Questionnaire-9 (PHQ-9), Hospital Anxiety and Depression Scale (HADS), and 36-Item Short Form Health Survey (SF-36) now routinely used, and interventions including motivational interviewing, cognitive behavioural therapy, stress management, and return-to-work planning.[3-6,65-68]

Guidelines now specify expectations for delivery. Centre-based, hybrid, and digital-based models are endorsed, with remote delivery encouraged for individuals who reside in rural areas, who are employed full-time, or those experiencing socioeconomic disadvantage.[69-71] Automatic referral at hospital discharge and simplified enrolment processes are recommended to maximise program uptake.[72,73] Programs are also expected to meet minimum safety standards, including resuscitation capacity.[3-6,51,52] National and international cardiac rehabilitation registries, together with continuous quality improvement approaches such as benchmarking and Plan-Do-Study Act cycles, are increasingly incorporated into routine practice.[74-76]

Gaps in cardiac rehabilitation research

Despite strong evidence for cardiac rehabilitation, persistent gaps remain in access to and completion of programs. In Australia, only 30% of eligible individuals are referred, and 28% of these proceed to participate, equating to approximately 8% of the total eligible population.[77] International participation rates vary, ranging from below 7% in China, around 30% in Australia and parts of Europe, and up to 75% in certain European programs.[77-80] Even in the countries with the highest participation, rates remain insufficient for equitable access.

While cardiac rehabilitation has evolved from year-long bedrest in the 1950s to outpatient delivery models, including the introduction of group-based programs in the 1980s; the overall structure has remained largely unchanged.[81] To date, few reviews have examined how the field has developed or assessed whether recent research priorities have adequately aligned with efforts to improve access and participation. To inform the modernisation of cardiac rehabilitation, it remains necessary to first describe how the field has developed over time, where research effort has been concentrated, and where important gaps remain.

Socioeconomic disparities in cardiac rehabilitation

In this thesis, socioeconomic disparities are examined within the Health Equity Framework.[82] Based on the social determinants of health, this conceptual framework recognises that population health outcomes are shaped by socioeconomic disparities operating at multiple levels. These include systemic factors, such as research focus and health system organisation; individual factors, such as educational attainment, employment status, income, financial strain, country of birth, and physiological health status; and network or area-level factors, such as the socioeconomic status and remoteness of the area in which individuals reside.[82]

Within cardiac rehabilitation, these socioeconomic disparities can operate across program availability, referral, participation, completion, and subsequent outcomes. Because socioeconomic disparities may act at multiple levels and across stages of care, understanding these disparities may require consideration of evidence from more than one perspective. At a conceptual level, bibliometric and systematic reviews of the research literature can provide insight into how systemic socioeconomic disparities are represented and linked to cardiac rehabilitation outcomes. Observational analyses of real-world registry and cohort data can provide complementary insight into how individual-, physiological-, and area-level socioeconomic characteristics may be linked to cardiac rehabilitation participation, completion, and outcomes across international, national, and local settings.

While socioeconomic status is commonly defined by educational attainment, employment status, and income, it can also be reflected in financial strain, country of birth, the socioeconomic status and remoteness of the area in which individuals reside. These characteristics consistently shape cardiovascular outcomes, although each captures different

aspects of socioeconomic circumstances and therefore may vary in their relevance to cardiac rehabilitation.

A multi-country study reported that individuals from socioeconomically disadvantaged backgrounds experienced 42% more premature CVD-related deaths than their more advantaged counterparts.[80] They are also less likely to undergo revascularisation or to be prescribed cardioprotective medications, with disparities extending to other aspects of care.[83,84] Individuals with lower levels of education or income often present with a greater burden of cardiovascular risk factors and lower CVD health literacy, which may limit their ability to advocate for referral to cardiac rehabilitation, understand program recommendations, and sustain participation or benefit once enrolled.[85,86]

These inequities are mirrored in cardiac rehabilitation delivery worldwide. A 2019 survey of 5,753 programs across 111 countries found that while most programs offered pre-program assessment, structured exercise, and at least one additional intervention, program capacity was constrained and varied markedly by continent.[15] Programs in high-income countries typically provide supervised, multidisciplinary services that include structured exercise training, risk management, and psychosocial support, often supplemented with remote delivery options.[3-6,51,52,87] By contrast, programs in low-resource settings are often shorter in duration, delivered with fewer staff, limited equipment, and reduced allied health input.[3-6,51,52,87] Even within Australia, program availability differs between major cities and remote or very remote areas, where services often operate with limited staff and resources.[88-90]

Even where programs are available, referral, participation, and completion rates remain lower among individuals experiencing socioeconomic disadvantage.[91-94] For example, in Denmark, individuals who attained less than a secondary level of education were 1.5 times less likely to participate in cardiac rehabilitation than those who attained a tertiary level of education.[94] Educational attainment influences health literacy, navigation, and engagement with care, which may affect participation and completion.[95-97] As a relatively stable characteristic that rarely changes over the life course, educational attainment may be particularly informative for understanding longer-term patterns of participation, but may be less sensitive to short-term constraints that arise once individuals are enrolled.[98]

Lower completion rates have also been reported among individuals experiencing financial strain or with caregiving responsibilities.[94] In settings without universal healthcare, program costs may create additional material pressure.[99] Financial strain may reflect more immediate material constraints during the cardiac rehabilitation program and may be particularly informative for understanding sustained participation and completion. At the same time, financial strain may co-occur with housing or food insecurity, which may reduce clarity around its independent association with participation and completion.[100]

Barriers such as geographic distance, older age, and being female have been consistently observed across studies in Europe, North America, and Iran.[80,92,101,102] Geographic distance may shape access to specialists and transport options, while older age may co-occur with greater comorbidity burden or functional limitation, which may affect the ability to participate in and complete cardiac rehabiltiation.[95-97,103,104] At the same time, younger individuals, those of non-Black race, and those admitted to hospitals with rehabilitation services available are more likely to participate.[105] Hospitals with rehabilitation services may also have more established referral pathways and follow-up processes, supporting enrolment and continuity of care.[106] Although area-level socioeconomic characteristics, including specialist availability, transport options, and the presence of hospitals with rehabilitation services, provide important contextual information, they may not fully capture individual resources or support within the same geographic area.[107]

Despite persistent inequities in access and completion, it remains uncertain whether the benefits of cardiac rehabilitation, including reduced premature death, hospital readmission, recurrent CVD events, or improvements in functional capacity, depressive symptoms, and quality of life, are equitably distributed across socioeconomic subgroups. Few studies have investigated whether outcomes differ by educational attainment, employment status, financial strain, age, country of birth, area-level socioeconomic status, or remoteness of residence, particularly in low-resource settings where individuals face competing priorities.[108,109] Real-world evidence addressing this gap remains limited, underscoring the rationale for this thesis. The following chapters address these disparities across international, national, and local contexts, and are guided by one overarching aim and five interrelated aims.

Thesis aims

This thesis aims to explore trends in cardiac rehabilitation research and to analyse how secondary clinical and psychosocial outcomes after completing cardiac rehabilitation vary by socioeconomic characteristics across international, national, and local settings. The research addresses this overarching aim through five interrelated aims:

1. To describe the global trends in cardiac rehabilitation research.
2. To systematically review published literature on the association between cardiac rehabilitation participation and clinical outcomes across socioeconomic subgroups.
3. To assess whether the association between cardiac rehabilitation participation and clinical outcomes varies by area-level socioeconomic status in an Australian cohort.
4. To assess whether individual-level socioeconomic characteristics are associated with cardiac rehabilitation completion and psychosocial outcomes in low-resource settings globally.
5. To assess whether individual-level socioeconomic characteristics are associated with cardiac rehabilitation psychosocial outcomes in a multicultural cohort.

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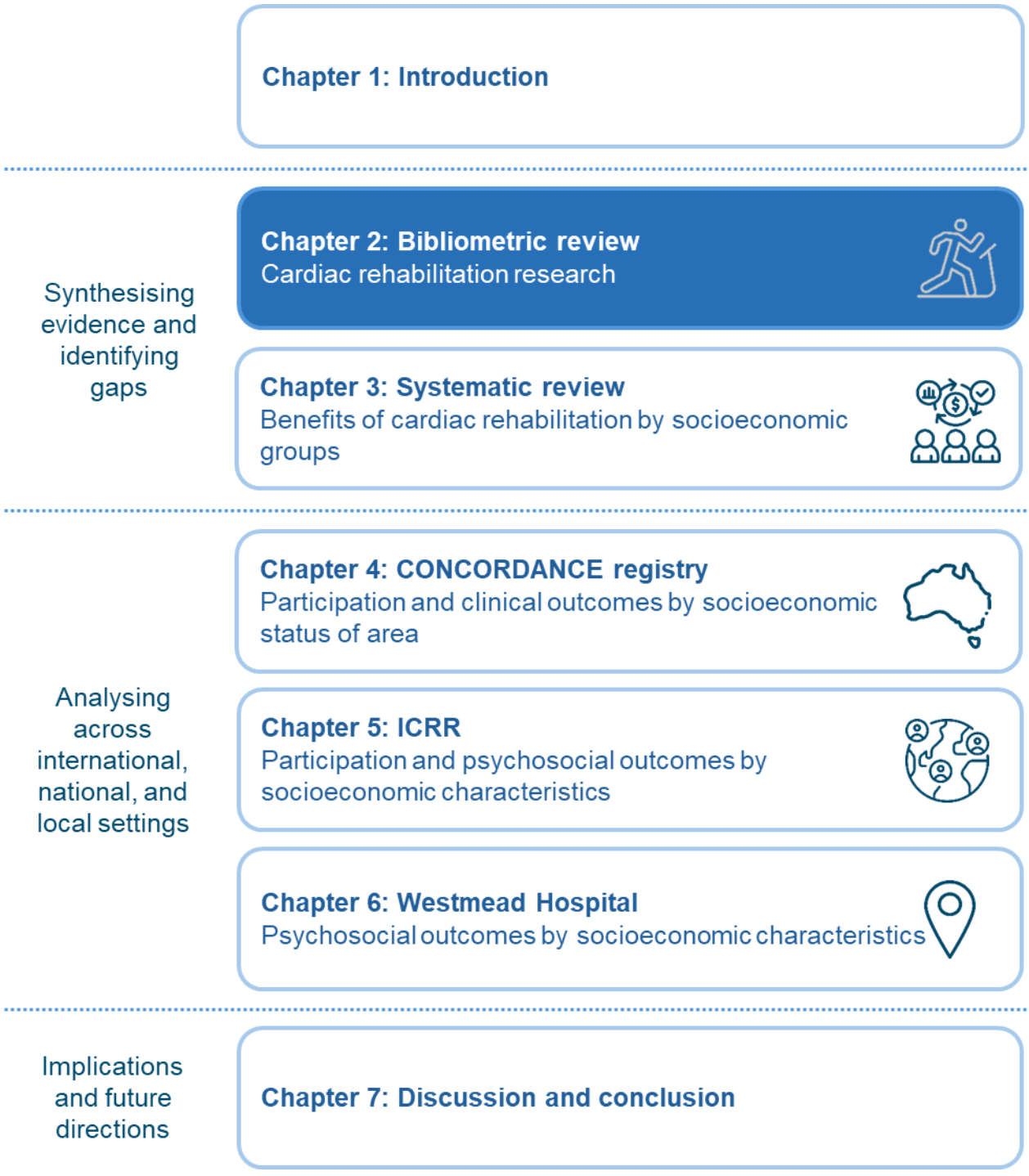
CHAPTER 2

Global cardiac rehabilitation research: A bibliometric review of publication trends, collaboration, and gaps



This chapter presents a bibliometric review of the global cardiac rehabilitation literature from 1927 to 2024. It builds on Chapter 1 by providing historical and thematic context for this thesis, including how the number publications, journal fields, geographic authorship, keyword trends, and citation patterns have evolved over time.

A total of 8,729 full original research articles, reviews, editorial materials, letters were identified across1,441 journals, authored by 26,909 individuals from 2,670 institutions in 120 countries. Most originated from high-income countries, with limited focus on socioeconomic risk factors, comorbidity, and disparity research. These findings inform subsequent chapters of this thesis, which review socioeconomic disparities in cardiac rehabilitation participation and outcomes.

> **Aim Addressed:** This chapter addresses **Aim 1** – to describe the global publication history of cardiac rehabilitation research.

This work, titled *"A century of cardiac rehabilitation research: Bibliometric review of publication history, keyword trends, and citations"*, has been published in *npj Cardiovascular Health.*

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STATEMENT OF AUTHORSHIP

Deborah Manandi led the conceptualisation, methodology, formal analysis, and writing – original draft. The roles of co-authors are as follows:

Task	**Role of co-authors**
Conceptualisation	KH, JR
Methodology	KH, DC, MH, QT, SG, AO, GKC, LZ, TB, SLG, RG, JR
Formal analysis	KH JR
Writing – reviewing & editing	KH, DC, MH, QT, SG, AO, GKC, LZ, TB, SLG, RG, JR

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A century of cardiac rehabilitation research: Bibliometric review of publication history, keyword trends, and citations

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Research into cardiac rehabilitation (CR), a key model for secondary prevention of cardiovascular disease, has evolved since first described in 1927. This review aimed to explore this evolution by identifying CR-related publications from the Web of Science Core Collection and summarizing CR research publication history, trends in publication keywords, and citations over time. A total of 8729 CR publications appeared across 1441 journals (median impact factor: 2.6) and were cited 315,819 times, with over 85% (7455/8729) published in the past two decades. These publications involved contributions from 26,909 authors across 120 countries, despite disproportionate domination by high-income countries. Publication keywords have consistently focused on exercise but have evolved from evaluating clinical events, quality-of-life, and return-to-work outcomes to improving accessibility using digital interventions. However, a broader focus on other cardiovascular risk factors, comorbidities, and various research designs may be needed to modernize CR, particularly in lower-income countries.

Cardiovascular disease (CVD) research has led to advancements in the prevention and management of CVD[1–3]. While there has been a steep global decline in CVD mortality−from 355 deaths per 100,000 people in 1990 to 240 in 2019−the prevalence of CVD has nearly doubled from 271 to 523 million, and years lived with CVD disability have also nearly doubled from 18 to 34 million[1,4]. This increased prevalence indicates that although fewer people are dying from CVD, many are living longer with associated complications, requiring lifelong management[5].

Scientific publications have accompanied this progress in CVD prognosis and outcomes[6]. Early publications addressed issues such as the reintegration of "cardiacs" into the workforce[7]. The development of catheterization procedures in 1944, followed by the integration of imaging techniques starting in 1953, revolutionized the diagnosis of CVD[8,9]. In the 1950s, the Framingham Heart Study identified risk factors such as hypertension, dyslipidemia, diabetes, and obesity[10–12]. The introduction of selective coronary angiography and bypass procedures in the 1960s, then stents and catheter-based interventions in the late 1970s, transformed treatment approaches for cardiac emergencies[13–16]. Alongside these developments and spurred on by the greater survival of initial CVD events, there was the development of cardiac rehabilitation[6]. This model of care initially focused on mobilization, subsequently exercise training, and as evidence evolved, expanded outpatient delivery, including disease education and psychosocial support for comprehensive secondary prevention in the 1970s[6]. More recently, the integration of technology and digital platforms gained momentum following the COVID-19 pandemic in 2020, revolutionizing remote CVD care[17].

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Research demonstrates the clear benefits of cardiac rehabilitation, including significant improvements in quality-of-life, reductions in recur-rent CVD events, a 23% reduction in CVD rehospitalizations, and a 26% reduction in CVD mortality[18]. Despite these clear benefits, participation rates remain low, ranging from 7% to 35%, with even lower rates in lower-resource settings where the burden of CVD is increasing[19–24]. Furthermore, the structure of cardiac rehabilitation programs has remained largely unchanged[6,25], raising questions about how research has influenced program delivery innovation and advancement beyond effectiveness. With longer life expectancy, the global burden of CVD will persist, imposing challenges for health systems. All countries will be affected by the future burden of CVD unless cardiac rehabilitation is modernized to adapt to the competing health resources and changing CVD landscape[4–6].

To address these challenges and guide the modernization of cardiac rehabilitation, it is important to explore how research in the field of cardiac rehabilitation has evolved over time. Bibliometric analysis can provide an overview of this evolution by summarizing publication history, geographic contributions, citation patterns, and publication keywords[22,26–28]. A bibliometric review also complements other study designs by capturing long-term trends and identifying underrepresented research focus areas that may not be addressed in individual studies, including systematic review, and by guiding future research within the changing context of CVD and secondary prevention. This bibliometric review aimed to summarize cardiac rehabilitation research publication history (journal field and quality, number, country, author collaboration), publication keywords, and citations over time to understand developments and apprise future research needs.

Results

Publication history: Journal field and quality

A total of 1441 journals published cardiac rehabilitation research. Most (n = 1257, 87%) of these journals were based in high-income countries (highest number based in the United States, the United Kingdom and Germany); 113 (7.8%) were based in upper-middle-income countries (highest number based in Brazil, Russia and China); 62 (4.3%) were based in lower-middle-income countries (highest number based in India, Iran and Pakistan); while 2 (0.1%) were based in low-income countries (Ethiopia and Malawi). The highest number of cardiac rehabilitation publications were in the Journal of Cardiopulmonary Rehabilitation and Prevention (n = 571; 6.5%), followed by the European Journal of Preventive Cardiology (n = 302, 3.5%) and the International Journal of Cardiology (n = 168, 1.9%; Fig. 1). Out of the journals with an impact factor in 2023 (n = 703, 49%), the median (interquartile range, IQR) impact factor was 2.6 (1.7–3.7). There were 28 journals that published at least 50 cardiac rehabilitation-related publications. Of these, 17 (61%) were in the subspecialty field of cardiology, 6 (21%) in rehabilitation or physiatry, 3 (11%) in medicine and 2 (7.1%) in nursing, with an increasing number of publications in the recent years in nursing (Fig. 1). Under the subspecialty of cardiology, the two most cardiac rehabilitation-published journals are: (1) the International Journal of Cardiology (Field-weighted citation impact [FWCI] in 2023: 1.01, H-index: 155), and (2) the American Journal of Cardiology (FWCI in 2023: 0.59, H-index: 243). Under the subspecialty of rehabilitation, the two most cardiac rehabilitation-published journals are: (1) the Journal of Cardiopulmonary Rehabilitation and Prevention (FWCI in 2023: 0.38, H-index: 80), and (2) the European Journal of Preventive Cardiology (FWCI in 2023: 1.92, H-index: 130). Under the specialty of medicine, the two most cardiac rehabilitation-published journals are: (1) the BMJ Open (FWCI in 2023: 0.94, H-index: 176), and (2) the Journal of Clinical Medicine (FWCI in 2023: 1.12, H-index: 132). Meanwhile, under the subspecialty of nursing, the two most cardiac rehabilitation-published journals are: (1) the European Journal of Cardio-vascular Nursing (FWCI in 2023: 2.74, H-index: 66), and (2) the Journal of Cardiovascular Nursing (FWCI in 2023: 0.90, H-index: 73).

Publication history: Publication numbers, country, and author collaboration

Up to the search date (August 12th, 2024), a total of 8729 publications were identified, comprising 72% (n = 6629) full original research articles, 13%

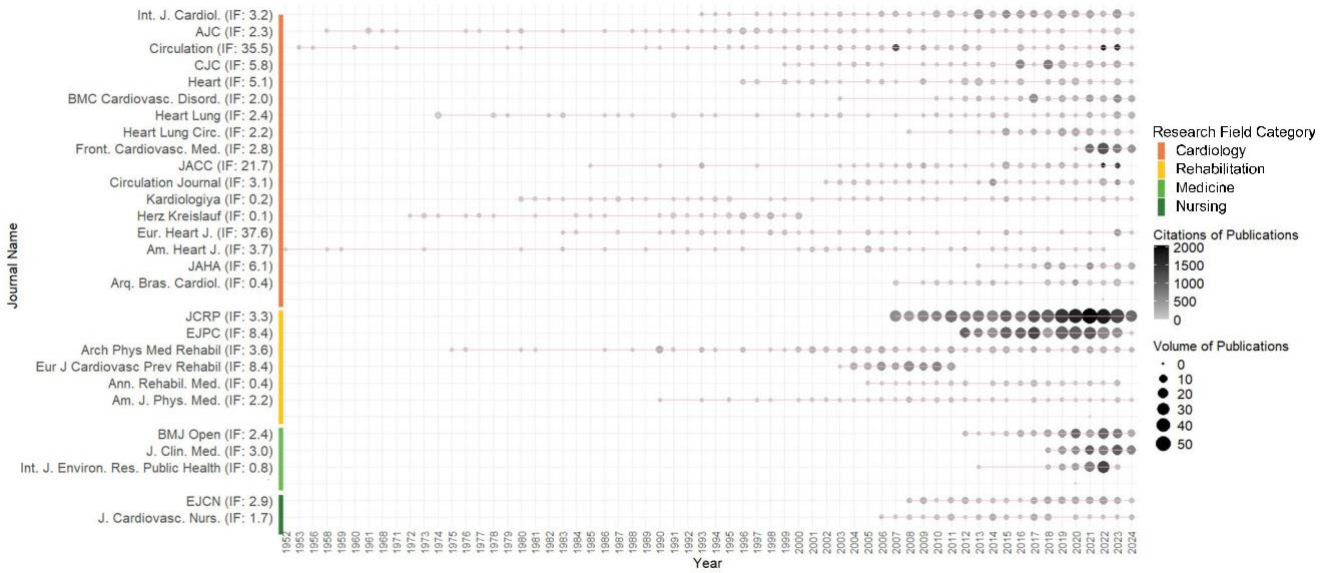


Fig. 1 | Journal name, as well as annual number and citations of cardiac reha-bilitation publications by full calendar year, ranked by the journal's research field category and number of publications. The figure presents journal names alongside the number and citation count of cardiac rehabilitation publications per year, ranked by research field category and total number of publications. Int. J. Cardio-l.International Journal of Cardiology, AJCAmerican Journal of Cardiology, CJCCa-nadian Journal of Cardiology, BMC Cardiovasc. Disord.BMC Cardiovascular Disorders, Heart LungHeart & Lung, Heart Lung Circ.Heart, Lung and Circulation, Front. Cardiovasc. Med.Frontiers in Cardiovascular Medicine, JACCJournal of the American College of Cardiology, Eur. Heart J.European Heart Journal, Am. Heart J.American Heart Journal, JAHAJournal of the American Heart Association, Arq. Bras. Cardiol.Arquivos Brasileiros de Cardiologia, JCRPJournal of Cardiopulmonary Rehabilitation and Prevention, EJPCEuropean Journal of Preventive Cardiology, Arch. Phys. Med. Rehabil.Archives of Physical Medicine and Rehabilitation, Eur. J. Cardiovasc. Prev. Rehabil.European Journal of Cardiovascular Prevention & Reha-bilitation, Ann. Rehabil. Med.Annals of Rehabilitation Medicine, Am. J. Phys. Med.American Journal of Physical Medicine & Rehabilitation, J. Clin. Med.Journal of Clinical Medicine, Int. J. Environ. Res. Public HealthInternational Journal of Environmental Research and Public Health, EJCNEuropean Journal of Cardiovas-cular Nursing, J. Cardiovasc. Nurs.Journal of Cardiovascular Nursing.

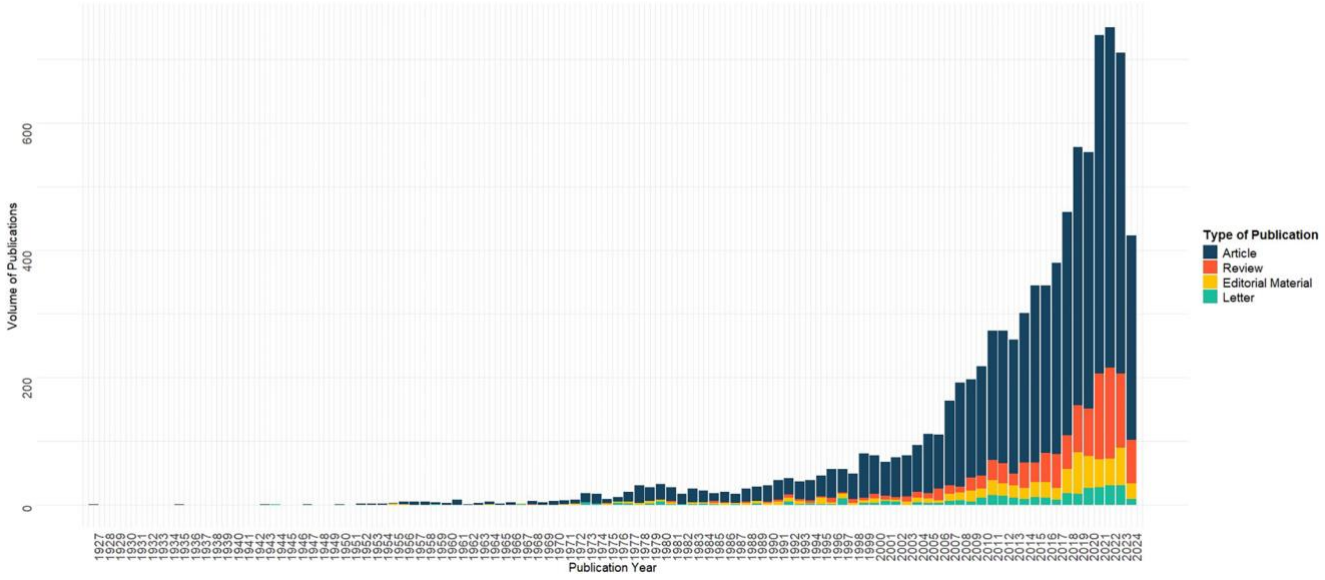
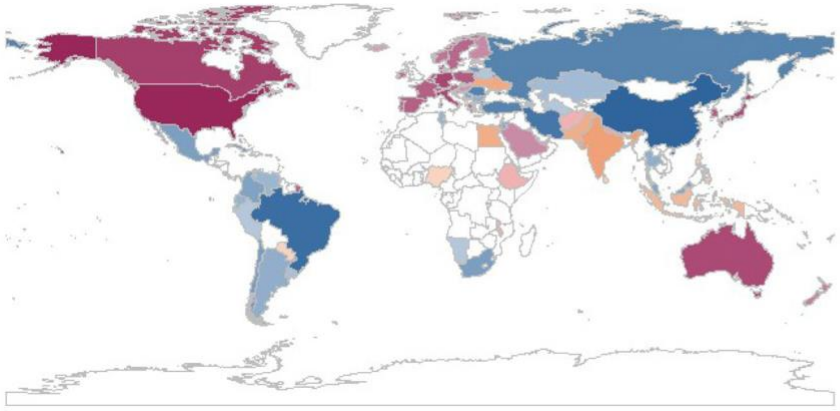


Fig. 2 | Annual number of cardiac rehabilitation publications (i.e., original research articles, reviews, editorial materials, and letters) by full calendar year from 1927 to 2023. The figure presents the number of cardiac rehabilitation publications per year, grouped by publication type from 1927 to 2023.



World Bank income classification
High-income country
Upper-middle-income country
Lower-middle-income country
Low income

Country	Publications n (%)
United States	1,597 (18)
Canada	691 (7.9)
United Kingdom	599 (6.9)
Italy	504 (5.8)
China	475 (5.4)
Germany	467 (5.3)
Australia	423 (4.8)
Japan	386 (4.4)
Brazil	253 (2.9)
Netherlands	203 (2.3)

Fig. 3 | Number of cardiac rehabilitation publications (i.e., original research articles, reviews, editorial materials, and letters) by country and World Bank income classification of the country of the corresponding author. The figure presents the number of cardiac rehabilitation publications by the corresponding author's country, grouped by World Bank income classification and shaded by the number of publications. Note: Shading represents the number of publications in descending gradient within each income classification.

(n = 1106) reviews, 7.4% (n = 651) editorial materials, and 3.9% (n = 343) letters. Cardiac rehabilitation publications were infrequent between 1927 and 1950, before appearing annually from 1952 onwards (Fig. 2).

The number of publications has grown substantially, particularly over the past two decades, when 85% (7455/8729) of all publications were published. For the first 70 years, the annual number of publications increased gradually (Fig. 2). The growth became exponential in the early 2000s, peaking at over 700 publications annually by 2022, despite slight declines in 2013, 2020, and 2023 (Fig. 2).

Collectively, cardiac rehabilitation publications involved 26,909 unique authors across 2670 institutional affiliations in 120 of the ~194 countries globally (Fig. 3). However, publications from authors in lower-income countries were limited, with particularly low representation from the African region. Most publications (n = 7823, 90%) involved collaboration among a median (IQR) of 5 (3–8) authors, with 17% (n = 1460) including multi-national collaboration.

Corresponding authors in high-income countries published 7.7 times more than those in upper-middle-income, and 22 times more than those in lower-middle-income countries. The highest number of publications was from corresponding authors in the United States (n = 1597; 18%) followed by Canada (n = 691, 7.9%) and the United Kingdom (n = 599, 6.9%). The 10 most-published corresponding authors' countries with more than 200 publications, along with their income classifications, across all time, are shown in Fig. 3. The number of publications from corresponding authors in upper-middle-income countries has increased significantly since 2020. Early publications in upper-middle-income countries were from Argentina in 1978, Russia in 1992, and Azerbaijan in 1994. Over 58% (553/959) of publications in upper-middle-income countries were published between 2020 and the search date (August 12th, 2024). Similarly, in lower-middle-income countries, early publications were from Iran in 2003, Egypt in 2007, and Jordan in 2009. Over 51% (175/341) of publications in lower-middle-income countries were published during the same period. Only three publications had corresponding authors from low-income countries (Malawi in 2021, Ethiopia in 2022, and Afghanistan in 2023).

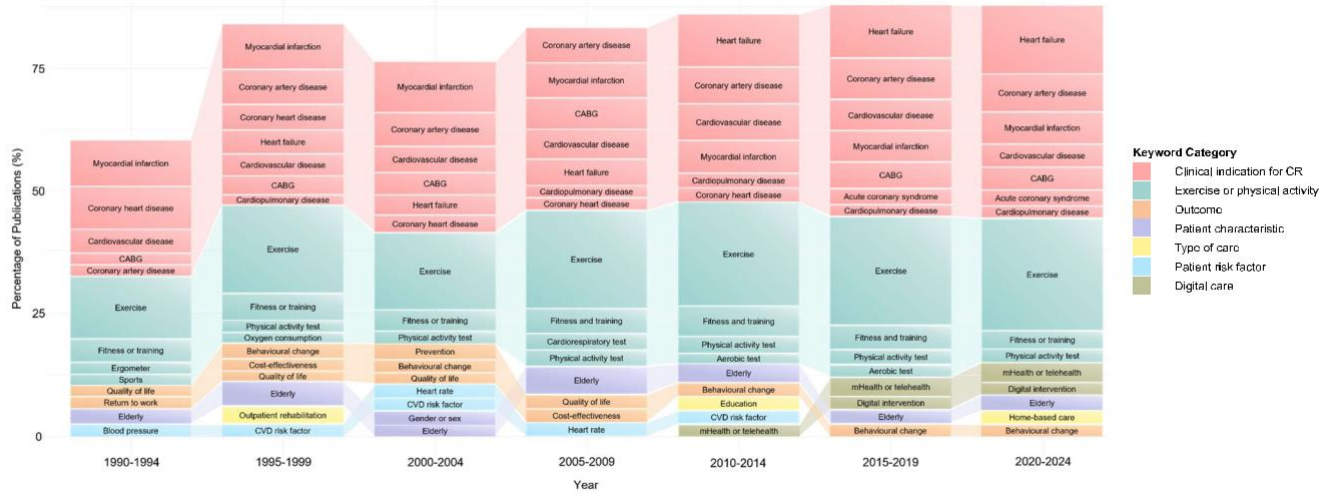


Fig. 4 | Percentage of publications using the top 15 most frequently used key-words per 5-year period, in descending order by keyword category and within each category. The figure presents the percentage of cardiac rehabilitation pub-lications using the 15 most frequently used keywords per 5-year period, grouped and ordered by keyword category. CABG coronary artery bypass graft, CVD cardio-vascular disease, mHealth mobile health, 6-min walk test six-minute walk test, CR cardiac rehabilitation. Note: The Aerobic test evaluates an individual's capacity to consume and utilize oxygen during sustained physical activity, serving as an indi-cator of their endurance. The cardiorespiratory test evaluates an individual's effi-ciency in delivering oxygen to active muscle and expelling carbon dioxide during physical activity, serving as an indicator of their integrated cardiovascular and respiratory fitness. Physical activity test tracks an individual's physical activity patterns, habits, and intensity using tools such as questionnaires.

Publication keyword

From 1990 onwards, when author-assigned keywords became available, cardiac rehabilitation publications have used a total of 539 unique keywords. Across each 5-year period, notable homogeneity was observed, with more than 50% of publications consistently using the same 15 keywords (Fig. 4). These keywords primarily related to clinical indications for cardiac rehabilitation, exercise or physical activity, outcomes, patient characteristics, type of care, patient risk factors, and digital care, as visualized in Fig. 4. The most frequently used keywords related to research design, were randomized controlled trials, followed by qualitative studies, systematic reviews, surveys and quality improvement studies.

Keyword related to exercise have remained a consistent focus, with around 20% of publications using the keyword in each 5-year period (Fig. 4). The most frequently used keyword related to clinical indications for cardiac rehabilitation has shifted over time, with myocardial infarction being the primary focus in earlier publications, whereas since 2010, heart failure has become a more commonly used keyword (Fig. 4). Between 1995 and 2009, there was an increased emphasis on keywords related to cardiac rehabilitation patient out-comes or efficacy, such as quality-of-life, return-to-work, cost-effectiveness, and adherence−either to the program or to heart-health behaviors (Fig. 4). Since 2010, keywords have increasingly focused on new delivery models, such as patient education, digital interventions and home-based care (Fig. 4).

In contrast, less frequently used keywords related to patient risk factors included depression, anxiety, diabetes, nutrition, and obesity. Similarly, keywords related to patient sub-groups, such as the elderly, or other out-comes such as cardioprotective medication adherence or patient satisfaction, have remained underrepresented across the history of this literature.

Citations

Cardiac rehabilitation publications have received a total of 315,819 citations across all time up to the search date (August 12th, 2024), with each pub-lication being cited a median (IQR) of 31 (19–44) times. However, corre-sponding authors in high-income countries were cited 7.7 times more than those in upper-middle-income countries, and 27 times more than those in lower-middle-income countries.

Among the 10 most-cited countries, the United States of America, Canada and England formed a citation cluster, with the strongest link between the United States and Canada, followed by the United States and England, and then Canada with England (Fig. 5). This cluster also included Australia and China (Fig. 5). Whereas several European countries, specifically Denmark, Germany, Italy, Netherlands and Switzerland, formed a separate citation cluster (Fig. 5).

Discussion

The field of cardiac rehabilitation research, comprising over 8000 publica-tions and over 300,000 citations, has been comprehensively summarized in the current review, detailing its history, publication keywords and citations from inception to the present[22,26–28]. Publications appeared across over 14,000 journals with a median impact factor of 2.6 in 2023, most frequently in two subspecialty journals: the Journal of Cardiopulmonary Rehabilitation and Prevention and the European Journal of Preventive Cardiology. Cardiac rehabilitation-related publications first appeared infrequently between 1927 and 1950, became consistent, and experienced substantial growth from 2004 onwards, reaching over 700 publications annually from 2021 onwards, and marking nearly a century of progress. While a median of five authors contributed to each publication, the over 26,000 authors involved in cardiac rehabilitation research across all time represented nearly two-thirds of countries globally. However, high-income countries have dis-proportionately dominated the number and citation of publications com-pared to lower-income countries. The field has consistently focused on exercise, progressing to establish efficacy, and more recently has expanded to address additional clinical indications and integrate technology-based delivery models[17,29,30].

The substantial growth in the cardiac rehabilitation research over the past 20 years mirrors similar trends seen across subspecialty fields within cardiology, such as CVD risk factors; specialty fields beyond cardiology, such as technology-based healthcare; and more broadly clinical research and study designs[31–34]. The two subspecialty journals most frequently publishing cardiac rehabilitation research, the Journal of Cardiopulmonary Rehabilitation and Prevention and the European Journal of Preventive Cardiology, underwent name changes in 1981 and 2012, respectively, reflecting the expanding focus areas within this field of research[35,36]. The journals most

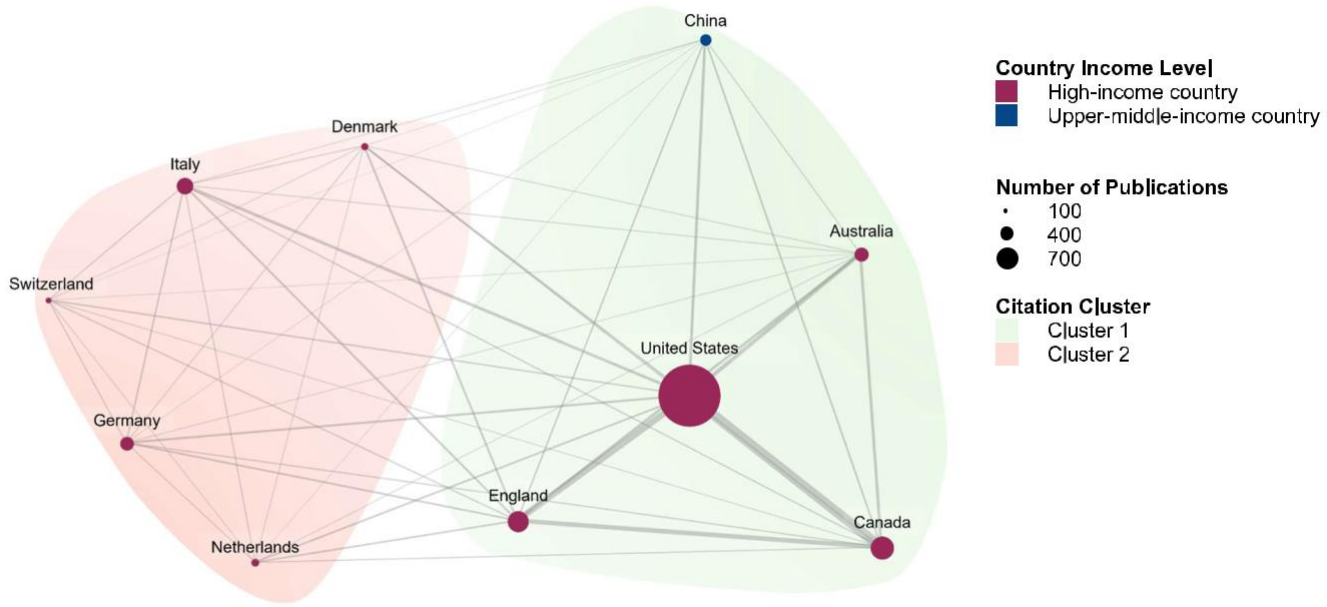


Fig. 5 | Citation patterns of cardiac rehabilitation publications by country and World Bank income classification of the country of the corresponding author. The figure presents citation patterns between countries based on the corresponding author's affiliation, grouped by World Bank income classification. Note: Lines between dots represent citation links.

frequently publishing cardiac rehabilitation research are in the subspecialty field of cardiology, followed by rehabilitation or physiatry, and more recently, nursing. These consistent contributions from cardiology journals, combined with the increased presence in allied health and nursing journals, confirm the growing involvement of multidisciplinary professionals in accommodating the delivery of not only exercise training but also education and psychosocial support in cardiac rehabilitation[6]. This trend is further emphasized by the citation metric among the most cardiac rehabilitation-published journals in each research field category. Notably, journals in the subspecialty field of nursing recorded relatively higher citation impact compared to the subspecialty field of rehabilitation. This discrepancy may reflect the broader and interdisciplinary appeal of nursing journals com-pared to rehabilitation journals. It also aligns with a broader shift in clinical practice from acute, hospital-based care to long-term, outpatient, and community-based models of secondary prevention.

Despite the century-long publication history of cardiac rehabilitation research, over half of the publications from corresponding authors in middle-income countries have encouragingly appeared within the past 5 years. This surge may be attributed to increased investment in cardiac rehabilitation infrastructure, research initiatives, and capacity-building efforts[37]. However, this number may still underestimate the true contributions from middle-income countries, since ~58% of their publications were found in non-indexed local repositories or websites[38]. Additionally, publishing in open-access journals often incurs publication fees, which can be prohibitive for authors in resource-constrained settings[39]. These publication and citation disparities have again been observed across subspecialty fields within cardiology, such as CVD risk factors, and more broadly, cardiology and clinical research[33,34,40]. Strategies to address these disparities could include supporting the indexing of local repositories from lower-income countries, waiving or subsidizing publication fees, and providing training in scientific writing, although its long-term impact of these efforts remains unclear[41]. Strengthening equitable authorship and global collaborations may increase the relevance of findings and support innovations that are locally responsive yet globally scalable.

Cardiac rehabilitation research is anticipated to continue evolving in response to the changing landscape of CVD, adapting to health system characteristics, financial realities, and patient needs[5,6]. Recent publications have highlighted the rising integration of technology-based models or digital platforms, including artificial intelligence, in CVD care—a trend accelerated by the COVID-19 pandemic[17,42]. This may reflect the increasing focus on improving patient access, enabling flexible delivery, and developing scalable, sustainable interventions to reduce disparities in access to secondary prevention. Despite these advancements, research remains comparatively focused on exercise, with less attention directed towards addressing mental health, comorbidities, sub-groups such as the elderly or women, and out-comes such as cardioprotective medication adherence or patient satisfaction. The ongoing focus on exercise in cardiac rehabilitation research is consistent with its central role in program delivery and its strong supporting evidence. However, the predominance of efficacy-focused randomized controlled trials suggests a lack of implementation and real-world studies, which may better inform policy and practice in diverse settings. Incorporating alternative research designs, such as implementation science, and involving patients in program design may enhance the scalability, sustain-ability, and relevance of cardiac rehabilitation interventions.

The main citation cluster comprising of North America, the United Kingdom, Australia and China, along with a second citation cluster of several European countries, likely reflect shared approaches to cardiac rehabilitation, geographic proximity, and the influence of the American Heart Association, the American College of Cardiology and the European Society of Cardiology in facilitating cross-continent research networks[43–46]. However, disparities in the number and citations of publications are evident, with limited representation from lower-income countries where the CVD burden continues to worsen, aside from notable representations from China and Brazil[4]. The particularly low representation from the African region may be attributed to its lowest availability and density of cardiac rehabilitation among all global regions[47–49]. Recent efforts in the African region to develop cardiac rehabilitation have been commendable and promising[50–52]. Indeed, greater representation both in collaboration or co-authorship with lower-income countries could drive innovations, cost-effective solutions to improve participation rates, and modernize cardiac rehabilitation practices[53–56]. For example, in the field of physical disability rehabilitation, community-based rehabilitation programs developed in lower-income countries have been successfully adapted for remote or underserved areas in high-income countries, such as Australia and Canada[57–60].

The current bibliometric review has several limitations. Biblio-metric reviews primarily involve quantitative analyses, which may overlook qualitative developments in cardiac rehabilitation research. First, the sole use of the Web of Science Core Collection may have excluded regional-specific, country-specific, or non-English publications and not-yet-indexed journals, which may limit the generalizability of the findings, particularly to lower-income countries. Second, the analysis of specific study designs was limited, as these details are not included in its bibliometric records. Regardless, the Web of Science Core Collection remains an appropriate and reliable source, given its broad representation of journals, longest continuous coverage of publications, consistent data on author affiliation, and stable tracking of citations, supporting the reproducibility of the current bibliometric review. Third, changes in journal impact factor, journal subspecialty FWCI, and H-index over time were not accounted for. Fourth, certain types of publication (i.e., book, case report, conference abstract, correction, dissertation or thesis, pre-print, or retracted publication) were excluded, which may have further limited the scope of the current review. To more comprehensively capture the full publication history and changing trends in citations, future reviews could expand their scope to include gray literature, which may uncover economic or political contexts that have shaped the evolution in cardiac rehabilitation research and practice, or to explore the change in journal impact factor, journal subspecialty FWCI, and H-index over time. Additionally, future reviews could use alternative techniques such as text-mining to help reduce the dominance of commonly used author-assigned keywords and analyze more accurately each publication's contribution to the field of cardiac rehabilitation research.

Modernizing cardiac rehabilitation will require research to more consistently focus beyond exercise and include other patient risk factors, comorbidities, and outcomes. Expanding the use of implementation-focused study designs may help ensure that cardiac rehabilitation remains responsive, relevant, and adaptable to the persistent global burden of CVD and competing demands on health resources.

Methods

Bibliometric review involves quantitative methods to analyze academic research and literature, exploring publication history, trends in publication keywords, and citations[61]. This study design uses metrics such as journal rankings, country, author contributions, publication keywords, and citation data[61]. The findings are reported in accordance with the preliminary guideline for reporting bibliometric reviews of the bibliometric literature (BIBLIO)[61].

Publication search and selection

Cardiac rehabilitation research was identified through a systematic search of the Web of Science Core Collection database for publications in English language up to August 12th, 2024, as specified in the publication. The search targeted titles (field tag: TI) or author keywords (field tag: AK) containing the terms "cardiac rehabilitation" or "heart rehabilitation". Variation of these terms was included using asterisks (*) and the Boolean operator OR. The Web of Science Core Collection was selected as it provides comprehensive journal-level metadata, standardized author affiliations data, and structured citation metadata within a single database, enabling reproducible evaluation of the trends in journal publications, author collaborations, and citation patterns, which are not collectively available across other databases[62–65].

Bibliographic data was exported in Excel and text formats, including year and type of publication. This review only analyzed full original research articles, reviews, editorial materials, and letters as categorized in Web of Science, and excluded other types of publication (i.e., book, case report, conference abstract, correction, dissertation or thesis, pre-print or retracted publication). Editorial materials com-prise commentaries, discussions, interviews, or symposia between individuals, groups, or organizations[66]. Letters comprise readers' comments, or questions and answers regarding a publication, addressed to the journal editor[66]. Journals, number of publications, affiliations, and countries of corresponding and co-authors were extracted, as well as author-assigned publication keywords and number of citations. The search strategy, excluded records, included studies, and the list of exported bibliographic data are provided in Supplementary Fig. 1. The country of the corresponding author was categorized according to the World Bank income classifications (i.e., low, lower-middle, upper-middle, or high-income)[67].

Publication history: Journal field and quality

To summarize publication history, the total number of journals publishing cardiac rehabilitation research was calculated, and journals were ranked by their total number of cardiac rehabilitation publications. Journal impact factor was obtained from the 2023 Journal Citation Reports by Clarivate[68]; this is calculated by dividing annual citations by the annual number of publications per journal[68]. The median (IQR) impact factors were calculated. The calculations were performed using the bibliometrix package in RStudio version 2024.04.2 +764[69]. The country of origin of journals was obtained from the SCImago Journal & Country Rank and categorized according to the World Bank income classifications[67,70]. Thematic analysis of journal titles was conducted to classify the journals by research field. This analysis was conducted by two independent reviewers (D.M. and K.H.), with any disagreement resolved through discussion. The annual number and citations of publications in journals, each with at least 50 cardiac rehabilitation publications, ranked by the journal's research field category and number of publications, were visualized using the ggplot2 package in RStudio 2024.04.2 +764[71]. The 2023 FWCI and H-index of the journals most frequently publishing cardiac rehabilitation research in each research field category were compared across field categories. Journal FWCI values were obtained from SciVal; this is calculated by comparing the total citations of all publications in a journal to the average citations of similar publications across all journals[72]. H-index values were obtained from SCImago Journal Rank; this is calculated as the number of publications in a journal that have each received at least the same number of citations as the number of publications[70].

Publication history: Publication numbers, country, and author collaboration

The total number, types, and annual number of cardiac rehabilitation publications were aggregated and visualized. The total number of authors, affiliations or institutions, and countries was calculated per publication and aggregated by year. The median (IQR) number of authors per publication and the percentage of publications involving multi-national collaboration were calculated. The distribution of publications across corresponding authors' country and the income classification of country were aggregated, compared, and visualized.

Publication keyword

To summarize publication keywords, this part of the review only analyzed cardiac rehabilitation publications from 1990 onwards, the earliest year when author-assigned keywords were available. After variations in spelling and phrasing of keywords were homogenized, the total number of unique keywords was calculated. These were aggregated by 5-year periods; for each, the total number of publications using each keyword was calculated, and the 15 most frequently used keywords in that period were identified. Keywords used in fewer than three publications were excluded from the analysis, while any keyword that was used as frequently as the 15th keyword was also included. Thematic keyword analysis was conducted to create semantically related groupings. This analysis was conducted by two independent reviewers (D.M. and K.H.), with any disagreement resolved through discussion. The identified keywords, ranked by the percentage of publications using each and their thematic group, were compared across the periods and visualized using the ggplot2 package in RStudio 2024.04.2 +764[71].

Citations

To summarize citations, the total number and median (IQR) citations of cardiac rehabilitation publications were calculated. The citation patterns across the country and the income classification of the country of the corresponding author were aggregated and compared. The calculations were performed using the bibliometrix package and visualizations using the ggplot2 package in RStudio version 2024.04.2 +764[69]. Citation links and clusters between the most common 10 countries of publication were calculated and visualized using VOSviewer version 1.6.20. A citation link was established between two countries when one country cites the other, regardless of the direction of citation[73]. Citation clusters were formed by grouping countries with similar patterns of citation links[73].

Data availability

The datasets generated and analyzed during the current study are not publicly available due to licensing restrictions of the Web of Science Core Collection, but are available from the corresponding author on reasonable request.

Code availability

The underlying code for this study is not publicly available but may be made available to qualified researchers on reasonable request from the corresponding author. Analyses were conducted using RStudio (version 2024.04.2 +764) with the bibliometrix and ggplot2 packages in R, and VOSviewer (version 1.6.20).

Abbreviations

CR	Cardiac rehabilitation
CVD	Cardiovascular disease
IQR	Interquartile range
FWCI	Field-weighted citation impact
H-index	Hirsch index

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Author contributions

D.M., K.H. and J.R. conceptualized the work, undertook the bibliometric analyses, and drafted the manuscript. D.C., M.H., Q.T., S.G., A.O., G.K.C., L.Z., T.B., S.L.G. and R.G. gave input on preliminary methods and results, as well as reviewed the manuscript. All authors approved the final version of the manuscript.

Competing interests
The authors declare no competing interests.

Additional information
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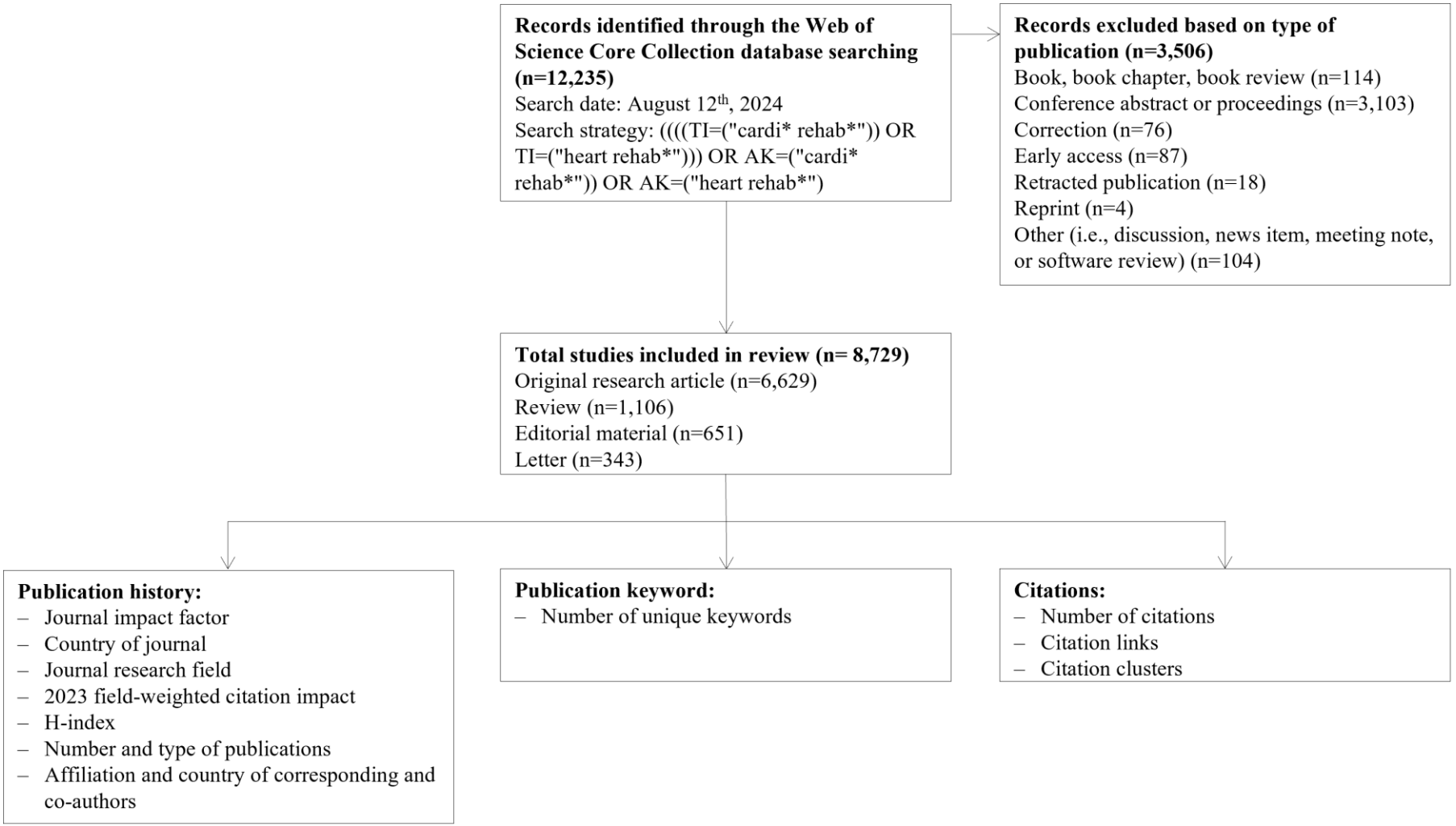
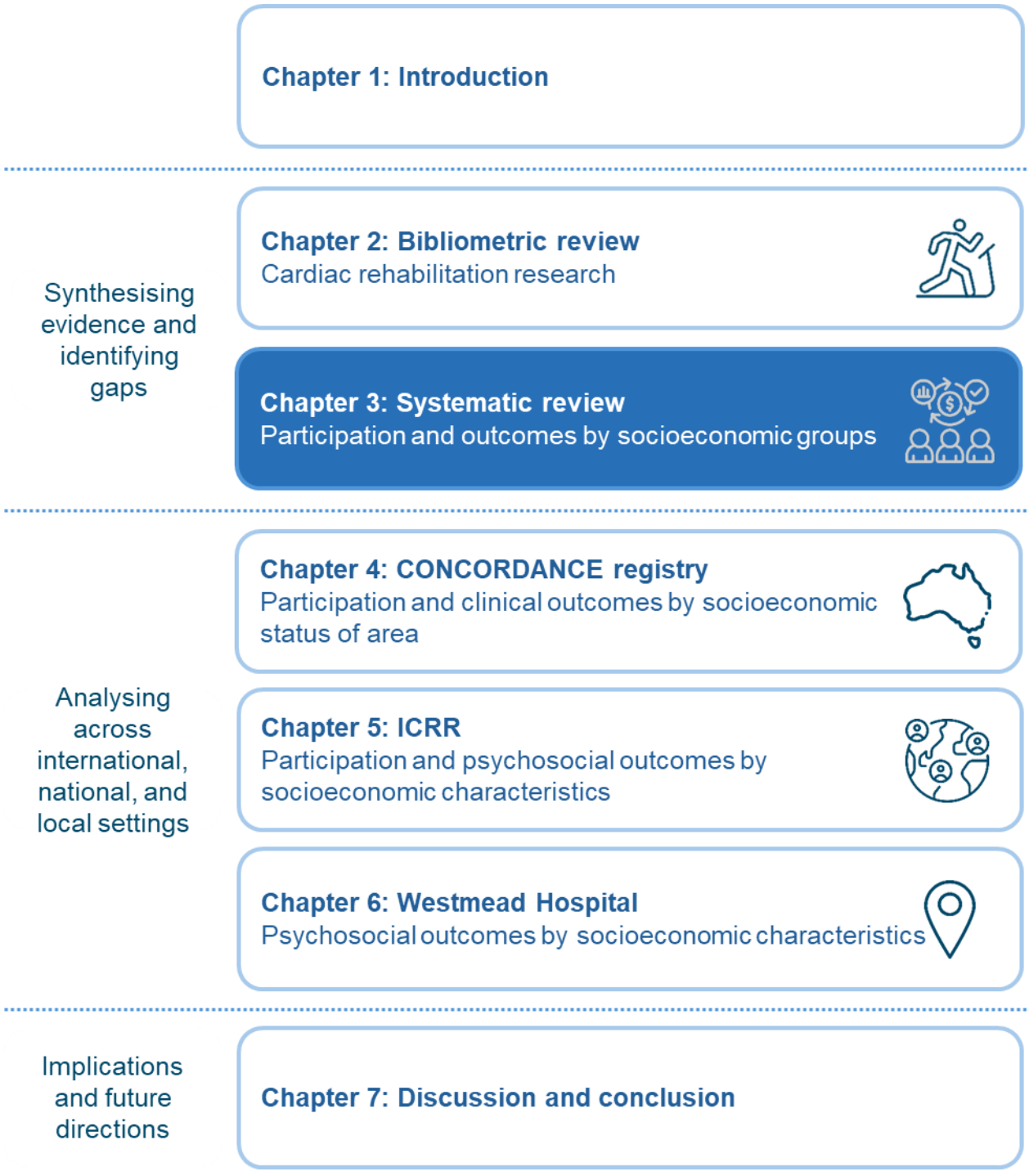
SUPPLEMENTARY MATERIALS

Supplementary Figure 1. Search strategy, excluded records, included studies, and list of exported bibliographic data



CHAPTER 3

Socioeconomic variation in outcomes of cardiac rehabilitation: A systematic review



This chapter presents a systematic review of whether cardiac rehabilitation participation is associated with differences in mortality, hospital readmission, return to work, and cardiovascular knowledge across socioeconomic subgroups. It builds on Chapter 2 by providing published evidence on disparities in participation and outcomes.

A total of six studies were included, comprising 555,731 individuals. Most evidence was related to disparities in participation and return to work by area of residence, with more limited evidence related to clinical outcomes by education and income. These findings inform subsequent chapters of this thesis, which assess registry data for disparities in cardiac rehabilitation participation and outcomes in real-life settings.

> **Aim Addressed:** This chapter addresses **Aim 2** – to systematically review the association between cardiac rehabilitation participation and clinical outcomes across socioeconomic subgroups.

This work, titled *"Socioeconomic variation in the relationship between cardiac rehabilitation participation and clinical outcomes: A systematic review and meta-analysis"*, is currently under review by *Open Heart*.

PUBLICATION

Manandi D, Redfern J, Tu Q, Chang AYJ, Hafiz N, Candelaria D, Hyun K. Socioeconomic variation in the relationship between cardiac rehabilitation participation and clinical outcomes: A systematic review and meta-analysis. *Open Heart*. (under review).

STATEMENT OF AUTHORSHIP

Deborah Manandi led the conceptualisation, methodology, formal analysis, and writing – original draft. The roles of co-authors are as follows:

Task	**Role of co-authors**
Conceptualisation	JR, KH
Methodology	JR, QT, KH
Formal analysis	QT, AJYC, NH, DC, KH
Writing – reviewing & editing	JR, QT, AJYC, NH, DC, KH

ABSTRACT

Aim: To systematically evaluate whether relationships between cardiac rehabilitation participation and clinical outcomes, return to work, or knowledge about cardiovascular disease vary across socioeconomic indicators.

Methods: A systematic review was conducted using CENTRAL, CINAHL, Embase, and Medline up to 1 November 2024. Studies were included if they compared outcomes between participants who received cardiac rehabilitation and those who did not or received an exercise programme. Outcomes included all-cause death, all-cause and cardiovascular-related rehospitalisation, return to work, and cardiovascular knowledge, stratified by socioeconomic indicators. Risk of bias was assessed using the Risk Of Bias In Non-Randomized Studies—of Interventions tool.

Results: Six studies involving 555,731 participants were included. Compared to non-participants, cardiac rehabilitation participants had lower rates of all-cause death (12.3%–16.9%) and all-cause rehospitalisation (15.2%–16.1%), with incidence rate differences in cardiovascular-related rehospitalization reaching up to 27.8 fewer events/100 person-years. Some of the greatest differences were among participants residing in more disadvantaged areas, although this was not consistent across studies. No significant differences were observed in the combined outcome of all-cause death and cardiovascular-related rehospitalisation when stratified by educational attainment levels. Return to work and knowledge outcomes showed greater variation across education and income subgroups, with higher values consistently observed among cardiac rehabilitation participants from less disadvantaged backgrounds. All studies were observational and had moderate risk of bias.

Conclusions: Cardiac rehabilitation improves clinical and functional outcomes across socioeconomic subgroups, although disparities in participation and outcomes persist. Tailoring programme delivery to be more flexible and responsive to literacy needs may help ensure its benefits are equitably achieved across patient subgroups.

INTRODUCTION

Cardiovascular disease remains a major contributor to the global health burden. It accounts for one-third of premature deaths and 15% of total healthcare expenditure annually.[1,2] The burden of cardiovascular disease is not equally distributed and tends to be higher among patients from disadvantaged socioeconomic backgrounds, regardless of area of residence, educational attainment, income level or stage of care.[3] Barriers such as limited access to public physical activity facilities, less leisure time and lower discretionary income may contribute to the accumulation of cardiovascular risk factors among patients who are from disadvantaged socioeconomic backgrounds.[3-6] A study involving 20 countries reported consistent socioeconomic disparity in cardiovascular outcomes, with more pronounced effects in low-income settings.[7] In high-income countries, those with secondary or lower education had a 1.2-fold higher risk of recurrent major cardiovascular events and a 1.5-fold higher risk of death compared to those with higher education.[7] In low-income countries, these risks increased to 1.5-fold and 2.8-fold, respectively.[7] Similarly, in one high-income setting, patients residing in the most disadvantaged areas had 1.6 to 1.8 times the risk of myocardial infarction and 1.3 to 1.5 times the risk of cardiovascular-related death compared with those in the least disadvantaged areas.[8]

The benefits of cardiac rehabilitation in improving clinical outcomes, including death, rehospitalisation, quality of life and exercise capacity, are well established.[9-11] However, patients with lower educational attainment and less disposable income−who may also have greater long-term care needs−are approximately half as likely to participate in or complete cardiac rehabilitation.[12] Socioeconomic disparities may not only affect access to cardiac rehabilitation but also influence its delivery and outcomes achieved.[13,14] While these disparities in access are well documented, to our knowledge, existing studies that report outcomes stratified by socioeconomic subgroups have yet to be systematically synthesized.[15,16] A systematic review is needed to clarify whether disparities persist in outcomes even when access is achieved, and whether specific strategies are needed to ensure that the benefits of cardiac rehabilitation are equitably distributed across patient populations.

Past reviews have primarily focused on disparities in participation and completion of cardiac rehabilitation, with limited attention to whether its benefits differ once participation is

achieved. To our knowledge, no review has yet summarised the extent of these disparities by socioeconomic indicators, including area of residence, educational attainment and income level. This review, therefore, aimed to systematically evaluate whether the relationship between cardiac rehabilitation participation and clinical outcomes, return to work, or knowledge about cardiovascular disease varies across socioeconomic indicators.

METHODS

This systematic review was conducted according to the protocol registered in the International Prospective Register of Systematic Reviews (PROSPERO; ID: CRD42022332355) and reported adhering to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines.[17]

Search strategy

A search was performed across four databases: (1) Cochrane Central Register of Controlled Trials (CENTRAL), (2) Cumulative Index of Nursing and Allied Health Literature (CINAHL), (3) Embase and (4) Medline until 1 November 2024. The search strategy included terms related and synonymous to 'cardiovascular disease', 'cardiac rehabilitation', 'participation' and 'socioeconomic indicator', using Boolean operators to ensure comprehensive retrieval of studies. The final search strategy is detailed in online supplemental table 1. The database selection and search terms were finalised in collaboration with University of Sydney librarians.

Study selection

Studies were included if they met the following criteria: (1) the population comprised adults (≥18 years) eligible for cardiac rehabilitation; (2) the intervention was cardiac rehabilitation; (3) the comparator was no cardiac rehabilitation or exercise training programme and (4) the outcome included patients' death, rehospitalisation, return to work or knowledge about cardiovascular disease, stratified by socioeconomic indicators. Cardiac rehabilitation was defined as a programme that included a baseline assessment of patients' demographics and clinical characteristics, structured exercise training—whether supervised or unsupervised—and at least one additional component to address cardiovascular risk factors.[18]

Studies were included if published in English or if they had English-language metadata (title, abstract or author-assigned keywords). Non-English studies were translated into English using Google Translate, which has been reported to be sufficiently accurate for selecting studies and extracting data in systematic reviews.[19] No restrictions were applied on publication period to support comprehensive retrieval of studies.

Titles and abstracts of eligible studies were independently screened by two of three reviewers (DM, QT and AYCJ). Full texts of the potentially relevant studies were again independently screened by two of five reviewers (DM, QT, AYCJ, NSH and DC). Disagreements were resolved through discussion with another reviewer (KH).

Data extraction

Data from the included studies were independently extracted and tabulated by two of three reviewers (DM, NSH and DC) using a standardised electronic data extraction form. The extracted data included first author, year of publication, country of patient enrolment and study design (number of enrolment centres, enrolment start and end dates and length of follow-up). For both cardiac rehabilitation and comparator groups (no cardiac rehabilitation or exercise training programme), the extracted data included intervention length and setting (face-to-face vs virtual; clinic vs public vs private). For the patient population of each study, the extracted data included baseline demographics (socioeconomic indicators, age and sex), clinical characteristics (comorbidities) and outcomes (all-cause death; all-cause and cardiovascular-related rehospitalisation; return to work; and knowledge about cardiovascular disease). Socioeconomic indicators were extracted as defined and classified in each study, but categorised into area of residence, educational attainment or income level. Definitions were retained and reported as in the original studies in table 1 and compared narratively because national-based socioeconomic indices, such as the Area Deprivation Index in the USA, census-based measures in the Netherlands and Denmark, or income-based measures in Brazil, were conceptually different and harmonising them risked misclassification.[20-23]

Analysis

The pooled mean and SD of age and the proportion of male participants across all included studies were calculated where available. If the mean age of the intervention or comparator group was not available, or if the mean age of all participants could not be calculated, the proportion of participants across different age subgroups was presented instead.

Outcomes (all-cause death; all-cause and cardiovascular-related rehospitalisation; return to work; and knowledge about cardiovascular disease) were compared between participants who did and did not participate in cardiac rehabilitation, stratified by socioeconomic indicators (area of residence, educational attainment or income level). For area of residence measures based on tertiles, quartiles or quintiles, lower category numbers indicate higher socioeconomic status, while higher numbers indicate lower socioeconomic status. The findings were summarised using narrative synthesis rather than meta-analysis due to differences in study design, outcome measurement, follow-up timing and reporting formats across studies. Results were reported using absolute differences for all-cause death and hospitalisation outcomes, expressed as percentages and incidence rates per 100 person-years; relative differences, expressed as ORs with 95% CIs for return to work and as HRs for the combined outcome of all-cause death and cardiovascular-related rehospitalisation; and mean scores for knowledge about cardiovascular disease.

Risk of bias assessment

The quality of the included studies was assessed using the Risk Of Bias In Non-Randomized Studies—of Interventions tool.[24] This tool assessed bias across seven domains: (1) confounding, (2) selection of participants into the study, (3) classification of interventions, (4) deviations from intended interventions, (5) missing data, (6) measurement of outcomes and (7) selection of the reported result.[24] The risk of bias of each study was independently assessed by two of four reviewers (DM, NSH, DC and KH), with disagreements resolved through discussion. Summary and graphical results are shown in figures 1 and 2.

	D1	D2	D3	D4	D5	D6	D7	Overall
Eijsvogels et al, 2020	–	–	+	–	+	+	+	–
Guhl et al., 2021	–	–	+	–	+	+	+	–
Kjesbu et al., 2022	–	–	+	–	+	+	+	–
Ghisi et al., 2014	–	×	+	–	+	+	+	–
Pedersen et al., 2023	–	–	+	–	+	+	+	–
Thompson et al., 2023	–	–	+	–	+	+	+	–

Figure 1. The summary of the risk of bias for each included studies

Judgement: , Low; , Moderate; , Serious; , Severe

Domains: D1, Bias due to confounding; D2, Bias due to selection of participants into the study; D3, Bias due to classification of interventions; D4, Bias arising from deviation from intended interventions; D5, Bias from missing data; D6, Bias from measurement of outcomes; D7, Bias from selection of the reported result

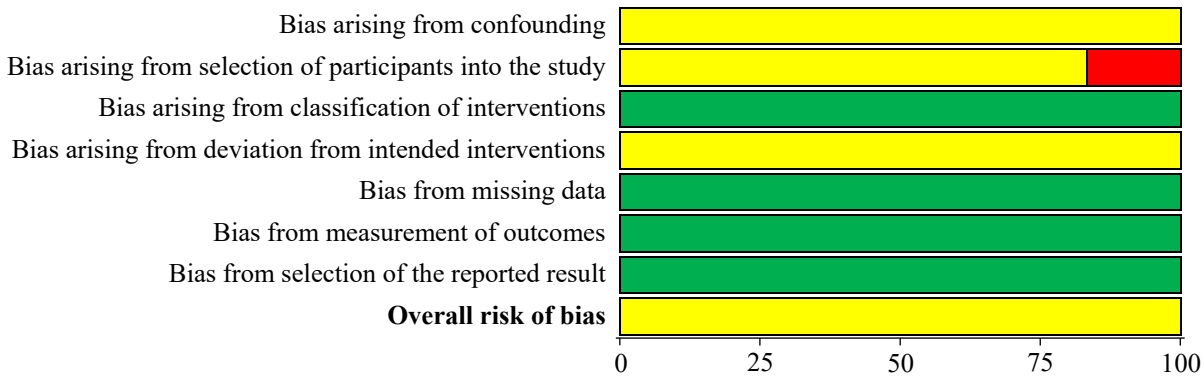


Figure 2. The graph of the risk of bias for all included studies

Judgement: , Low risk; , Moderate risk; , Serious risk; , Severe risk

RESULTS

Study selection

The systematic review was conducted and reported in accordance with the PRISMA 2020 guidelines. A total of 7,756 non-duplicated studies were screened. Six studies—five observational cohort studies and one cross-sectional comparative study—were included, comprising 555,731 participants (figure 3).[25-30] The characteristics of the included studies, their cardiac rehabilitation interventions, exercise training programme comparator and patient populations are summarised in table 1.

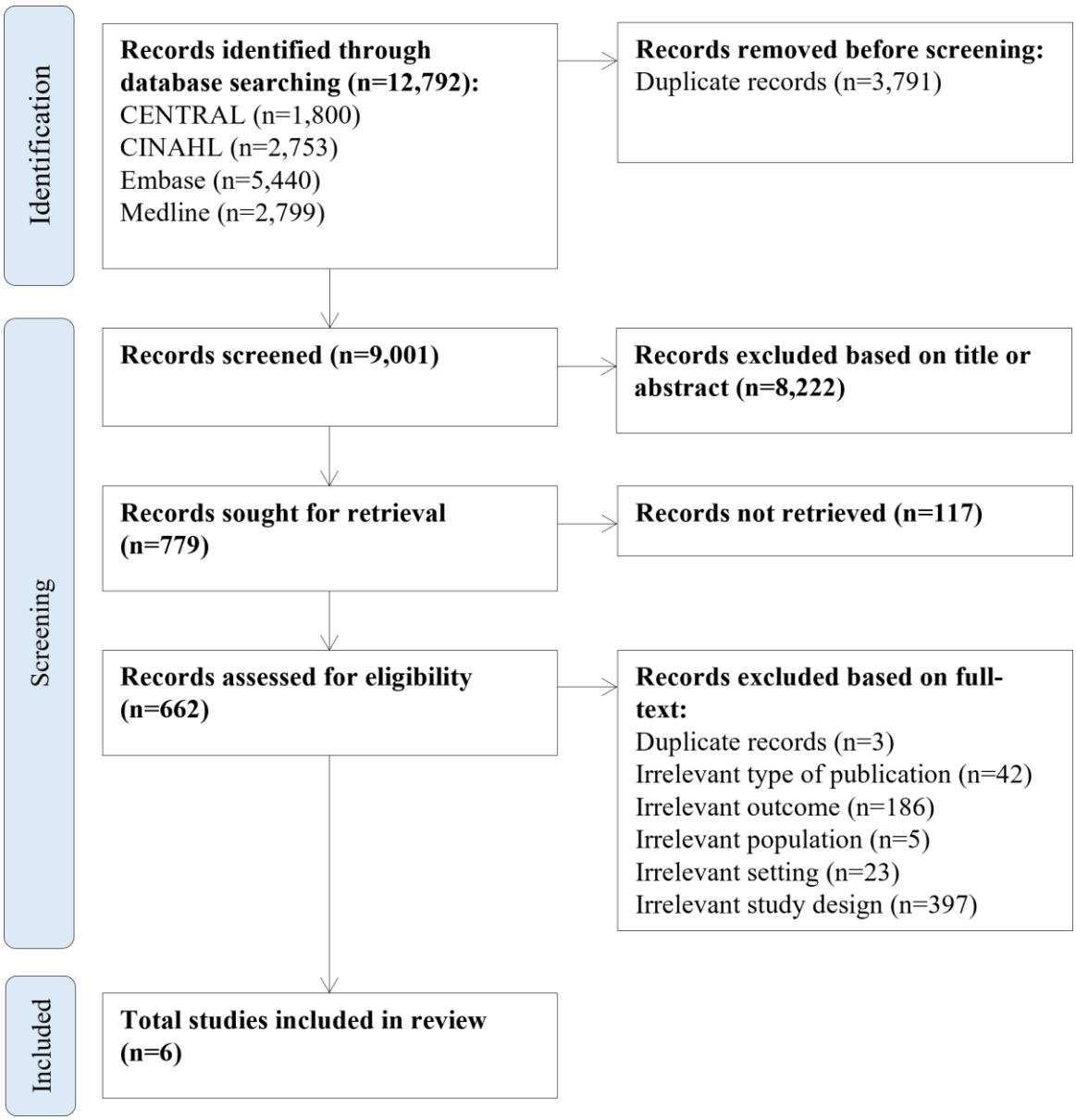


Figure 3. The Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) flow diagram of the study selection process

Table 1. Characteristics of the included studies, their cardiac rehabilitation interventions, exercise training program comparator, and participants

Characteristic	Eijsvogels et al., 2020[25]		Guhl et al., 2021[26]		Kjesbu et al., 2022[27]		Ghisi et al., 2014[30]		Pedersen et al., 2023[28]		Thompson et al., 2023[29]	
Country	Netherlands		USA		Denmark		Brazil		Denmark		USA	
Study design	Observational cohort study		Observational cohort study		Observational cohort study		Cross-sectional comparative study		Observational cohort study		Observational cohort study	
Number of enrolment centres	89		4		Not specified		2		Not specified		Not specified	
Enrolment period	2012-2017		2010-2018		2015-2018		Not specified		2014-2018		2016-2018	
Length of follow-up (years)	1-7.7		3		0.6-3.3		Not specified		0.25-1		1	
CR vs. no CR or exercise training programme	CR	No CR	CR	No CR	CR	No CR	CR	Exercise training programme	CR	No CR	CR	No CR
Number of participants (CR vs. no CR)	26,171	57,516	1,272	5,685	19,383	15,128	42	42	7,881	7,881	155,872	258,858
Component	6 to 12 weeks of exercise training and educational sessions (mental health and stress relief, social health, and cardiovascular risk management)	Not applicable	Not specified	Not applicable	Immediate phase 1, 8-12 weeks of phase 2 exercise training and educational sessions, and phase 3 follow-up	Not applicable	3 to 5 times a week of exercise training and educational sessions (dietary counselling, nurse and physician counselling, and psychological guidance)	3 times a week exercise training	2 to 15 weeks following PCI, or 6 to 19 following CABG of exercise training and educational sessions	Not applicable	36 sessions of exercise training and educational sessions	Not applicable
Setting	Face-to-face	Not applicable	Face-to-face and/or online	Not applicable	Face-to-face	Not applicable	Face-to-face	Face-to-face	Face-to-face	Not applicable	Face-to-face	Not applicable
Patient population characteristics												
Socioeconomic status	**Socioeconomic status of area:** [1] Least disadvantaged tertile: Upper 30% based on income, wealth, education and recent labour from Statistics Netherlands, [2] Middle tertile: Middle 30%,		**Socioeconomic status of area:** [1] Least disadvantaged quartile: Based on poverty, education, housing and employment from ADI by UW, [2] Second least disadvantaged quartile,		**Education:** [1] >3 years of higher education, [2] ≤3 years of higher education, [3] Secondary or vocational education, [4] Primary education		**Education:** [1] Postgraduate studies, [2] Higher education, [3] Incomplete higher education, [4] Secondary education, [5] Primary education, **Income:** [1] >20 times the minimum wage,		**Education:** [1] >3 years of higher education, [2] ≤3 years of higher education, [3] Secondary education, [4] Vocational education **Income:** [1] Above the third quartile,		**Socioeconomic status of area:** [1] Least disadvantaged quintile: Based on zip code level rate of education, employment, household income, housing vacancy, local establishments and poverty from Distressed	

	[3] Most disadvantaged tertile: Bottom 40%	[3] Second most disadvantaged quartile, [4] Most disadvantaged quartile		[2] 10-20 times the minimum wage, [3] 5-10 times the minimum wage, [4] 1-5 times the minimum wage	[2] Between the first and third quartile	Community Index by the Economic Innovation group, [2] Second least disadvantaged quintile, [3] Middle quintile, [4] Second most disadvantaged quintile, [5] Most disadvantaged quintile
Mean age (SD) (years)	67 (12)	69 (13)	67 (11)	67 (10)	[1] Age 18-39: 3.2% [2] Age 40-49: 21% [3] Age 50-59: 47% [4] Age 60-70: 29%	75 (7)
Male (n (%))	50,512 (60)	4,303 (62)	22,526 (65)	67 (80)	13,738 (87)	269,218 (65)
Comorbidities	Cancer, dementia, diabetes mellitus, gout, parkinson disease, respiratory diseases, thyroid diseases	Atrial fibrillation, coronary artery disease, diabetes, hypertension, liver disease, obesity, stroke	Cancer, chronic obstructive pulmonary disease, depression, kidney disease, muscle or skeletal disease, peripheral artery disease, stroke	Not specified	Anxiety, atrial fibrillation, depression, diabetes, heart failure	Not specified
Outcome	[1] All-cause death	[1] All-cause death, [2] CVD-related rehospitalization	[1] All-cause death and CVD-related rehospitalization	[1] Knowledge about CVD	[1] Return to work	[1] All-cause death, [2] All-cause rehospitalization, [3] CVD-related rehospitalization
Timing of outcome	Date of death	At 36-month follow-up	At 12-month follow-up	Not specified	At 3-, 6-, 9- and 12-month follow-up	At 12-month follow-up

Abbreviations: USA, the United States of America; CR, cardiac rehabilitation; PCI, percutaneous coronary intervention; CABG, coronary artery bypass graft; ADI, Area Deprivation Index; DCI, Distressed Community Index; UW, University of Wisconsin; SD, standard deviation; CVD, cardiovascular disease

The included studies were conducted in the Netherlands, USA, Denmark and Brazil, across at least 95 centres. Three studies referred to multiple centres without specifying exact numbers. Follow-up periods ranged from 3 months to 8 years (table 1). Five studies compared cardiac rehabilitation (n=210,579) with no cardiac rehabilitation (n=345,068).[25-29] One study compared cardiac rehabilitation (n=42) with an exercise training programme (n=42).[30] The mean age across five of the six studies was 73 (SD: 8) years. Sixty-five per cent (360,364/555,731) of participants across the six studies were male.

All-cause death

All-cause death was evaluated in three observational studies, with follow-up periods ranging from 1 to 8 years.[25,26,29] Outcomes were reported either as numbers and percentages or incidence rates (per 100 person-years), stratified by cardiac rehabilitation participation and socioeconomic status of area of residence. Across studies, cardiac rehabilitation participants (n=173,315) had lower rates of all-cause death compared with those who did not participate (n=322,060), with differences ranging from 12.3% to 16.9%, depending on socioeconomic subgroups (table 2).

Eijsvogels *et al*[25] reported a progressive increase in difference between cardiac rehabilitation and no cardiac rehabilitation groups across socioeconomic tertiles: from -14.1% in the least disadvantaged tertile, -15.7% in the middle tertile, to -16.9% in the most disadvantaged tertile. Guhl *et al*[26] reported the greatest incidence rate difference in the least disadvantaged quartile (-15.1 events per 100 person-years), followed by smaller differences in middle quartiles (-11.4 to -12.4 events per 100 person-years), and a modest increase again in the most disadvantaged quartile (-13.6 events per 100 person-years). In contrast, Thompson *et al*[29] reported comparable differences across all quintiles, with absolute differences ranging from -12.3% to -12.7%.

Table 2. Outcomes of the included studies, stratified by cardiac rehabilitation participation and socioeconomic indicator (defined by area of residence, education, or income)

Outcome	Study	Socioeconomic indicator	Socioeconomic subgroups^	CR	No CR or exercise training programme	Difference
All-cause death	Eijsvogels et al., 2020[25]	Socioeconomic status of area	Tertile 1	n (%): 444 (6.6)	n (%): 2,974 (20.7)	-14.1%
			Tertile 2	n (%): 622 (7.6)	n (%): 4,086 (23.3)	-15.7%
			Tertile 3	n (%): 900 (8.0)	n (%): 6,383 (24.9)	-16.9%
	Guhl et al., 2021[26]	Socioeconomic status of area	Quartile 1	Incidence rate (per 100 person-year): 1.9 (95% CI: 1.0, 3.5)	Incidence rate (per 100 person-year): 17.0 (95% CI: 14.8, 19.6)	Incidence rate (per 100 person-year): -15.1
			Quartile 2	Incidence rate (per 100 person-year): 2.7 (95% CI: 1.8, 3.8)	Incidence rate (per 100 person-year): 14.1 (95% CI: 12.9, 14.4)	Incidence rate (per 100 person-year): -11.4
			Quartile 3	Incidence rate (per 100 person-year): 2.9 (95% CI: 2.1, 4.0)	Incidence rate (per 100 person-year): 15.3 (95% CI: 14.3, 16.5)	Incidence rate (per 100 person-year): -12.4
			Quartile 4	Incidence rate (per 100 person-year): 1.8 (95% CI: 1.1, 3.0)	Incidence rate (per 100 person-year): 15.4 (95% CI: 14.2, 16.7)	Incidence rate (per 100 person-year): -13.6
	Thompson et al., 2023[29]	Socioeconomic status of area	Quintile 1	n (%): 899 (2.0)	n (%): 7,632 (14.6)	-12.6%
			Quintile 2	n (%): 857 (2.3)	n (%): 7,662 (14.7)	-12.4%
			Quintile 3	n (%): 770 (2.5)	n (%): 7,531 (14.8)	-12.3%
			Quintile 4	n (%): 655 (2.6)	n (%): 8,007 (15.1)	-12.5%
			Quintile 5	n (%): 472 (2.7)	n (%): 7,746 (15.4)	-12.7%
All-cause rehospitalization	Thompson et al., 2023[29]	Socioeconomic status of area	Quintile 1	n (%): 13,979 (31.3)	n (%): 24,551 (47.0)	-15.7%
			Quintile 2	n (%): 11,728 (31.8)	n (%): 25,070 (47.9)	-16.1%
			Quintile 3	n (%): 10,019 (32.3)	n (%): 24,234 (47.5)	-15.2%
			Quintile 4	n (%): 8,472 (33.0)	n (%): 25,663 (48.5)	-15.5%
			Quintile 5	n (%): 5,094 (33.4)	n (%): 24,673 (49.0)	-15.6%
CVD-related rehospitalization	Guhl et al., 2021[26]	Socioeconomic status of area	Quartile 1	Incidence rate (per 100 person-year): 19.3 (95% CI: 15.4, 24.3)	Incidence rate (per 100 person-year): 42.6 (95% CI: 38.1, 47.7)	Incidence rate (per 100 person-year): -23.3
			Quartile 2	Incidence rate (per 100 person-year): 17.7 (95% CI: 15.0, 20.8)	Incidence rate (per 100 person-year): 41.4 (95% CI: 38.7, 44.3)	Incidence rate (per 100 person-year): -23.7
			Quartile 3	Incidence rate (per 100 person-year): 19.5 (95% CI: 16.8, 22.6)	Incidence rate (per 100 person-year): 42.0 (95% CI: 39.8, 44.4)	Incidence rate (per 100 person-year): -22.5

			Quartile 4	Incidence rate (per 100 person-year): 19.3 (95% CI: 15.9, 23.3)	Incidence rate (per 100 person-year): 47.1 (95% CI: 44.3, 50.1)	Incidence rate (per 100 person-year): -27.8
	Thompson et al., 2023[29]	Socioeconomic status of area	Quintile 1	n (%): 2,481 (5.6)	n (%): 5,594 (10.7)	-5.1%
			Quintile 2	n (%): 2,199 (6.0)	n (%): 5,605 (10.7)	-4.7%
			Quintile 3	n (%): 1,997 (6.4)	n (%): 5,499 (10.8)	-4.4%
			Quintile 4	n (%): 1,695 (6.6)	n (%): 6,164 (11.6)	-5.0%
			Quintile 5	n (%): 1,176 (6.7)	n (%): 5,955 (11.8)	-5.1%
All-cause death and CVD-related rehospitalization	Kjesbu et al., 2022[27]	Education attainment	>3 years of higher education			HR: 1.20 (95% CI: 0.89. 1.50)*
			≤3 years of higher education			HR: 0.96 (95% CI: 0.83, 1.10)*
			Secondary or vocational education			HR: 1.00 (95% CI: 0.94, 1.10)*
			Primary education			HR: 1.00 (95% CI: 0.94, 1.10)*
Return to work	Pedersen et al., 2023[28]	Education attainment	>3 years of higher education			OR at 3-month: 1.35 (95% CI: 1.21, 1.51)
						OR at 6-month: 1.16 (95% CI: 1.02, 1.33)
						OR at 9-month: 1.26 (95% CI: 1.09, 1.46)
						OR at 1-year: 1.23 (95% CI: 1.06, 1.44)
			≤3 years of higher education			OR at 3-month: 1.09 (95% CI: 1.01, 1.18)
						OR at 6-month: 1.09 (95% CI: 0.99, 1.20)
						OR at 9-month: 1.29 (95% CI: 1.16, 1.43)
						OR at 1-year: 1.33 (95% CI: 1.19, 1.48)
			Secondary education			OR at 3-month: 1.28 (95% CI: 1.09, 1.51)
						OR at 6-month: 1.35 (95% CI: 1.10, 1.66)
						OR at 9-month: 1.42 (95% CI: 1.13, 1.78)
						OR at 1-year: 1.36 (95% CI: 1.08, 1.71)
			Vocational education			OR at 3-month: 0.98 (95% CI: 0.92, 1.04)
						OR at 6-month: 0.98 (95% CI: 0.92, 1.05)

						OR at 9-month: 1.08 (95% CI: 1.01, 1.17)
						OR at 1-year: 1.10 (95% CI: 1.02, 1.19)
	Pedersen et al., 2023[28]	Socioeconomic status of area	Quartile 1			OR at 3-month: 1.90 (95% CI: 1.74, 2.07)
						OR at 6-month: 2.36 (95% CI: 2.14, 2.61)
						OR at 9-month: 2.31 (95% CI: 2.07, 2.57)
						OR at 1-year: 2.41 (95% CI: 2.15, 2.69)
			Quartile 2-4			OR at 3-month: 1.28 (95% CI: 1.19, 1.38)
						OR at 6-month: 1.62 (95% CI: 1.50, 1.76)
						OR at 9-month: 1.61 (95% CI: 1.48, 1.76)
						OR at 1-year: 1.57 (95% CI: 1.44, 1.72)
Knowledge about CVD	Ghisi et al., 2014[30]	Education attainment	Postgraduate studies	Mean score: 46.0 (SD: 2.0)	Mean score: 41.3 (SD: 6.6)	Difference in mean score: 4.7
			Higher education	Mean score: 45.9 (SD: 4.8)	Mean score: 40.0 (SD: 7.3)	Difference in mean score: 5.9
			Incomplete higher education	Mean score: 48.3 (SD: 4.0)	Mean score: 31.0 (SD: 6.0)	Difference in mean score: 17.3
			Secondary education	Mean score: 36.0 (SD: 8.1)	Mean score: 34.3 (SD: 4.7)	Difference in mean score: 1.7
			Primary education	Mean score: 29.5 (SD: 3.5)	Mean score: 27.2 (SD: 8.5)	Difference in mean score: 2.3
	Ghisi et al., 2014[30]	Income	Above 20 times the minimum wage	Mean score: 46.1 (SD: 7.0)	Mean score: 40.0 (SD: 7.5)	Difference in mean score: 6.1
			10-20 times the minimum wage	Mean score: 43.9 (SD: 6.9)	Mean score: 38.1 (SD: 9.9)	Difference in mean score: 5.8
			5-10 times the minimum wage	Mean score: 34.8 (SD: 12.0)	Mean score: 35.3 (SD: 6.3)	Difference in mean score: -0.5
			1-5 times the minimum wage minimum wage	No participants	Mean score: 33.2 (SD: 6.3)	NA

Abbreviations: CR, cardiac rehabilitation; CI, confidence interval; CVD, cardiovascular disease; HR, hazard ratio; NA, not applicable; OR, odds ratio; SD, standard deviation

* adjusted for age, sex, comorbidity index, hypertension, diabetes, hypercholesterolemia and index-event

^ For tertiles, quartiles, and quintiles, lower category numbers indicate higher socioeconomic status, while higher numbers indicate lower socioeconomic status

Rehospitalisation

All-cause rehospitalisation

All-cause rehospitalisation was evaluated in one observational study with a 1-year follow-up.[29] Outcomes were reported as numbers and percentages, stratified by cardiac rehabilitation participation and socioeconomic status of area of residence. Cardiac rehabilitation participants (n=155,872) had lower rates of all-cause rehospitalisation compared with those who did not participate (n=258,858). Thompson *et al*[29] reported comparable differences between cardiac rehabilitation and no cardiac rehabilitation groups across all socioeconomic quintiles, with absolute differences ranging from -15.2% to -16.1%. This was consistent with the comparable differences reported for all-cause death in the same study, which were also observed across all quintiles.

Cardiovascular-related rehospitalisation

Cardiovascular-related rehospitalisation was evaluated in two observational studies, with follow-up periods ranging from 1 to 3 years.[26,29] Outcomes were reported either as numbers and percentages or incidence rates (per 100 person-years), stratified by cardiac rehabilitation participation and socioeconomic status of area of residence. Cardiac rehabilitation participants (n=157,144) had lower rates of cardiovascular-related rehospitalisation compared with those who did not participate (n=264,543), with differences depending on socioeconomic subgroups (table 2).

Guhl *et al*[26] reported incidence rate difference between cardiac rehabilitation and no cardiac rehabilitation groups that were relatively comparable across most socioeconomic quartiles, ranging from -22.5 to -23.3 events per 100 person-years. The greatest difference was observed in the most disadvantaged quartile (-27.8 events per 100 person-years). Meanwhile, Thompson *et al*[29] reported comparable differences across all quintiles, with absolute differences ranging from -4.4% to -5.1%. These were consistent with the comparable differences reported for all-cause death and all-cause rehospitalisation in the same study, which were also observed across all quintiles.

All-cause death and cardiovascular-related rehospitalisation

The combined outcome of all-cause death and cardiovascular-related rehospitalisation was evaluated in one observational study with a 1-year follow-up.[27] Outcomes were reported as HRs and corresponding 95% CIs, stratified by cardiac rehabilitation participation and educational attainment (>3 years of higher education, ≤3 years of higher education, secondary or vocational education and primary education). Cardiac rehabilitation participants (n=19,383) had no statistically significant differences in rates of the combined outcome compared with those who did not participate (n=15,128), across socioeconomic subgroups.

While not statistically significant, Kjesbu *et al*[27] reported the highest HR between cardiac rehabilitation and no cardiac rehabilitation groups among participants whose highest attained education was >3 years of higher education (HR: 1.20, 95% CI 0.89 to 1.50), slightly lower among those whose highest attained education was ≤3 years of higher education (HR: 0.96, 95% CI 0.83 to 1.10), and identical among those whose highest attained education was secondary or vocational education (HR: 1.00, 95% CI 0.94 to 1.10), and primary education (HR: 1.00, 95% CI 0.94 to 1.10).[27]

Return to work

Return to work was evaluated in one observational study with a 1-year follow-up.[28] Outcomes were reported as ORs and corresponding 95% CIs at 3, 6, 9 months and 1 year, stratified by cardiac rehabilitation participation and two socioeconomic indicators: educational attainment (>3 years of higher education, ≤3 years of higher education, secondary education and vocational education) and income level (above the third quartile and between the first and third quartile). Cardiac rehabilitation participants (n=7,881) had higher odds of returning to work compared with those who did not participate (n=7,881), with differences depending on both education and income subgroups (table 2).

Pedersen *et al*[28] reported that differences in return to work between cardiac rehabilitation and no cardiac rehabilitation groups were observed at all time points among participants whose highest attained education was secondary education or higher education. Among those whose highest attained education was vocational education, no differences were observed at 3 and 6

months, but higher odds were observed at 9 months (OR: 1.08, 95% CI 1.01 to 1.17) and 12 months (OR: 1.10, 95% CI: 1.02 to 1.19). At 1 year, the highest odds were observed among those whose highest attained education was secondary education (OR: 1.36, 95% CI: 1.08 to 1.71) and ≤3 years of higher education, followed by >3 years of higher education (OR: 1.23, 95% CI 1.06 to 1.44) and vocational education (OR: 1.10, 95% CI 1.02 to 1.19).

When stratified by income, Pedersen *et al*[28] reported participants with incomes above the third quartile had the greatest odds of returning to work at 1 year (1.23, 95% CI 1.06 to 1.44), followed by those with incomes between the first and third quartiles (OR: 1.10, 95% CI 1.02 to 1.19).

Knowledge about cardiovascular disease

Knowledge about cardiovascular disease was evaluated in one cross-sectional comparative study.[30] Outcomes were reported as mean knowledge scores, stratified by cardiac rehabilitation participation and two socioeconomic indicators: educational attainment (postgraduate studies, higher education, incomplete higher education, secondary education and primary education) and income level (>20 times the minimum wage, 10-20 times the minimum wage, 5-10 times the minimum wage and 1 to 5 times the minimum wage). Cardiac rehabilitation participants (n=48) had higher knowledge scores compared with those who received an exercise training programme without an educational session (n=48), with differences depending on both education and income subgroups (table 2).

Ghisi *et al*[30] reported higher knowledge scores between cardiac rehabilitation and no cardiac rehabilitation groups among participants with higher educational attainment. The greatest differences were observed among participants whose highest attained education was incomplete higher education (+17.3 points), followed by those whose highest attained education was postgraduate studies (+4.7 points), higher education (+5.9 points), secondary education (+1.7 points) and primary education (+2.3 points).

When stratified by income level, similar trends were observed. The greatest differences were observed among participants who earned >20 times the minimum wage (+6.1 points), followed by those who earned 10-20 times the minimum wage (+5.8 points). In contrast, no difference was observed among those who earned 5-10 times the minimum wage and no participants who earned 1 to 5 times the minimum wage received cardiac rehabilitation. However, thresholds for clinical significance were not reported, limiting conclusions whether score differences reflect meaningful improvements.

Risk of bias assessment

All six included studies were classified as having a moderate risk of bias, primarily related to confounding, selection of participants and deviation from intended interventions (figures 2 and 3). Moderate bias related to confounding was observed in all six included studies, attributed to their observational study designs and limited randomisation. Moderate bias related to selection of participants was observed in five included studies and serious risk was observed in one. This bias was attributed to the underrepresentation of participants from more disadvantaged socioeconomic backgrounds in the cardiac rehabilitation groups. While moderate bias related to deviation from intended intervention was observed in all six included studies, attributed to the limited reporting on adherence rates to either cardiac rehabilitation or exercise training programme. Low risk was observed in all six included studies for classification of interventions, missing data, measurement of outcomes, and selection of the reported result.

DISCUSSION

The current systematic review evaluated whether the relationship between participation in cardiac rehabilitation and clinical or functional outcomes varied across socioeconomic indicators. Cardiac rehabilitation participation was consistently linked with lower rates of all-cause death, all-cause rehospitalisation, and cardiovascular-related rehospitalisation. The overall direction of findings was consistent across studies. Differences between cardiac rehabilitation and no cardiac rehabilitation were observed across socioeconomic subgroups, with some studies reporting greater differences in all-cause death and cardiovascular-related rehospitalisation among participants residing in more disadvantaged areas. However, this trend was not consistent across all studies. No significant differences were found in the effect of cardiac rehabilitation on the combined outcome across education levels, with HRs highest in the most educated and lowest in those with primary or vocational education. In contrast, return to work and knowledge about cardiovascular disease outcomes showed greater variation across socioeconomic subgroups. The greatest differences were among participants who attained higher educational levels or earned higher income levels. All six studies showed a moderate risk of bias, primarily in the domains of confounding, selection of participants, and deviations from intended interventions, necessitating careful interpretation of findings.

Barriers to accessing cardiac rehabilitation remain a challenge for patients who may benefit the most from participation. Those from disadvantaged socioeconomic backgrounds often face a greater burden of cardiovascular risk factors, experience poorer cardiovascular outcomes, yet have lower participation in cardiac rehabilitation.[31-36] Encouragingly, some of the largest differences in all-cause death and rehospitalisation were observed among participants residing in more disadvantaged areas, suggesting that cardiac rehabilitation may support greater cardiovascular risk reduction in this subgroup.[9-11,37] Increasing participation among patients from disadvantaged backgrounds is therefore essential to ensure they can benefit from cardiac rehabilitation.[31-36] Strategies such as expanding access to digital or virtual cardiac rehabilitation programmes may help address logistical barriers, particularly for patients with limited transportation options or less flexible working hours.[38-40] Transport support, such as van rides, public transport vouchers or partnerships with ride-share services, could also help improve access, but would likely require additional external funding.[41] These strategies could build on previous interventions that have successfully reduced missed

healthcare appointments.[41] Greater integration of general practitioners into the delivery of cardiac rehabilitation components, such as in-person or virtual consultation, exercise prescriptions, or individualised educational sessions on risk management, may also support cardiac rehabilitation access by embedding secondary prevention into routine and ongoing contacts with familiar primary care providers.[42,43]

Despite comparable clinical outcomes across educational attainment levels, patients who attained higher education or earned higher income demonstrated greater improvements in return to work and knowledge about cardiovascular disease. This suggests potential disparities in health literacy and self-efficacy, even when cardiac rehabilitation includes educational sessions. Patients who attained higher education or earned higher income may be better equipped to apply learnings from the educational sessions, seek additional resources and support independently, and negotiate flexible transition back to work in a modified capacity.[44-46] To address these disparities, cardiac rehabilitation programmes may benefit from tailoring educational materials to different literacy levels or extending sessions for those needing additional support.[44,47-49] Obtaining programme and encouraging providers certification may also help ensure accessibility and consistency of these educational materials.[48,49] Yet, longitudinal research is still needed to explore how work-related outcomes differ by factors such as employment status (full-time, part-time, modified roles vs retirement) or occupation type (blue-collar vs white-collar) and how these influence education or income.

Beyond the bias within the eligible studies, several limitations remain in the current systematic review. First, in five of the included studies, it could not be ascertained whether participants who did not participate in cardiac rehabilitation also refrained from engaging in structured exercise independently, whether supervised or unsupervised, outside of formal healthcare setting. This limited the ability to fully contrast these groups to the one study that compared cardiac rehabilitation to an exercise-only training programme. Second, heterogeneity in the definitions and categorisation of socioeconomic indicators, as well as inconsistencies in sample size, outcome measurement and timing, limited the comparability and generalisability of the findings. We reported the study by Ghisi *et al*[30], which contributed fewer than 100 participants and only to the outcome of knowledge about cardiovascular

disease, as narrative summary rather than including it in the pooled analysis. Given the variability in definitions and classifications of socioeconomic indicators across countries, we retained and reported them as in the original studies and presented outcome differences stratified by these definitions. This variability likely contributed to the differences observed across studies. Additionally, future studies could evaluate broader outcomes, such as psychosocial recovery, quality of life and contacts with primary care providers, to better reflect the multifaceted benefits of cardiac rehabilitation across populations from varied socioeconomic backgrounds.

CONCLUSION

Cardiac rehabilitation supports lower rates of all-cause death and rehospitalisation across socioeconomic subgroups, with some of the greatest differences observed among participants residing in more disadvantaged areas. Participants with higher education or income levels appear more likely to return to work and report greater knowledge gains following participation. These findings highlight disparities in how different socioeconomic subgroups benefit from cardiac rehabilitation. Addressing these disparities may require more tailored and flexible digital or virtual delivery of programs, including transport support, stronger primary care integration and accessible educational sessions.

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SUPPLEMENTARY MATERIALS

Supplemental Table 1. Final search terms related and synonym to 'cardiovascular disease' eligible for cardiac rehabilitation, 'cardiac rehabilitation', 'participation' and 'socioeconomic indicator'

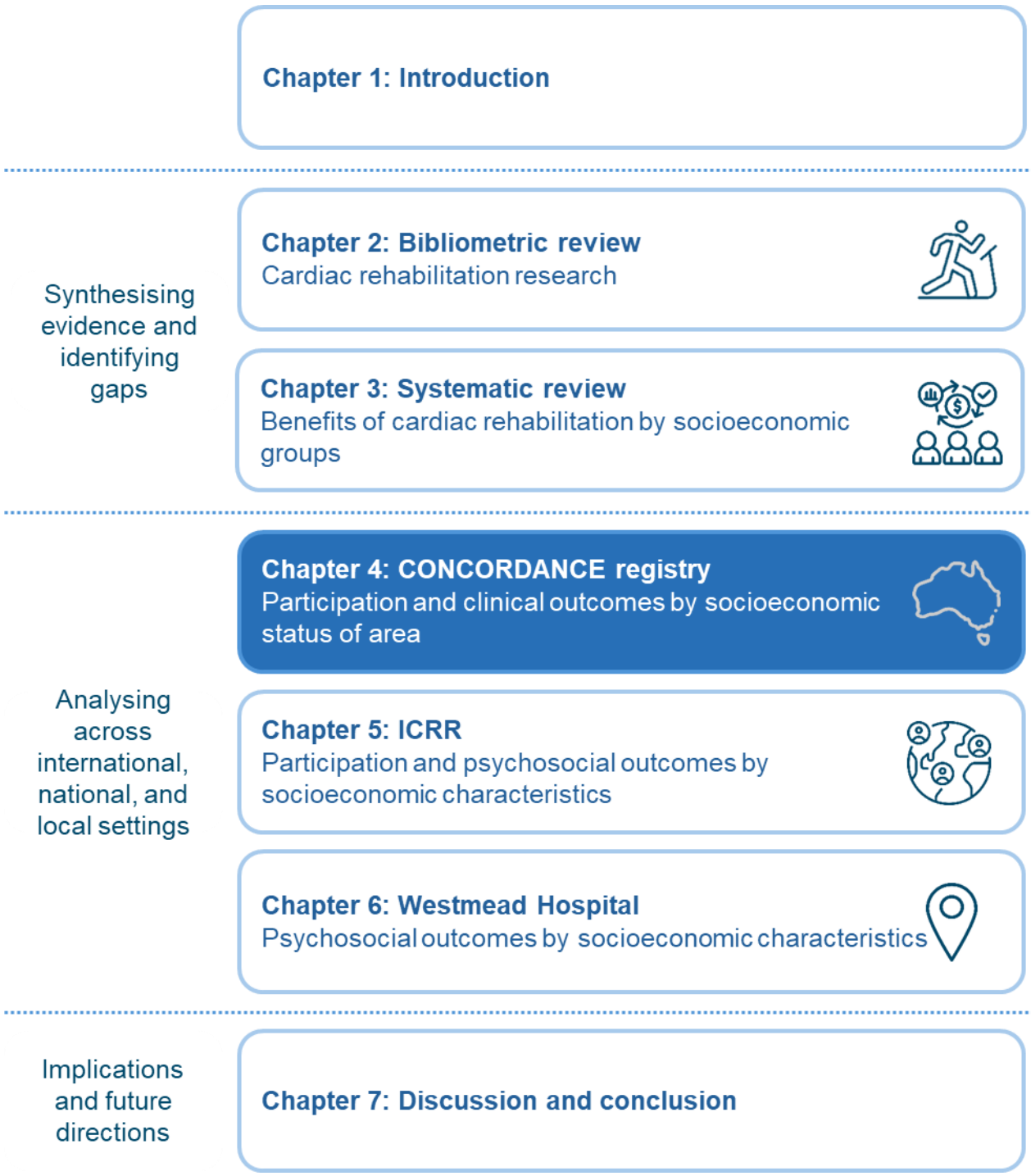
CENTRAL	CINAHL	Embase	Medline
1. Acute Coronary Syndrome/	1. (MH "Angina Pectoris")	1. angina pectoris/	1. Angina Pectoris/
2. Angina Pectoris/	2. "angina*"	2. angina*.mp.	2. angina*.mp.
3. angina*.mp.	3. (MH "Angioplasty")	3. angioplasty/	3. angioplast*.mp.
4. angioplast*.mp.	4. "angioplast*"	4. angioplast*.mp.	4. Atrial Fibrillation/
5. Atrial Fibrillation/	5. (MH "Atrial Fibrillation")	5. atrial fibrillation/	5. atrial fibrillation*.mp.
6. atrial fibrillation*.mp.	6. "atrial fibrillation*"	6. atrial fibrillation*.mp.	6. atherectom*.mp.
7. atherectom*.mp.	7. "atherectom*"	7. "*cardia* arrest".mp.	7. "*cardia* arrest".mp.
8. "*cardia* arrest".mp.	8. (MH "Heart Arrest")	8. cardiomyopathy/	8. Cardiomyopathies/
9. Cardiomyopathies/	9. "*cardia* arrest"	9. cardiomyopath*.mp.	9. cardiomyopath*.mp.
10. cardiomyopath*.mp.	10. (MH "Cardiomyopathies, Alcoholic") OR (MH "Cardiomyopathy, Dilated") OR (MH "Cardiomyopathy, Hypertrophic")	10. coronary artery bypass graft/	10. Coronary Artery Bypass/
11. Myocardial Revascularization/	11. "cardiomyopath*"	11. coronary artery disease/	11. Coronary Artery Disease/
12. Coronary Artery Disease/	12. (MH "Myocardial Revascularization")	12. (coronary adj3 (bypass or disease* or dilat* or interven* or revascular* or syndrome* or thrombo*)).mp.	12. Acute Coronary Syndrome/
13. Coronary Thrombosis/	13. (MH "Myocardial Ischemia")	13. defibrillat*.mp.	13. Coronary Thrombosis/
14. (coronary adj3 (bypass or disease* or dilat* or interven* or revascular* or syndrome* or thrombo*)).mp.	14. (MH "Coronary Thrombosis")	14. endoluminal repair*.mp.	14. (coronary adj3 (bypass or disease* or dilat* or interven* or revascular* or syndrome* or thrombo*)).mp.
15. Defibrillators/	15. (coronary W3 (bypass or disease* or dilat* or interven* or revascular* or syndrome* or thrombo*))	15. heart failure/	15. Defibrillators, Implantable/
16. defibrillat*.mp.	16. (MH "Defibrillators")	16. heart transplantation/	16. defibrillat*.mp.
17. endoluminal repair*.mp.	17. "defibrillat*"	17. (heart adj3 (attack* or disease* or fail* or infarct* or interven* or isch?emi* or transplant*)).mp.	17. endoluminal repair*.mp.
18. Heart Arrest/	18. "endoluminal repair*"	18. hypercholesterolemia/	18. Heart Arrest/
19. Heart Failure/	19. (MH "Heart Failure")	19. hypercholesterol?emia*.mp.	19. Heart Failure/
20. Heart Transplantation/	20. (MH "Heart Transplantation")	20. heart infarction/	20. Heart Transplantation/
21. (heart adj3 (attack* or disease* or fail* or infarct* or interven* or isch?emi* or transplant*)).mp.	21. (heart W3 (attack* or disease* or fail* or infarct* or interven* or isch?emi* or transplant*)	21. (myocardi* adj3 (infarct* or isch?emi*)).mp.	21. (heart adj3 (attack* or disease* or fail* or infarct* or interven* or isch?emi* or transplant*)).mp.
22. Hypercholesterolemia/	22. (MH "Hypercholesterolemia")	22. cardiac rhythm management device/	22. Hypercholesterolemia/
23. hypercholesterol?emia*.mp.	23. "hypercholesterol#emia*"	23. pacemaker*.mp.	23. hypercholesterol?emia*.mp.
24. Myocardial Infarction/	24. (myocardi* W3 (infarct* or isch#emi*))	24. percutaneous coronary intervention/	24. Myocardial Infarction/
25. (myocardi* adj3 (infarct* or isch?emi*)).mp.	25. (MH "Pacemaker, Artificial")	25. percutaneous coronary intervention*.mp.	25. (myocardi* adj3 (infarct* or isch?emi*)).mp.
26. Pacemaker, Artificial/	26. "pacemaker*"	26. cardiovascular stent/	26. Pacemaker, Artificial/
27. pacemaker*.mp.	27. (MH "Percutaneous Coronary Intervention")	27. stent*.mp.	27. pacemaker*.mp.
28. Percutaneous Coronary Intervention/	28. "percutaneous coronary intervention*"	28. transcatheter aortic valve implantation/	28. Percutaneous Coronary Intervention/
29. percutaneous coronary intervention*.mp.	29. (MH "Stents")	29. (valve* adj3 (device* or implant* or repair* or replace* or surger*)).mp.	29. percutaneous coronary intervention*.mp.
30. Stents/	30. "stent*"	30. (vascular adj3 (disease* or interven*)).mp.	30. Stents/
31. stent*.mp.			31. stent*.mp.
			32. Heart Valve Prosthesis Implantation/

32. Heart Valve Prosthesis Implantation/ 33. (valve* adj3 (device* or implant* or repair* or replace* or surger*)).mp. 34. (vascular adj3 (disease* or interven*)).mp. 35. (ventricular adj3 device*).mp. 36. "*stemi".mp. 37. percutaneous transluminal coronary angioplast*.mp. 38. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37	31. (MH "Heart Valve Prosthesis") 32. (valve* W3 (device* or implant* or repair* or replace* or surger*)) 33. (vascular W3 (disease* or interven*)) 34. (ventricular W3 device*) 35. "percutaneous transluminal coronary angioplast*" 36. (MH "ST Elevation Myocardial Infarction") 37. "*stemi" 38. S1 OR S2 OR S3 OR S4 OR S5 OR S6 OR S7 OR S8 OR S9 OR S10 OR S11 OR S12 OR S13 OR S14 OR S15 OR S16 OR S17 OR S18 OR S19 OR S20 OR S21 OR S22 OR S23 OR S24 OR S25 OR S26 OR S27 OR S28 OR S29 OR S30 OR S31 OR S32 OR S33 OR S34 OR S35 OR S36 OR S37	31. (ventricular adj3 device*).mp. 32. "*stemi".mp. 33. percutaneous transluminal coronary angioplast*.mp. 34. atherectom*.mp. 35. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34	33. (valve* adj3 (device* or implant* or repair* or replace* or surger*)).mp. 34. (vascular adj3 (disease* or interven*)).mp. 35. (ventricular adj3 device*).mp. 36. "*stemi".mp. 37. percutaneous transluminal coronary angioplast*.mp. 38. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37
39. exp Cardiac Rehabilitation/ 40. (cardi* adj3 rehab*).mp. 41. heart adj3 rehab*.mp. 42. Exercise Therapy/ 43. ((aerobic or balance or behavio?r* or endurance or exercise* or fitness* or flexibility* or physical or resistan* or strength) adj3 (activit* or intervention* or therap* or training* or treatment* or prescription* or program*)).tw, kw. 44. 39 or 40 or 41 or 42 or 43	39. (MH "Rehabilitation, Cardiac+") 40. (MH "American Association of Cardiovascular and Pulmonary Rehabilitation") OR (MH "Cardiac Rehabilitation (Saba CCC)") OR (MH "Cardiac Care: Rehabilitative (Iowa NIC)") 41. (cardi* W3 rehab*) 42. (heart W3 rehab*) 43. (MH "Physical Therapy") 44. ((aerobic or balance or behavio#r* or endurance or exercise* or fitness* or flexibility* or physical or resistan* or strength) W3 (activit* or intervention* or therap* or training* or treatment* or prescription* or program*)) 45. S39 OR S40 OR S41 OR S42 OR S43 OR S44	36. exp heart rehabilitation/ 37. (cardi* adj3 rehab*).mp. 38. (heart adj3 rehab*).mp. 39. physical medicine/ 40. ((aerobic or balance or behavio?r* or endurance or exercise* or fitness* or flexibility* or physical or resistan* or strength) adj3 (activit* or intervention* or therap* or training* or treatment* or prescription* or program*)).tw, kw. 41. 36 or 37 or 38 or 39 or 40	39. Cardiac Rehabilitation/ 40. (cardi* adj3 rehab*).mp. 41. heart adj3 rehab*).mp. 42. Exercise Therapy/ 43. ((aerobic or balance or behavio?r* or endurance or exercis* or fitness* or flexibility* or physical or resistan* or strength) adj3 (activit* or intervention* or therap* or training* or treatment* or prescription* or program*)).tw, kw. 44. 39 or 40 or 41 or 42 or 43
45. exp "Patient Acceptance of Health Care"/ 46. access*.mp. 47. adher*.mp. 48. attend*.mp. 49. complet*.mp. 50. complian*.mp. 51. drop?out.mp. 52. finish*.mp. 53. non?adher*.mp. 54. non?attend*.mp. 55. non?complian*.mp. 56. participat*.mp. 57. utilisation*.mp. 58. engagement*.mp. 59. uptake*.mp.	S46. (MH "Patient Compliance+") S47. (MH "Health Services Accessibility") S48. "access*" S49. "adher*" S50. "attend*" S51. "complet*" S52. "complian*" S53. (MH "Patient Dropouts") S54. "drop#out" S55. "finish*" S56. "non#adher*" S57. "non#attend*" S58. "non#complian*" S59. "participat*" S60. (MH "Health Resource Utilization")	42. patient attitude/ 43. access*.mp. 44. adher*.mp. 45. attend*.mp. 46. complet*.mp. 47. complian*.mp. 48. drop?out.mp. 49. finish*.mp. 50. non?adher*.mp. 51. non?attend*.mp. 52. non?complian*.mp. 53. participat*.mp. 54. utilisation*.mp. 55. engagement*.mp. 56. uptake*.mp.	45. exp "Patient Acceptance of Health Care"/ 46. access*.mp. 47. adher*.mp. 48. attend*.mp. 49. complet*.mp. 50. complian*.mp. 51. drop?out.mp. 52. finish*.mp. 53. non?adher*.mp. 54. non?attend*.mp. 55. non?complian*.mp. 56. participat*.mp. 57. utilisation*.mp. 58. engagement*.mp. 59. uptake*.mp.

60. 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53 or 54 or 55 or 56 or 57 or 58 or 59	S61. “utili?ation*” S62. “engagement*” S63. “uptake*” S64. S46 OR S47 OR S48 OR S49 OR S50 OR S51 OR S52 OR S53 OR S54 OR S55 OR S56 OR S57 OR S58 OR S59 OR S60 OR S61 OR S62 OR S63	57. 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53 or 54 or 55 or 56	60. 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53 or 54 or 55 or 56 or 57 or 58 or 59
61. exp Socioeconomic Factors/ 62. deprivation*.mp. 63. disparit*.mp. 64. disadvantage*.mp. 65. education*.mp. 66. employ*.mp. 67. economic* marginali*.mp. 68. "food *secur*".mp. 69. housing*.mp. 70. "*income*".mp. 71. Neighborhood Characteristics/ 72. neighbo?rhood*.mp. 73. poverty.mp. 74. social class*.mp. 75. “*privilege*”.mp. 76. occupation*.mp. 77. socio?economic*.mp. 78. 61 or 62 or 63 or 64 or 65 or 66 or 67 or 68 or 69 or 70 or 71 or 72 or 73 or 74 or 75 or 76 or 77	S65. (MH “Socioeconomic Factors”) S66. (MH “Sociodemographic Factors”) S67. (MH “Social Class”) S68. (MH “Healthcare Disparities”) S69. (MH “Health Status Disparities”) S70. “deprivation*” S71. “disparit*” S72. (MH “Social Deprivation”) S73. “disadvantage*” S74. “education*” S75. (MH “Employment Status”) S76. “employ*” S77. “economic* marginali*” S78. “food *secur*" S79. (MH “Food Security”) S80. “housing*” S81. “*income*” S82. (MH “Neighborhood Characteristics”) S83. “neighbo#rhood*” S84. “occupation*” S85. (MH “Poverty”) S86. “poverty” S87. “social class*” S88. “socio#economic*” S89. “*privilege*” S90. S65 OR S66 OR S67 OR S68 OR S69 OR S70 OR S71 OR S72 OR S73 OR S74 OR S75 OR S76 OR S77 OR S78 OR S79 OR S80 OR S81 OR S82 OR S83 OR S84 OR S85 OR S86 OR S87 OR S88 OR S89	58. socioeconomics/ 59. deprivation*.mp. 60. health disparity/ 61. health care disparity/ 62. disadvantage*.mp. 63. education*.mp. 64. employment/ 65. employ*.mp. 66. economic* marginali*.mp. 67. food security/ 68. "food *secur*".mp. 69. housing*.mp. 70. "*income*".mp. 71. neighborhood characteristic/ 72. neighbo?rhood*.mp. 73. occupation/ 74. occupation*.mp. 75. poverty.mp. 76. social class/ 77. socio?economic*.mp. 78. “*privilege*”.mp. 79. disparit*.mp. 80. social class*.mp. 81. 58 or 59 or 60 or 61 or 62 or 63 or 64 or 65 or 66 or 67 or 68 or 69 or 70 or 71 or 72 or 73 or 74 or 75 or 76 or 77 or 78 or 79 or 80	61. exp Socioeconomic Factors/ 62. deprivation*.mp. 63. disparit*.mp. 64. disadvantage*.mp. 65. education*.mp. 66. employ*.mp. 67. economic* marginali*.mp. 68. Social Class/ 69. housing*.mp. 70. "*income*".mp. 71. "food *secur*".mp. 72. Neighborhood Characteristics/ 73. neighbo?rhood*.mp. 74. occupation*.mp. 75. Poverty/ 76. poverty.mp. 77. social class*.mp. 78. socio?economic*.mp. 79. “*privilege*”.mp. 80. 61 or 62 or 63 or 64 or 65 or 66 or 67 or 68 or 69 or 70 or 71 or 72 or 73 or 74 or 75 or 76 or 77 or 78 or 79
79. 38 and 44 and 60 and 78	S91. S38 AND S45 AND S64 AND S90	82. 35 and 41 and 57 and 81	81. 38 and 44 and 60 and 80

CHAPTER 4

Cardiac rehabilitation participation and outcomes by socioeconomic status of area of residence: Analysis of the Australian CONCORDANCE registry



This chapter presents a quantitative analysis of the CONCORDANCE registry on whether cardiac rehabilitation participation is associated with major adverse cardiovascular events (MACE; defined as heart failure, myocardial infarction, stroke, or cardiac-cause mortality) and all-cause mortality at 12 months, and whether these associations differ by socioeconomic disadvantage of area of residence. It builds on Chapter 3 by providing real-world evidence from a national Australian cohort.

A total of 1,834 individuals referred to cardiac rehabilitation at hospital discharge, followed up at 6 and 12 months, and who reported participation were included. Cardiac rehabilitation participation was lower among individuals residing in more disadvantaged areas, and although participation was associated with reduced risk of all-cause mortality, this association did not differ across socioeconomic subgroups. These findings inform subsequent chapters of this thesis, which assess registry data from low-resource and local settings.

> **Aim Addressed:** This chapter addresses **Aim 3** – to assess whether the association between cardiac rehabilitation participation and clinical outcomes differs by area-level socioeconomic status.

This work, titled *"Socioeconomic variation in the association between participation in cardiac rehabilitation and clinical outcomes in patients with acute coronary syndrome"*, has been accepted for publication in *Journal of Cardiopulmonary Rehabilitation and Prevention*.

PUBLICATION

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STATEMENT OF AUTHORSHIP

Deborah Manandi led the conceptualisation, methodology, formal analysis, and writing – original draft. The roles of co-authors are as follows:

Task	**Role of co-authors**
Conceptualisation	DB, JR, KH
Methodology	DB, JR, QT, TB, KH
Formal analysis	DB, KH
Writing – reviewing & editing	DB, JR, QT, TB, NH, KH

ABSTRACT

Purpose: To investigate (1) the relationship between socioeconomic status of patients with acute coronary syndrome and participation in cardiac rehabilitation and (2) the relationship between patient participation stratified by socioeconomic status and their outcomes at 12 months.

Methods: Analyzed data were from the CONCORDANCE registry. Patients were stratified (quintiles) according to the National Index of Relative Socio-Economic Disadvantage. The odds of a major adverse cardiovascular event (MACE; defined as heart failure, myocardial infarction, stroke, or cardiac-cause death) and separately all-cause death between hospital discharge and 12 months were analyzed using multilevel logistic regression models, adjusting for clinical history and hospital clustering.

Results: Of 3,787 patients referred to cardiac rehabilitation, followed up at 6 and 12 months, 1,834 (48%) participated in cardiac rehabilitation. Participation rate was higher among patients in least socioeconomically disadvantaged quintiles (Q5 [least disadvantaged]: 61%, Q4: 53%, Q3: 42%, Q2: 47%, Q1 [most disadvantaged]: 42%). The odds of MACE were not different between participants and non-participants (6% vs 8%, OR = 0.87: 95% CI, 0.66-1.15). However, the odds of death were lower among participants than non-participants (0.4% vs 2%, OR = 0.35: 95% CI, 0.16 - 0.78). The association between participation and MACE and death did not differ by socioeconomic status ($P_{\text{interaction}} = .6943$ and $P_{\text{interaction}} = .6339$, respectively).

Conclusions: Although patient socioeconomic status may influence their participation rates in cardiac rehabilitation, no significant differences were observed in the relationships between participation and MACE or mortality at 12 months across socioeconomic groups. Targeted strategies are needed to improve participation rates across all socioeconomic groups.

INTRODUCTION

Acute coronary syndrome is associated with a higher risk of short- and long-term recurrent cardiovascular events.[1] Cardiac rehabilitation supports patients with acute coronary syndrome through structured individual or group programs to build lifestyle or medication adherence habits after leaving the hospital.[2] There is clear evidence that participation in cardiac rehabilitation contributes to reductions in myocardial infarction, all-cause hospital readmissions, and limited evidence of meaningful improvements in quality of life.[3] However, participation in cardiac rehabilitation among eligible patients remains consistently low.[4-7]

Rates of participation in cardiac rehabilitation are likely to vary between individuals, cardiac rehabilitation programs, and countries, with socioeconomic background being a significant contributing factor variable. Studies have found that participation rates ranged from 7% in Shanghai, China to 28% in South Australian public hospitals to 35% in Switzerland and to 75% in Leiden, the Netherlands.[4,8-10] Patients from disadvantaged socioeconomic backgrounds exhibit even poorer participation rates, despite having had worse risk factor profiles and less knowledge about cardiovascular disease management compared to the rest of the population.[11-16] In Denmark, patients with less than a secondary level of education were approximately 1.5 times less likely to participate in any cardiac rehabilitation compared to those with tertiary level education.[17] Additionally, patients with lower disposable income were nearly twice as likely to only participate in the first session of the program.[17]

Despite the poorer participation rate in those with lower socioeconomic status, whether the associations between cardiac rehabilitation programs and cardiovascular outcomes are comparable across socioeconomic groups is underexplored. Therefore, the purpose of this study was to (1) investigate the relationship between socioeconomic status of patients with acute coronary syndrome and their participation in cardiac rehabilitation and (2) investigate the relationship between participation in cardiac rehabilitation, stratified by socioeconomic status, and major adverse cardiovascular event (MACE) or all-cause death outcomes at 12 months.

METHODS

Study design

This study analyzed data from the Cooperative National Registry of Acute Coronary Care, Guideline Adherence and Clinical Events (CONCORDANCE) registry. The CONCORDANCE registry collected and electronically retained personal and medical information of the first 10 consecutive patients with acute coronary syndrome presenting to any of 43 representative Australian hospitals from the beginning of each month of years 2009 to 2018.[18]

The CONCORDANCE registry used an opt-out approach. Patient demographics, clinical history, pre- and in-hospital assessments, management, clinical outcomes, and referral to cardiac rehabilitation were collected from the medical records. Six- and 12-month follow-ups were conducted via mail or telephone interviews, or data were collected from primary care providers or hospital records. Patient participation in cardiac rehabilitation was collected at the 6-month follow-up, and morbidity and mortality were collected at the 12-month follow-up. The design of the CONCORDANCE registry is detailed elsewhere.[18] Ethical approval for the CONCORDANCE study was obtained from the Sydney Local Health District Concord Human Research Ethics Committee (CH62/6/2008-141).

Study cohort

The CONCORDANCE registry included patients aged 18 years and above admitted to hospital with acute coronary syndrome. However, patients were excluded if their acute coronary syndrome was secondary to non-cardiovascular disease comorbidities.[18] Patients were included in this sub-study if they were alive at hospital discharge, referred to cardiac rehabilitation, and followed up at 6 and 12 months.

Measures

Residential postcodes of patients were presented as the Australian Bureau of Statistics' Index of Relative Socio-Economic Disadvantage.[19] The socioeconomic deciles of usual residence generated by the Australian Bureau of Statistics were grouped into quintiles. For this study,

patients who responded “yes” to the question, “Since the index admission has the patient participated in cardiac rehabilitation,” were categorized as participants. However, the remaining patients were categorized as non-participants. Participation status was self-reported, hence only reported among patients alive at 6-month follow-up.

Study outcomes

Outcomes of interest of this sub-study included MACE and all-cause death between hospital discharge and 12 months, where MACE was defined as heart failure, myocardial infarction, stroke, or cardiac-cause death.

Statistical analyses

Baseline demographics and clinical history were reported as number and percentage for the categorical variables, mean ± SD for continuous variables that were normally distributed, or median and IQR for the continuous variables that were not normally distributed. The trend in participation rate across socioeconomic quintiles was compared using Cochran-Armitage test.

Adjusted OR and 95% CI for the association between the outcomes and cardiac rehabilitation participation by socioeconomic quintiles were estimated using multilevel logistic regression models with an interaction term between the socioeconomic quintiles and participation status. The main effects (ie, socioeconomic quintiles and participation status) were included in the models along with statistically and clinically significant variables from unadjusted analysis between the outcomes and participation. The independent variables included in each model are reported in Supplemental Digital Content Table 1. These multilevel logistic regression models were analyzed with hospital ID as a random intercept to account for the hospital clustering effect, and the estimator used was residual pseudo-likelihood.[20] When the interaction term was not significant, the same models were repeated excluding the interaction term to analyse the main effect. Statistical analyses were performed using SAS 9.4 (SAS Institute Inc.).

RESULTS

In total, 3,787 patients were referred at discharge and followed up at 6 and 12 months. Among those, 1,834 (48%) patients participated in cardiac rehabilitation.

Post-discharge cardiovascular disease care

Although the trend was not linear, patients in the more disadvantaged quintile were less likely to participate in cardiac rehabilitation (Q5 [least disadvantaged]: 61%, Q4: 53%, Q3: 42%, Q2: 47%, Q1 [most disadvantaged]: 42%). Difference in patient baseline demographics and clinical history compared by patient socioeconomic quintile of usual residence and participation status is included in Table 1. Patients who were older, female, spoke English as a second language, or with comorbidities such as previous coronary artery bypass graft or congestive heart failure were also less likely to participate (Table 1).

Types of post-discharge care

The majority of patients participated in 1 session of a hospital-based (44%) or community-based (49%) program compared to those who received risk factor counselling via telephone- or internet-based programs and self-managed programs (Table 2). This trend did not seem to differ across patient socioeconomic quintile of usual residence (Table 2).

Table 1. Baseline Clinical and Demographic Characteristics by Socioeconomic Status and Participation in Cardiac Rehabilitation Among Patients with Acute Coronary Syndrome Referred to Cardiac Rehabilitation and Followed Up at 12-Months After Hospital Discharge

	IRSD 1 (Most Disadvantaged) n=845		IRSD 2 n=898		IRSD 3 n=825		IRSD 4 n=500		IRSD 5 (Least Disadvantaged) n=719			
	CR n=357	No CR n=488	CR n=426	No CR n=472	CR n=344	No CR n=481	CR n=265	No CR n=235	CR n=442	No CR n=277	Total CR n=1,834	Total no CR n=1,953
Age	63 ± 12	63 ± 13	63 ± 12	67 ± 12	64 ± 12	64 ± 13	62 ± 12	64 ± 13	64 ± 12	65 ± 13	63 ± 13	64 ± 13
Sex												
Male	267 (75%)	330 (68%)	319 (75%)	330 (70%)	277 (81%)	334 (69%)	197 (74%)	168 (72%)	366 (83%)	216 (78%)	1426 (78%)	1378 (71%)
Female	90 (25%)	158 (32%)	107 (25%)	142 (30%)	67 (20%)	147 (31%)	68 (26%)	67 (29%)	76 (17%)	61 (22%)	408 (22%)	575 (29%)
Birth country												
Australia and New Zealand	277 (79%)	346 (74%)	352 (84%)	364 (77%)	267 (79%)	367 (78%)	210 (80%)	160 (69%)	310 (71%)	182 (66%)	1,416 (78%)	1,419 (74%)
Other countries	63 (18%)	103 (22%)	64 (15%)	89 (19%)	66 (19%)	97 (21%)	48 (18%)	63 (27%)	119 (27%)	84 (31%)	360 (20%)	436 (23%)
Unknown	9 (3%)	16 (3%)	5 (1%)	17 (4%)	7 (2%)	9 (2%)	5 (2%)	10 (4%)	9 (2%)	8 (3%)	35 (2%)	60 (3%)
Language spoken												
English as first language	301 (84%)	352 (72%)	395 (93%)	419 (89%)	311 (90%)	399 (83%)	247 (93%)	185 (79%)	382 (86%)	218 (79%)	1,636 (89%)	1,573 (81%)
English as second language	48 (13%)	112 (23%)	25 (6%)	38 (8%)	27 (8%)	46 (10%)	15 (6%)	41 (17%)	55 (12%)	54 (20%)	170 (9%)	291 (15%)
Unknown	8 (2%)	24 (5%)	6 (1%)	15 (3%)	6 (2%)	36 (8%)	3 (1%)	9 (4%)	5 (1%)	5 (2%)	28 (2%)	89 (5%)
Has a regular GP	320 (94%)	439 (93%)	381 (91%)	427 (93%)	311 (95%)	429 (93%)	238 (92%)	215 (95%)	392 (92%)	249 (91%)	1,642 (92%)	1,759 (93%)
Hospital location region												
Major cities of Australia	129 (37%)	202 (42%)	161 (38%)	189 (41%)	160 (47%)	190 (40%)	194 (74%)	172 (74%)	400 (91%)	242 (87%)	1,044 (57%)	995 (51%)
Inner regional Australia	129 (37%)	132 (27%)	195 (46%)	197 (42%)	113 (33%)	123 (26%)	43 (16%)	24 (10%)	28 (6%)	15 (5%)	508 (28%)	491 (25%)
Other regional Australia	57 (16%)	72 (15%)	59 (14%)	61 (13%)	22 (6%)	58 (12%)	24 (9%)	35 (15%)	9 (2%)	18 (7%)	171 (9%)	244 (13%)
Remove/very remote Australia/unknown	38 (11%)	78 (16%)	6 (1%)	20 (4%)	47 (14%)	109 (23%)	3 (1%)	3 (1%)	5 (1%)	2 (1%)	99 (5%)	212 (11%)
Medical history												
Previous atrial fibrillation	17 (5%)	44 (9%)	22 (5%)	55 (12%)	30 (9%)	52 (11%)	15 (6%)	13 (5%)	31 (7%)	18 (7%)	115 (6%)	182 (9%)
Previous DVT/PE	13 (4%)	14 (3%)	14 (3%)	17 (4%)	9 (3%)	18 (4%)	5 (2%)	5 (2%)	12 (23%)	13 (5%)	53 (3%)	67 (3%)
Chronic renal failure	26 (7%)	60 (12%)	19 (5%)	38 (8%)	22 (6%)	43 (9%)	10 (4%)	13 (6%)	17 (4%)	12 (4%)	94 (5%)	166 (9%)
Diabetes	105 (29%)	186 (38%)	109 (26%)	129 (27%)	89 (26%)	158 (33%)	57 (22%)	61 (26%)	92 (21%)	65 (24%)	452 (25%)	599 (31%)
Impaired mobility	13 (4%)	36 (7%)	10 (2%)	40 (9%)	11 (3%)	33 (7%)	5 (2%)	12 (5%)	12 (3%)	9 (3%)	51 (3%)	130 (7%)
Previous heart failure	17 (5%)	33 (7%)	15 (4%)	26 (6%)	11 (3%)	29 (6%)	13 (5%)	12 (5%)	17 (4%)	12 (4%)	73 (4%)	112 (6%)
Previous myocardial infarction	91 (26%)	155 (32%)	86 (20%)	143 (30%)	66 (19%)	137 (29%)	50 (19%)	56 (24%)	59 (13%)	70 (25%)	352 (19%)	561 (29%)
Previous PAD	19 (5%)	29 (6%)	16 (4%)	33 (7%)	6 (2%)	26 (5%)	6 (2%)	8 (3%)	14 (3%)	6 (2%)	61 (3%)	102 (5%)
Previous Stroke/TIA	20 (6%)	29 (6%)	22 (5%)	35 (7%)	11 (3%)	26 (5%)	9 (3%)	13 (6%)	11 (3%)	6 (2%)	73 (4%)	109 (6%)
Previous CVD event[b]	135 (38%)	205 (42%)	130 (31%)	215 (46%)	103 (30%)	191 (40%)	75 (28%)	76 (32%)	106 (24%)	96 (35%)	549 (30%)	783 (40%)
Previous CVD procedure												
Previous PCI	63 (18%)	112 (23%)	63 (15%)	116 (25%)	54 (16%)	93 (19%)	33 (13%)	43 (18%)	53 (12%)	58 (21%)	266 (15%)	422 (22%)
Previous CABG	27 (8%)	63 (13%)	25 (6%)	54 (11%)	21 (6%)	51 (11%)	22 (8%)	17 (7%)	15 (3%)	18 (7%)	110 (6%)	203 (10%)
In-Hospital assessments and management												
GRACE risk score	104 (28%)	105 (30%)	106 (27%)	109 (29%)	107 (27%)	104 (29%)	105 (28%)	106 (30%)	106 (27%)	107 (29%)	106 (27%)	106 (29%)
Cardiac arrest on hospital admission	14 (4%)	11 (2%)	17 (4%)	10 (2%)	13 (4%)	10 (2%)	15 (6%)	5 (2%)	17 (4%)	12 (4%)	76 (4%)	48 (3%)
BMI category												

Underweight, BMI <18.5	105 (29%)	160 (33%)	90 (21%)	107 (23%)	117 (34%)	218 (45%)	42 (16%)	64 (27%)	85 (19%)	74 (27%)	439 (24%)	623 (32%)
Healthy, BMI 18.5-24	48 (13%)	77 (16%)	71 (17%)	86 (18%)	55 (16%)	62 (13%)	34 (13%)	42 (18%)	98 (22%)	49 (18%)	306 (17%)	316 (16%)
Overweight, BMI 25-29	95 (27%)	127 (26%)	108 (25%)	132 (28%)	92 (27%)	95 (20%)	106 (40%)	61 (26%)	147 (33%)	78 (28%)	548 (30%)	493 (25%)
Obese, BMI ≥30	109 (31%)	124 (25%)	157 (37%)	147 (31%)	80 (23%)	106 (22%)	83 (31%)	68 (29%)	112 (25%)	76 (27%)	541 (30%)	521 (27%)
Dyslipidemia	201 (56%)	287 (59%)	221 (52%)	268 (57%)	167 (49%)	269 (56%)	120 (45%)	131 (56%)	208 (47%)	139 (50%)	917 (50%)	1,094 (56%)
Diastolic blood pressure, mmHg	83 ± 16	82 ± 16	81 ± 16	82 ± 17	83 ± 16	81 ± 15	84 ± 17	80 ± 16	81 ± 16	83 ± 17	82 ± 16	82 ± 16
Systolic blood pressure, mmHg	142 ± 26	142 ± 25	141 ± 26	143 ± 26	141 ± 26	141 ± 27	143 ± 27	140 ± 26	141 ± 27	144 ± 27	141 ± 26	142 ± 26
Hypertension	226 (63%)	330 (68%)	251 (59%)	292 (62%)	193 (56%)	294 (61%)	132 (50%)	133 (57%)	236 (53%)	156 (56%)	1,038 (57%)	1205 (62%)
Smoking history												
Never smoked	121 (34%)	153 (31%)	149 (35%)	161 (34%)	135 (39%)	169 (35%)	100 (38%)	88 (37%)	203 (46%)	124 (45%)	708 (39%)	695 (36%)
Ex-smoker	124 (35%)	169 (35%)	154 (36%)	181 (38%)	116 (34%)	156 (32%)	93 (35%)	72 (31%)	142 (32%)	92 (33%)	629 (34%)	670 (34%)
Current smoker	112 (31%)	166 (34%)	123 (29%)	130 (28%)	93 (27%)	156 (32%)	72 (27%)	75 (32%)	97 (22%)	61 (22%)	497 (27%)	588 (30%)
Family history of CHD	112 (31%)	148 (30%)	174 (41%)	174 (37%)	131 (38%)	149 (31%)	91 (34%)	72 (31%)	175 (40%)	96 (35%)	683 (37%)	639 (33%)
PCI	206 (58%)	233 (48%)	267 (63%)	240 (51%)	209 (61%)	238 (50%)	195 (74%)	132 (56%)	341 (77%)	184 (66%)	1,218 (66%)	1,027 (53%)
CABG	61 (17%)	57 (12%)	61 (14%)	38 (8%)	57 (17%)	41 (9%)	34 (13%)	23 (10%)	45 (10%)	15 (5%)	258 (14%)	174 (9%)
In-hospital Diagnoses												
ACS												
STEMI	156 (44%)	134 (28%)	173 (41%)	131 (28%)	148 (43%)	131 (27%)	125 (47%)	86 (37%)	221 (50%)	103 (37%)	823 (45%)	585 (30%)
NSTEMI	151 (42%)	270 (55%)	214 (50%)	244 (52%)	151 (44%)	242 (50%)	112 (42%)	115 (49%)	185 (42%)	145 (52%)	813 (44%)	1,016 (52%)
UA	42 (12%)	55 (11%)	29 (7%)	71 (15%)	38 (11%)	81 (17%)	19 (7%)	24 (10%)	30 (7%)	20 (7%)	158 (9%)	251 (13%)
Other	8 (2%)	29 (6%)	10 (2%)	26 (6%)	7 (2%)	27 (6%)	9 (3%)	10 (4%)	6 (1%)	9 (3%)	40 (2%)	101 (5%)
Atrial fibrillation	37 (10%)	42 (9%)	32 (8%)	46 (10%)	31 (9%)	46 (10%)	22 (8%)	18 (8%)	20 (5%)	20 (7%)	142 (8%)	172 (9%)
Cardiac arrest	14 (4%)	12 (3%)	12 (3%)	3 (1%)	11 (3%)	8 (2%)	7 (3%)	0 (0%)	13 (3%)	6 (2%)	57 (3%)	29 (2%)
Cardiogenic shock	9 (3%)	6 (1%)	8 (2%)	7 (2%)	9 (3%)	5 (1%)	5 (2%)	4 (2%)	12 (3%)	3 (1%)	43 (2%)	25 (1%)
Congestive heart failure	25 (7%)	47 (10%)	27 (6%)	42 (9%)	15 (5%)	45 (10%)	14 (5%)	9 (4%)	21 (5%)	17 (6%)	102 (6%)	160 (8%)
Major bleeding	23 (6%)	34 (7%)	31 (7%)	41 (9%)	27 (8%)	25 (5%)	13 (5%)	11 (5%)	20 (5%)	7 (3%)	114 (6%)	118 (6%)
Myocardial infarction	11 (3%)	5 (1%)	7 (2%)	9 (2%)	4 (1%)	2 (0.4%)	5 (2%)	1 (0.4%)	2 (1%)	4 (1%)	29 (2%)	21(1%)
Recurrent ischemia	12 (3%)	20 (4%)	18 (4%)	21 (4%)	11 (3%)	23(5%)	9 (3%)	12 (5%)	16 (4%)	11 (4%)	66 (4%)	87 (5%)
Stroke	0 (0%)	3 (1%)	2 (1%)	1 (0.2%)	1 (0.3%)	2 (0.4%)	0 (0%)	0 (0%)	1 (0.2%)	0 (0%)	4 (0.2%)	6 (0.3%)

[a]Data are presented as mean ± SD or n (%).

[b]Defined as previous atrial fibrillation, previous deep vein thrombosis/pulmonary embolism, previous heart failure, previous myocardial infarction, previous peripheral arterial disease, or previous stroke/transient ischemic attack.

Abbreviations: ACS, acute coronary syndrome; BMI, body mass index; CABG, coronary artery bypass grafting; CHD, coronary heart disease; CR, cardiac rehabilitation; CVD, cardiovascular disease; DVT, deep vein thrombosis; GRACE, Global Registry of Acute Coronary Events; GP, general practitioner; IRSD, index of relative socio-economic disadvantage; NSTEMI, non-ST-elevation myocardial infarction; PAD, peripheral arterial disease; PCI, percutaneous coronary intervention; PE, pulmonary embolism; TIA, transient ischemic attack; STEMI, ST-elevation myocardial infarction; UA, unstable angina.

Table 2. Comparison of Cardiac Rehabilitation Type Participated in by Patients with Acute Coronary Syndrome Referred to Cardiac Rehabilitation and Followed Up at 12-Months After Hospital Discharge[a]

Cardiac Rehabilitation Type	IRSD 1 (Most Disadvantaged) n=357	IRSD 2 n=426	IRSD 3 n=344	IRSD 4 n=265	IRSD 5 (Least Disadvantaged) n=442	Total n=1,834
1 session of group-based program (hospital-based)	148 (43%)	186 (45%)	175 (54%)	86 (34%)	180 (42%)	775 (44%)
Risk-factor counselling program (telephone- or internet-based)	18 (5%)	29 (7%)	8 (3%)	11 (4%)	12 (3%)	78 (5%)
Community-based program	167 (49%)	192 (47%)	128 (40%)	154 (60%)	229 (53%)	870 (49%)
Self-managed program	11 (3%)	4 (1%)	11 (3%)	4 (2%)	8 (2%)	38 (2%)

[a]Data are presented as n (%).

Abbreviation: IRSD, index of relative socio-economic disadvantage.

Twelve-month clinical events

Differences in patient 12-month clinical outcomes compared by patient socioeconomic quintile of usual residence and participation status are included in Table 3. Across the socioeconomic quintiles, cardiac rehabilitation participants were more likely to receive dietary advice or be prescribed cardioprotective medications (Table 3). Meanwhile, unadjusted analyses showed that participants were less likely to experience MACE (6% vs 8%, $P = .0079$) and die at 12 months (0.4% vs. 2%, $P < .0001$) (Table 3). Following adjustment, participants and non-participants did not have significantly different odds of experiencing 12-month MACE (OR = 0.87: 95% CI, 0.66 - 1.15; Figure 1). However, participants continued to have lower odds of death than non-participants after adjustment (OR = 0.35: 95% CI, 0.16 - 0.78; Figure 2). There was no difference in the association between socioeconomic quintile and participation status for 12-month MACE ($P_{interaction} = .6943$; Supplemental Digital Content Figure 1) and all-cause death ($P_{interaction} = .6339$; Supplemental Digital Content Figure 2). The intraclass correlation coefficient was 0.49 for MACE and 0.14 for death.

Table 3. Comparison of Medications and Clinical Outcomes by Socioeconomic Status and Participation in Cardiac Rehabilitation Among Patients with Acute Coronary Syndrome Referred to Cardiac Rehabilitation and Followed Up at 12-Months After Hospital Discharge[a]

	IRSD 1 (Most Disadvantaged) n=845		IRSD 2 n=898		IRSD 3 n=825		IRSD 4 n=500		IRSD 5 (Least Disadvantaged) n=719			
	CR n=357	No CR n=488	CR n=426	No CR n=472	CR n=344	No CR n=481	CR n=265	No CR n=235	CR n=442	No CR n=277	Total CR n=1,834	Total no CR n=1,953
Assessments and management at 12-month follow-up												
Blood sugar level checked	173 (62%)	216 (68%)	199 (57%)	204 (57%)	165 (63%)	197 (60%)	118 (53%)	84 (53%)	150 (42%)	113 (53%)	805 (55%)	814 (59%)
Dietary advice received	123 (47%)	118 (41%)	140 (41%)	126 (36%)	136 (53%)	116 (36%)	93 (43%)	57 (38%)	127 (36%)	79 (39%)	619 (43%)	496 (38%)
Smoking status												
Current smoker	47 (14%)	89 (19%)	56 (14%)	68 (15%)	37 (12%)	76 (17%)	27 (11%)	34 (16%)	35 (8%)	31 (12%)	202 (12%)	298 (16%)
Ex-smoker (ceased before ACS)	97 (28%)	108 (23%)	125 (31%)	125 (28%)	115 (38%)	118 (27%)	94 (37%)	63 (29%)	186 (44%)	102 (39%)	617 (36%)	516 (28%)
Ex-smoker (ceased after ACS)	115 (34%)	118 (26%)	142 (35%)	156 (35%)	94 (31%)	95 (22%)	76 (30%)	64 (29%)	137 (32%)	76 (29%)	564 (33%)	509 (28%)
Never smoked	46 (13%)	45 (10%)	58 (14%)	43 (10%)	34 (11%)	41 (9%)	36 (14%)	19 (9%)	46 (11%)	22 (8%)	220 (13%)	170 (9%)
Unknown	38 (11%)	101 (22%)	26 (6%)	56 (13%)	27 (9%)	107 (25%)	21 (8%)	39 (18%)	23 (5%)	33 (13%)	135 (8%)	336 (18%)
Consultation with a GP	4 (2, 6)	4 (2, 6)	3 (2, 5)	4 (2, 6)	4 (2, 6)	4 (2, 6)	3 (2, 5)	4 (2, 6)	2 (2, 4)	3 (2, 4)	3 (2, 5)	3 (2, 6)
Consultation with a cardiologist	1 (0, 1)	1 (0, 1)	1 (1, 2)	1 (0, 2)	1 (1, 2)	1 (1, 2)	1 (1, 2)	1(1, 2)	1 (1, 1)	1 (1, 2)	1 (1, 2)	1 (0, 2)
Medications at 12-month follow-up												
ACEi or ARB	240 (67%)	296 (61%)	271 (64%)	272 (58%)	228 (66%)	258 (54%)	178 (67%)	137 (58%)	301 (68%)	173 (63%)	1,218 (66%)	1,136 (58%)
Aspirin	275 (77%)	344 (71%)	343 (81%)	321 (69%)	257 (76%)	317 (67%)	227 (87%)	166 (71%)	367 (83%)	207 (75%)	1,469 (81%)	1,355 (70%)
Antiplatelet	192 (54%)	243 (50%)	225 (53%)	224 (48%)	166 (48%)	213 (44%)	146 (55%)	123 (52%)	245 (55%)	152 (55%)	974 (53%)	955 (49%)
Beta-blocker	257 (72%)	292 (60%)	314 (74%)	299 (64%)	216 (64%)	288 (60%)	190 (73%)	146 (62%)	321 (73%)	172 (62%)	1,298 (71%)	1,197 (62%)
Statin or other lipid lowering drug	306 (86%)	381 (78%)	374 (88%)	374 (79%)	286 (83%)	349 (73%)	244 (92%)	190 (81%)	403 (91%)	231 (83%)	1,613 (88%)	1,525 (78%)
At least 4 out of 5 medications[b]	220 (67%)	245 (58%)	261 (65%)	224 (53%)	188 (60%)	226 (56%)	168 (66%)	123 (59%)	295 (70%)	160 (65%)	1,132 (66%)	978 (57%)
Outcomes between hospital discharge and 12-month follow-up												
Hospital readmission for heart disease	35 (10%)	71 (15%)	38 (9%)	58 (12%)	39 (12%)	58 (12%)	22 (8%)	19 (8%)	31 (7%)	15 (5%)	165 (9%)	221 (11%)
Heart failure	2 (1%)	11 (2%)	5 (1%)	6 (1%)	3 (1%)	9 (2%)	1 (0.4%)	4 (2%)	4 (1%)	1 (0.4%)	15 (1%)	31 (2%)
Myocardial infarction	10 (3%)	20 (4%)	4 (1%)	13 (3%)	6 (2%)	6 (1%)	3 (1%)	4 (2%)	2 (0.5%)	3 (2%)	25 (1%)	46 (2%)
Stroke	1 (0.2%)	0 (0%)	2 (1%)	2 (0.4%)	0 (0%)	3 (1%)	0 (0%)	0 (0%)	1 (0.2%)	0 (0%)	4 (0.2%)	5 (0.3%)
Cardiac-cause death	0 (0%)	2 (0.4%)	0 (0%)	4 (1%)	1 (0.3%)	1 (0.2%)	0 (0%)	0 (0%)	0 (0%)	2 (1%)	1 (0.1%)	9 (0.5%)
MACE[c]	13 (4%)	28 (6%)	11 (3%)	23 (5%)	8 (2%)	18 (4%)	4 (2%)	7 (3%)	7 (2%)	6 (2%)	103 (6%)	158 (8%)
Death	1 (0.3%)	14 (3%)	3 (1%)	6 (1%)	2 (1%)	11 (2%)	1 (0.4%)	5 (2%)	1 (0.2%)	2 (1%)	8 (0.4%)	38 (2%)

[a]Data are presented as n (%) or median (IQR).

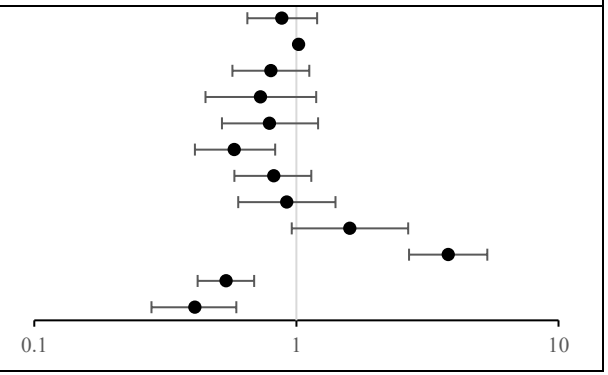
[b]Angiotensin-converting enzyme inhibitor or angiotensin receptor blockers, aspirin, antiplatelet, beta-blocker, and statin or other lipid lowering drug.

[c]Defined as heart failure, myocardial infarction, stroke, or cardiac-cause death.

Abbreviations: ACEi, angiotensin-converting enzyme inhibitor; ACS, acute coronary syndrome; ARB, angiotensin receptor blockers; CR, cardiac rehabilitation; GP, general practitioner; IRSD, index of relative socio-economic disadvantage; MACE, major adverse cardiovascular event.

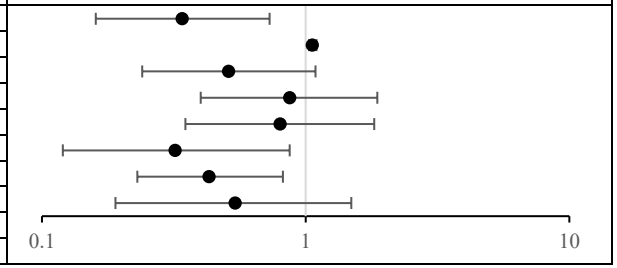
Figure 1. Adjusted odds ratios with corresponding 95% CI for the association between cardiac rehabilitation participation and other covariates and major adverse cardiovascular events among patients with acute coronary syndrome at 12-month follow-up

Variable	Odds Ratio (95% CI)	p-value	
Participated in cardiac rehabilitation	0.87 (0.66, 1.15)	0.3375	
Age	1.03 (1.01, 1.04)	<0.0001	
IRSD Q2 vs. IRSD Q1	0.82 (0.56, 1.20)	0.2328	
IRSD Q3 vs. IRSD Q1	0.74 (0.50, 1.09)		
IRSD Q4 vs. IRSD Q1	0.79 (0.49, 1.26)		
IRSD Q5 vs. IRSD Q1	0.58 (0.36, 0.94)		
Inner Regional vs. Major Cities Hospitals	0.82 (0.55, 1.22)	0.1125	
Outer Regional vs. Major Cities Hospitals	0.87 (0.54, 1.40)		
Remote/Very Remote/Unknown vs. Major Cities Hospitals	1.56 (0.91, 2.68)		
Congestive HF	3.74 (2.62, 5.35)	<0.0001	
PCI	0.54 (0.42, 0.69)	<0.0001	
CABG	0.42 (0.25, 0.68)	0.0005	



Abbreviations: CABG, coronary artery bypass grafting; HF, heart failure; IRSD, index of relative socio-economic disadvantage; PCI, percutaneous coronary intervention; Q, quintile.

Figure 2. Adjusted odds ratios with corresponding 95% CI for the association between cardiac rehabilitation participation and other covariates and all-cause death among patients with acute coronary syndrome at 12-month follow-up

Variable	Odds Ratio (95% CI)	p-value	
Participated in cardiac rehabilitation	0.35 (0.16, 0.78)	0.0098	
Age	1.07 (1.04, 1.10)	<0.0001	
IRSD Q2 vs. IRSD Q1	0.53 (0.22, 1.27)	0.3663	
IRSD Q3 vs. IRSD Q1	0.87 (0.39, 1.91)		
IRSD Q4 vs. IRSD Q1	0.85 (0.31, 2.31)		
IRSD Q5 vs. IRSD Q1	0.32 (0.09, 1.18)		
PCI	0.43 (0.22, 0.84)	0.0139	
CABG	0.54 (0.18, 1.58)	0.2577	

Abbreviations: CABG, coronary artery bypass grafting; IRSD, index of relative socio-economic disadvantage; PCI, percutaneous coronary intervention; Q, quintile.

DISCUSSION

This large-scale national registry of acute coronary syndrome found that only 50% of patients who survived acute coronary syndrome at discharge and were referred to a cardiac rehabilitation program participated in the program. Patients from disadvantaged socioeconomic status participated in the program less often compared to those from advantaged socioeconomic status. Despite this, participation in cardiac rehabilitation was significantly associated with lower odds of mortality within 12 months, and this did not differ by patient socioeconomic status. The findings also suggest that there is no association between participation and MACE after adjustment, and, further, it did not differ by socioeconomic status.

This study found there was poorer participation among patients residing in more disadvantaged areas. This remained consistent with studies across Denmark[17] and the southeastern United States.[21] Aside from the lack of awareness about cardiac rehabilitation, patients have attributed their suboptimal participation to the lack of time and transport options to access programs far from their usual residence.[22,23] Patients from disadvantaged socioeconomic status may have less flexible working schedules and job security.[24] Future programs aiming to reduce barriers experienced by patients from more disadvantaged socioeconomic status may include patient education regarding the benefits of cardiac rehabilitation, increasing the accessibility of programs with an educational component in socioeconomically disadvantaged areas, and supporting health care workforce to proactively provide technology- or home-based cardiac rehabilitation to the underserved population.[25-30] Poorer participation among patients who were female or spoke English as a second language observed in our study also affirms past studies.[31,32] While limited in availability, women-focused programs have improved their access to secondary cardiovascular disease care.[33,34] Translated technology-based cardiac rehabilitation programs, such as for Mandarin speaking patients in Australia, have shown to be effective for patients who speak English as a second language.[35]

The current study showed that while socioeconomic status appeared to influence the rate of participation in cardiac rehabilitation, the association between participation and 12-month

MACE or death was comparable across socioeconomic groups. This finding is a confirmation of the equitable provision of secondary preventive care in Australia, consistent with previous cohort studies from the United States and the Netherlands. These studies found that participating in secondary cardiovascular disease care lowers patient odds of all-cause death, regardless of their socioeconomic status.[36,37] Moreover, the United States cohort study found that cardiac rehabilitation participants had a lower odds of cardiac-related hospital readmission compared to non-participants, which also did not differ by socioeconomic status.[36]

This study has its limitations. Firstly, this sub-study analyzed patients referred to cardiac rehabilitation. Therefore, clinical outcomes of patients not referred to cardiac rehabilitation who may have been deemed by their physicians not to require the program were not analyzed. Secondly, participation was defined as attending at least 1 session of a cardiac rehabilitation program as we had only collected whether patients had participated in cardiac rehabilitation since the index admission (yes/no) as a part of the 6-month follow-up. Thirdly, the date or period of cardiac rehabilitation participation was not captured, so for those who participated in a cardiac rehabilitation program, it was not possible to determine whether the patients experienced a clinical event before, during, or after the program. Fourthly, this was an observational study, so there could be potential confounding variables that were not collected. Lastly, the follow-up data was self-reported thus, there may be recall bias. Although the type of cardiac rehabilitation (1 session of group-based program delivered in hospital, risk-factor counselling program delivered through telephone or internet, community-based program, or self-managed program) patients participated in was collected, limited data regarding the duration, intensity, components, and each patient's adherence rate to the rehabilitation programs were collected. Therefore, the impact of duration, intensity, and components of the rehabilitation programs on patient clinical outcomes could not be determined.

CONCLUSION

There persists a disparity in cardiac rehabilitation participation between patients from varying socioeconomic statuses. There was no significant difference in the associations between participation and mortality and MACE at 12 months across socioeconomic groups. Strategies to improve participation in cardiac rehabilitation across socioeconomic groups are needed.

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SUPPLEMENTARY MATERIALS

Supplemental Digital Content Table 1. Independent variables included in the multilevel logistic regression models

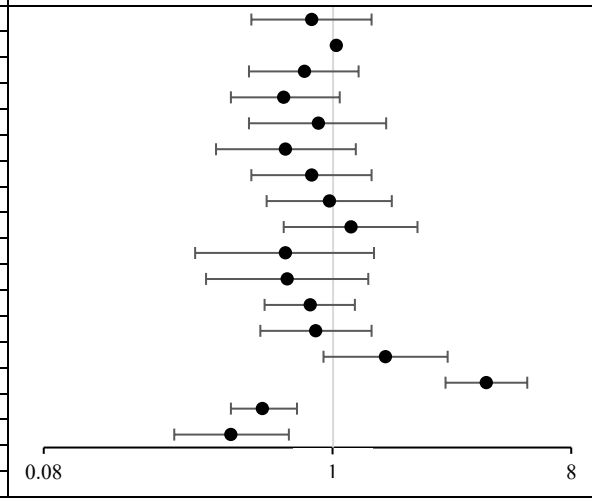
Dependent Variable	Independent Variable	Levels
MACE	Participation in cardiac rehabilitation	Yes
		No
	Age	
	Socioeconomic status	IRSD Q1 [most disadvantaged]
		IRSD Q2
		IRSD Q3
		IRSD Q4
		IRSD Q5 [least disadvantaged]
	Participation in cardiac rehabilitation × socioeconomic status[a]	Participated in CR × IRSD Q1 [most disadvantaged]
		Participated in CR × IRSD Q2
		Participated in CR × IRSD Q3
		Participated in CR × IRSD Q4
		Participated in CR × IRSD Q5 [least disadvantaged]
		Did not × IRSD Q1 [most disadvantaged]
		Did not × IRSD Q2
		Did not × IRSD Q3
		Did not × IRSD Q4
		Did not × IRSD Q5 [least disadvantaged]
	Hospital location region	Major cities of Australia
		Inner regional Australia
		Outer regional Australia
		Remote Australia/very remote Australia/unknown
	In-hospital congestive HF	Yes
		No
	In-hospital PCI	Yes
		No
	In-hospital CABG	Yes
		No
	Hospital clustering	
All-cause death	Participation in cardiac rehabilitation	Yes
		No
	Age	
	Socioeconomic status	IRSD Q1 [most disadvantaged]
		IRSD Q2
		IRSD Q3
		IRSD Q4
		IRSD Q5 [least disadvantaged]

	Participation in cardiac rehabilitation × socioeconomic status[a]	Participated in CR × IRSD Q1 [most disadvantaged]
		Participated in CR × IRSD Q2
		Participated in CR × IRSD Q3
		Participated in CR × IRSD Q4
		Participated in CR × IRSD Q5 [least disadvantaged]
		Did not × IRSD Q1 [most disadvantaged]
		Did not × IRSD Q2
		Did not × IRSD Q3
		Did not × IRSD Q4
		Did not × IRSD Q5 [least disadvantaged]
	In-hospital PCI	Yes
		No
	In-hospital CABG	Yes
		No
	Hospital clustering	

Abbreviations: CI, confidence interval; IRSD, index of relative socio-economic disadvantage; Q1, Quintile 1; Q2, Quintile 2; Q3, Quintile 3; Q4, Quintile 4; Q5, Quintile 5; HF, heart failure; PCI, percutaneous coronary intervention; CABG, coronary artery bypass grafting; CR, cardiac rehabilitation.

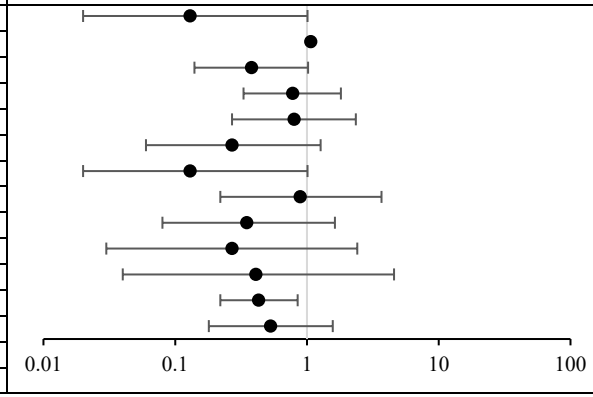
[a] When the interaction term was not significant, the same model was repeated excluding the interaction term to analyse the main effects

Supplemental Digital Content Figure 1. Adjusted odds ratios with corresponding 95% confidence interval for the interaction effect of cardiac rehabilitation participation and socioeconomic status on 12-month major adverse cardiovascular event among patients with acute coronary syndrome

Variable	Level	Odds Ratio (95% CI)	p-value	
Participated in cardiac rehabilitation		0.83 (0.49, 1.40)	0.2333	
Age		1.03 (1.01, 1.04)	<0.0001	
IRSD Q2 vs. IRSD Q1		0.78 (0.48, 1.25)	0.2998	
IRSD Q3 vs. IRSD Q1		0.65 (0.41, 1.06)		
IRSD Q4 vs. IRSD Q1		0.88 (0.48, 1.59)		
IRSD Q5 vs. IRSD Q1		0.66 (0.36, 1.22)		
IRSD Q1	Participated in CR vs. did not	0.83 (0.49, 1.40)	0.6943	
IRSD Q2	Participated in CR vs. did not	0.97 (0.56, 1.67)		
IRSD Q3	Participated in CR vs. did not	1.17 (0.65, 2.09)		
IRSD Q4	Participated in CR vs. did not	0.66 (0.30, 1.43)		
IRSD Q5	Participated in CR vs. did not	0.67 (0.33, 1.36)		
Inner Regional vs. Major Cities Hospitals		0.82 (0.55, 1.21)	0.0975	
Outer Regional vs. Major Cities Hospitals		0.86 (0.53, 1.40)		
Remote/Very Remote/Unknown vs. Major Cities Hospitals		1.58 (0.92, 2.72)		
Congestive HF		3.81 (2.67, 5.45)	<0.0001	
PCI		0.54 (0.41, 0.73)	<0.0001	
CABG		0.41 (0.25, 0.68)	0.0005	

Abbreviations: CI, confidence interval; IRSD, index of relative socio-economic disadvantage; Q2, Quintile 2; Q1, Quintile 1; Q3, Quintile 3; Q4, Quintile 4; Q5, Quintile 5; CR, cardiac rehabilitation; HF, heart failure; PCI, percutaneous coronary intervention; CABG, coronary artery bypass grafting.

Supplemental Digital Content Figure 2. Adjusted odds ratios with corresponding 95% confidence interval for the interaction effect of cardiac rehabilitation participation and socioeconomic status on 12-month all-cause death among patients with acute coronary syndrome

Variable	Level	Odds Ratio (95% CI)	p-value	
Participated in cardiac rehabilitation		0.13 (0.02, 1.01)	0.0175	
Age		1.07 (1.04, 1.10)	<.0001	
IRSD Q2 vs. IRSD Q1		0.38 (0.14, 1.02)	0.7777	
IRSD Q3 vs. IRSD Q1		0.78 (0.33, 1.81)		
IRSD Q4 vs. IRSD Q1		0.80 (0.27, 2.35)		
IRSD Q5 vs. IRSD Q1		0.27 (0.06, 1.27)		
IRSD Q1	Participated in CR vs. did not	0.13 (0.02, 1.01)	0.6339	
IRSD Q2	Participated in CR vs. did not	0.89 (0.22, 3.68)		
IRSD Q3	Participated in CR vs. did not	0.35 (0.08, 1.63)		
IRSD Q4	Participated in CR vs. did not	0.27 (0.03, 2.41)		
IRSD Q5	Participated in CR vs. did not	0.41 (0.04, 4.58)		
PCI		0.43 (0.22, 0.85)	0.0148	
CABG		0.53 (0.18, 1.57)	0.2500	

Abbreviations: CI, confidence interval; IRSD, index of relative socio-economic disadvantage; Q2, Quintile 2; Q1, Quintile 1; Q3, Quintile 3; Q4, Quintile 4; Q5, Quintile 5; CR, cardiac rehabilitation; PCI, percutaneous coronary intervention; CABG, coronary artery bypass grafting.

CHAPTER 5

Cardiac rehabilitation participation and psychosocial outcomes by socioeconomic characteristics: Analysis of the International Cardiac Rehabilitation Registry (ICRR) in low-resource settings

Chapter 1: Introduction

Synthesising evidence and identifying gaps

Chapter 2: Bibliometric review
Cardiac rehabilitation research

Chapter 3: Systematic review
Benefits of cardiac rehabilitation by socioeconomic groups

Analysing across international, national, and local settings

Chapter 4: CONCORDANCE registry
Participation and clinical outcomes by socioeconomic status of area

Chapter 5: ICRR
Participation and psychosocial outcomes by socioeconomic characteristics

Chapter 6: Westmead Hospital
Psychosocial outcomes by socioeconomic characteristics

Implications and future directions

Chapter 7: Discussion and conclusion

This chapter presents a quantitative analysis of the ICRR on whether financial strain, age group, educational attainment, and employment status are associated with cardiac rehabilitation completion, changes in depressive symptoms (measured using the Patient Health Questionnaire-2 [PHQ-2]), and changes in quality of life (measured using Cantril's Ladder). It builds on Chapter 4 by providing real-world evidence from lower-income countries and low-resource settings within high-income countries.

A total of 2,190 individuals who completed cardiac rehabilitation were included. Depressive symptoms and quality of life improved overall. However, improvements in depressive symptoms were greater among individuals reporting frequent financial strain and more modest among those who were employed, while changes in quality of life did not differ by socioeconomic subgroup. These findings inform the subsequent chapter of this thesis, which assesses registry data from a local setting.

> **Aim Addressed:** This chapter addresses **Aim 4** – to assess whether socioeconomic characteristics are associated with cardiac rehabilitation completion and psychosocial outcomes.

This work, titled *"Association between socioeconomic characteristics among individuals who completed cardiac rehabilitation in low-resource settings with their depressive symptoms and quality of life: Analysis from the International Cardiac Rehabilitation Registry"*, is currently under review by *Journal of the American Heart Association*.

PUBLICATION

Manandi D, Turk-Adawi K, Candelaria D, Zende A, Jiandani M, Ka MM, Chen SY, Cuenza L, Redfern J*, Hyun K*, on behalf of the ICRR collaborators. Association between socioeconomic characteristics among individuals who completed cardiac rehabilitation in low-resource settings with their depressive symptoms and quality of life: Analysis from the International Cardiac Rehabilitation Registry. *Journal of the American Heart Association*. (under review).

STATEMENT OF AUTHORSHIP

Deborah Manandi led the conceptualisation, methodology, formal analysis, and writing – original draft. The roles of co-authors are as follows:

Task	**Role of co-authors**
Conceptualisation	KT, DC, JR, KH
Methodology	KT, DC, JR, KH
Formal analysis	KH
Writing – reviewing & editing	KT, DC, AZ, MJ, MMK, SYC, LC, QT, NH, JR, KH

ABSTRACT

Background: Cardiac rehabilitation (CR) supports recovery after cardiac events, but it is unclear whether outcomes differ by socioeconomic characteristics in low-resource settings. This study aimed to identify whether pre-program socioeconomic characteristics (financial strain, age, educational attainment, and employment status) were associated with CR completion, and–among individuals who completed–to examine associations with changes in depressive symptoms and quality of life (QoL) from pre- to post-program.

Methods: Individuals who provided pre-program data (2021-May 2024) to the International Cardiac Rehab Registry (ICRR) in low-resource settings across 17 programs in 11 countries were included. Outcomes were changes in PHQ-2 depressive symptoms and Cantril's Ladder QoL scores. Among individuals who completed CR, associations were examined using robust linear mixed-effects models, adjusting for characteristics, with a random intercept for site.

Results: Of 3,520 individuals, 2,190 (62%) completed CR. Completion was more common among those without financial strain (20% vs. 10%, $p<0.001$), with >12 years of education (57% vs. 44%, $p<0.001$), and employed (40% vs. 20%, $p<0.001$). Among completers, median depressive symptoms improved from 1 (IQR=2) to 0 (IQR=0), and QoL from 8 (IQR=2) to 10 (IQR=2). Reporting financial strain often was associated with greater improvement in depressive symptoms (β=-0.337, 95% CI=-0.534, -0.140, p=0.021), while employment was associated with smaller improvement (β=0.297, 95% CI=0.104, 0.489, p=0.019). No association was found between age or education and change in depressive symptoms. No socioeconomic characteristics were associated with change in QoL.

Conclusions: These findings suggest socioeconomic pressures are associated with differences in recovery. Flexible CR models may support individuals in low-resource settings.

INTRODUCTION

Cardiac rehabilitation is a structured model of care that supports recovery following cardiac events through supervised exercise, risk factor modification, education sessions, and psychosocial support.[1-4] These core components have been associated with consistent benefits from cardiac rehabilitation in high-income countries, including reductions in recurrent cardiac events and hospitalizations, and improvements in functional capacity, depressive symptoms, and quality of life.[5-7] However, access remains limited globally, with only half of countries reporting the availability of a formal program.[8,9] Even where available, participation and completion rates are often suboptimal.[8,9] In high-income countries such as Australia, Canada, Denmark, and the United Kingdom, program completion is unequally distributed.[10-12] Evidence suggests that individuals with lower household income, lower levels of educational attainment, or unstable employment are less likely to participate in or complete cardiac rehabilitation, and may experience different outcomes.[13-15] In a national Australian study, over half of individuals who survived acute coronary syndrome reported economic hardship 18 months after discharge, which likely contributes to underutilization of cardiac rehabilitation despite greater clinical and psychosocial need.[16-19]

Socioeconomic disparities in cardiac rehabilitation reflect broader inequities in secondary prevention. These may arise from both systemic differences in care delivery and individual-level barriers. The Prospective Urban Rural Epidemiology study, which included over 150,000 participants across 20 countries, found that individuals with lower educational attainment had a 1.2–1.5-fold higher risk of recurrent cardiovascular events and mortality in high-income countries, increasing to 1.5–2.8-fold in lower-income settings.[20] These disparities reflect gaps in infrastructure and workforce, but also differences in health system design and out-of-pocket costs.[21-23]

Although some programs in lower-income countries have demonstrated improvements in functional capacity, depressive symptoms, and quality of life, the evidence remains limited.[24-26] In high-income countries, outcomes are occasionally analyzed according to socioeconomic characteristics, although often using area-level rather than individual-level measures. For example, studies from the United States and the Netherlands have found that participation in cardiac rehabilitation is associated with fewer cardiac events and reduced mortality, with

similar associations observed across socioeconomic areas.[6,7] In contrast, a study from South Korea found that while participation improved physical quality of life regardless of educational attainment and income, mental health improvements were observed only among individuals with higher levels of educational attainment or income.[27] Such analyses remain largely absent in lower-income countries, where outcomes are rarely examined by area-level socioeconomic characteristics, let alone specific individual-level characteristics such as financial strain, age group, educational attainment, and employment status.[28,29] In many low-resource settings, inconsistent referral pathways, limited funding, and workforce constraints may further limit the applicability of program models developed in high-income countries.[28-32]

The International Cardiac Rehab Registry (ICRR) is the first global registry to collect standardized individual-level data on cardiac rehabilitation delivery and outcomes across lower-income countries and low-resource settings within high-income countries.[33] Depressive symptoms and quality of life are commonly assessed in cardiac rehabilitation programs using validated tools. The Patient Health Questionnaire-2 (PHQ-2) is a two-item screening measure for depressive symptoms, while Cantril's Ladder is a single-item measure of overall quality of life.[34,35] This study draws on ICRR data to examine socioeconomic variation in program completion and psychosocial outcomes by socioeconomic characteristics, contributing multinational evidence on equity in cardiac rehabilitation. Specifically, we aimed to describe differences in pre-program socioeconomic characteristics, including financial strain, age group, educational attainment, and employment status, between individuals who completed and did not complete cardiac rehabilitation, and among individuals who completed cardiac rehabilitation, to examine associations with changes in depressive symptoms and quality of life from pre- to post-program.

METHODS

Study Data

Due to the sensitive nature of the data collected for this study, requests to access the dataset from qualified researchers trained in human subject confidentiality protocols may be sent to the International Council of Cardiovascular Prevention and Rehabilitation (ICCPR) at iccpr.icrr@gmail.com.

This study used data extracted from the International Cardiac Rehab Registry (ICRR; 5 November 2024).[33] The registry collected standardized data from cardiac rehabilitation programs at three timepoints: pre-program, post-program (corresponding with planned program completion, based on site-defined program duration), and annually. This study is based on pre- and post-program data. Programs were eligible to participate if they were considered to be in low-resource settings and offered phase II cardiac rehabilitation, defined as a program that assessed individuals before entry, offered structured exercise interventions, and included at least one other component of cardiovascular risk factor management.[36] All participating sites obtained institutional ethics approvals for data collection and all subjects gave informed consent. This study was approved by the University of Sydney Human Research Ethics Committee (2024/HE000866).

For the aims of this study, individuals were eligible for inclusion if they completed pre-program assessments at least six months before the data extraction date (5 November 2024). Individuals who completed at least some program components and had post-program assessments were classified as having completed cardiac rehabilitation. All others were classified as not having completed the program.

Pre-Program and Post-Program Measures

Site-reported pre-program measures included age, sex, referral diagnoses, cardiac interventions, body mass index, systolic and diastolic blood pressure, and functional capacity. Functional capacity was measured in peak metabolic equivalents of task (METs) according to site protocols. Individual-reported measures included comorbidities, emotional and health-

related support, and out-of-pocket costs for heart medications. These measures were reassessed post-program according to site protocols

Socioeconomic Characteristics

Individual participant-reported pre-program socioeconomic characteristics included financial strain (measured as worry about meeting basic needs), educational attainment, and employment status. Financial strain was assessed using the question, "How much do you worry about having enough money to meet your basic needs, including for health and health care?", with responses categorized as 'not at all', 'sometimes', or 'often'. These were treated as ordinal categories, with 'often' representing the highest level of strain. Age was grouped as ≤60 or >60 years according to the higher cardiovascular risk and different guideline-based therapy recommendations observed among individuals aged >60years.[37-39] Educational attainment was categorized as ≤12 or >12 years. Employment status was categorized as full- or part-time (including self-employed), on disability or modified duties, retired, unemployed, or other. Age was included as a socioeconomic characteristic given its relevance to economic hardship and access to healthcare in low-resource settings.[40] Country-income level was not treated as an individual-level socioeconomic characteristic but was included in adjusted models as a covariate.

Outcomes

Primary outcomes were changes in depressive symptoms and quality of life, calculated as post-program minus pre-program scores. Depressive symptoms were assessed using the PHQ-2 (score range 0-6, with higher scores reflecting more symptoms), and quality of life using Cantril's Ladder (score range 0-10, with higher scores reflecting better quality of life).[34,35] Program completion was treated as a secondary outcome and examined descriptively by comparing pre-program socioeconomic characteristics between individuals who completed and did not complete cardiac rehabilitation. These individual-reported outcomes were collected at both timepoints, using electronic or paper-based surveys with staff support, including translation when needed. As PHQ-2 increases reflect worse depressive symptoms, negative change indicates improvement, and positive change indicates worsening. As Cantril's Ladder score increases reflect better quality of life, positive change indicates improvement, and negative change indicates worsening. In this study, β coefficients

reflect the direction and extent of change: for PHQ-2, a positive β indicates smaller improvement in depressive symptoms and a negative β indicates greater improvement; for Cantril's Ladder, a positive β indicates greater improvement in quality of life while a negative β indicates smaller improvement.

Statistical Analyses

Pre-program characteristics were compared between individuals who completed cardiac rehabilitation and those who did not using Chi-squared or Fisher's exact tests (if >20% of expected cell counts are <5) for categorical variables. Independent t-tests for normally distributed continuous variables or Wilcoxon rank-sum tests for non-normally distributed variables were used. Pre-program characteristic comparisons were also conducted across socioeconomic subgroups using Chi-squared tests for categorical, one-way ANOVA for normally distributed continuous variables, or Kruskal-Wallis tests for skewed continuous variables when comparing between more than two categories.

Changes in depressive symptoms and quality of life were compared across socioeconomic subgroups using Wilcoxon rank-sum tests for two-group comparisons and Kruskal-Wallis tests for comparisons between more than two groups.

Among individuals who completed cardiac rehabilitation, associations between pre-program characteristics and changes in depressive symptoms and quality of life were examined using robust linear mixed-effects models, with a random intercept for site. Robust standard errors were applied using the cluster-robust variance estimator type 2 correction to account for site-level clustering and small-sample bias. The models included covariates prespecified based on literature. Final models adjusted for pre-program depressive symptoms (for the depressive symptoms outcome) or pre-program quality of life (for the quality of life outcome), financial strain, age group, educational attainment, employment status, and country-income level. Associations are presented as β-coefficients with 95% confidence intervals (CIs). All analyses were conducted using R version 4.3.1.

RESULTS

Seventeen cardiac rehabilitation sites contributed data during the study period. These included Brazil (n=2), Colombia (n=1), Czech Republic (n=1), India (n=3), Iran (n=1), Malaysia (n=1), Mexico (n=1), Pakistan (n=3), Qatar (n=1), Senegal (n=2), and Taiwan (n=1). Of these, 53% were in lower-middle-income (n=9), 29% in upper-middle-income (n=5), and 18% in high-income countries (n=3). Among 3,520 eligible individuals, the mean age was 59 (Standard Deviation [SD]=12), and 79% were male. Pre-program characteristics by completion status are presented in Table 1.

A total of 2,190 individuals (62%) completed cardiac rehabilitation. Program completion did not differ by age group (53% vs. 54%, p=0.483), but was more common among males (81% vs. 77%, p=0.004). Completion was more common among individuals who had >12 years of educational attainment (57% vs. 44%, p<0.001), and those employed full-time or part-time (40% vs. 20%, p<0.001). Fewer individuals who completed the program reported frequent financial strain (10% vs. 20%, p<0.001). Individuals who completed the program were also more likely to report no out-of-pocket costs for heart medications (20% vs. 17%, p=0.009), and to receive definite health-related support (59% vs. 44%, p<0.001). Completion was more common among individuals attending programs in upper-middle-income (37% vs. 20%) or high-income (21% vs. 10%) countries (p<0.001).

Table 1. Cardiac rehabilitation patient demographic, clinical characteristics and attendance rate in supervised exercise session by completion status

Variable	Level	Completer n=2,190 n (%)	Non-completer n=1,330 n (%)	p-value
Age	Median (IQR)	60 (15)	60 (15)	0.213
	≤60 years	1,143 (53)	695 (54)	0.483
Sex	Male	1,769 (81)	997 (77)	0.004**
Educational attainment	≤12 years	930 (44)	715 (57)	<0.001***
Employment status	Full-time or part-time	864 (40)	261 (20)	<0.001***
	Disability or modified duties	461 (21)	460 (36)	
	Retired	449 (21)	260 (20)	
	Unemployed	303 (14)	253 (20)	
	Other	93 (4.3)	49 (3.8)	
Financial strain	Frequent	223 (10)	261 (20)	< 0.001**
	Occasional	970 (45)	511 (40)	
	No	981 (45)	510 (45)	
Out-of-pocket cost for heart medications	Yes	1728 (80)	1061 (83)	0.009**
Have health-related support	Definite	1287 (59)	563 (44)	<0.001***
	Most of the time	627 (29)	487 (38)	
	Some of the time, rarely, or none			
Country income	Lower-middle-income	922 (42)	905 (70)	<0.001***
	Upper-middle-income	804 (37)	261 (20)	
	High-income	464 (21.2)	134 (10)	
Diagnosis at referral	Acute coronary syndrome	1031 (52)	776 (64)	<0.001***
	Stable coronary artery disease or stable angina	647 (33)	275 (23)	
	Heart failure	113 (5.7)	35 (2.9)	
	Other cardiac	198 (9.0)	124 (10)	
Cardiac intervention at referral	Percutaneous coronary intervention	1142 (56)	644 (52)	0.03
	Coronary artery bypass surgery	528 (26)	351 (29)	
	Other procedures	214 (10)	120 (9.7)	
Body mass index category	Underweight	26 (1.9)	25 (1.9)	0.142
	Healthy	722 (33)	422 (33)	
	Overweight	936 (43)	526 (41)	
	Obese	480 (22)	310 (24)	
Systolic blood pressure (mmHg)	Mean (SD)	120 (16)	120 (16)	0.162
Diastolic blood pressure (mmHg)	Mean (SD)	73 (10)	71 (10)	<0.001***
Functional capacity (METs)	Median (IQR)	4.2 (4.5)	2.6 (1.6)	<0.001***
Comorbidity	Stroke or vascular disease	19 (1.5)	11 (1.45)	0.023*
	Diabetes	262 (20)	126 (18)	

	Liver or kidney disease	19 (1.4)	14 (2.0)	
	Lung disease	17 (1.3)	7 (1.0)	
	Musculoskeletal issues	47 (3.6)	29 (4.2)	
	Other	448 (35)	296 (43)	
	None	500 (38)	214 (31)	

*significant at p<0.1, **significant at p<0.01, ***significant at p<0.001

Abbreviations: mmHg, millimeters of mercury; SD, standard deviation; METs, metabolic equivalent of tasks; IQR, interquartile range

Referral diagnosis and functional status also differed between groups. Individuals referred after stable coronary artery disease or angina (33% vs. 23%, p<0.001) or heart failure (5.7% vs. 2.9%, p<0.001) were more likely to complete the program, whereas completion was less common among those referred after acute coronary syndrome (52% vs. 64%, p<0.001). Those who completed cardiac rehabilitation experienced higher functional capacity at pre-program (median [Interquartile Range, IQR] 4.2 [4.5] vs. 2.6 [1.6], p<0.001). Comparisons of participant characteristics by socioeconomic characteristics among those who completed the program are reported in Supplemental Table 1.

Pre-program characteristics by socioeconomic characteristics

Among individuals who completed cardiac rehabilitation, several pre-program characteristics differed by socioeconomic characteristics (Supplemental Table 1). Individuals who reported frequent financial strain were more likely to be older than 60 years (49% vs. 38%, p<0.001), have ≤12 years of education (63% vs. 39%, p<0.001), and be unemployed (28% vs. 15%, p<0.001). Individuals with >12 years of educational attainment were more likely to attend programs in upper-middle- (31% among those with >12 years of education vs. 22% among those with ≤12 years) or high-income countries (25% vs. 13%, p<0.001). Unemployed or retired individuals experienced lower functional capacity at pre-program (median [IQR] METs 3.9 [3.8] vs. 5.2 [5.1], p<0.001) and were more likely to report a comorbidity (47% vs. 23%, p<0.001) than those employed full- or part-time. Retired individuals completed more supervised sessions than those employed full- or part-time (median [IQR] 17 [24] vs. 17 [18], p=0.002).

Depressive symptoms and quality of life

Among individuals who completed cardiac rehabilitation, depressive symptoms improved overall from a median PHQ-2 score of 1 (IQR=2) at pre-program to 0 (IQR=0) at post-program, with a median change of 0 (IQR=2, p<0.001). Quality of life improved from a median Cantril's Ladder score of 8 (IQR=2) to 10 (IQR=2), with a median change of 2 (IQR=3, p<0.001).

Change in depressive symptoms by socioeconomic characteristics

Changes in depressive symptoms differed by socioeconomic characteristics (Table 2). Individuals who reported frequent financial strain experienced greater improvement in depressive symptoms more often those who did not (median [IQR] change 1 [2] vs. 0 [2], p=0.01). Individuals older than 60 years experienced similar change compared with those aged 60 years or younger (1 [2] vs. 0 [0], p=0.693), with no meaningful difference in scores. Educational attainment was statistically associated with change in depressive symptoms (p=0.002), although the median change was 0 in both categories, with only small differences in variability (0 [1] vs. 0 [2]). Individuals who were unemployed experienced greater improvement in depressive symptoms more often than those who were retired (median [IQR] change -1 [2] vs. 0 [0], p=0.001).

In adjusted models, financial strain and employment status remained independently associated with change in depressive symptoms (Table 3). Compared with individuals reporting no financial strain, those reporting frequent and occasional financial strain were more likely to experience greater improvement (β=-0.337, 95% CI=-0.534, -0.140, p=0.021; β=-0.168, 95% CI= -0.289, -0.047, p=0.034, respectively). Individuals who were employed full- or part-time experienced smaller improvement more often than those who were unemployed (β=0.297, 95% CI=0.104, 0.489, p=0.019). Retired individuals experienced a similar pattern, although this association was not statistically significant (β=0.194, 95% CI=0.022, 0.365, p=0.069). No significant associations were observed for age group, educational attainment, or country-income level.

Table 2. Changes in depressive symptoms and quality of life outcomes from pre-program to post-program of participants who completed the program by self-reported financial strain, age, educational attainment, and employment status

Variable	Level	Frequent financial strain n=233	Occasional financial strain n=970	No financial strain n=981	p-value	Age ≤60 years n=1,143	Age >60 years n=1,047	p-value	Education ≤12 years n=930	Education >12 years n=1,209	p-value	Full-time or part-time n=864	Disability or modified duties n=461	Retired n=449	Unemployed n=303	Other employment n=93	p-value
Change in PHQ-2 depressive symptoms score	Median (IQR)	1 (2)	0 (2)	0 (2)	0.010	1 (2)	0 (0)	0.693	0 (1)	0 (2)	0.002	0 (1)	0 (2)	0 (0)	-1 (2)	0 (1)	<0.001***
Change in Cantril's Ladder quality of life score	Median (IQR)	2 (0)	0 (2)	2 (0)	<0.001***	0 (2)	0 (2)	0.149	0 (2)	0 (0)	0.951	0 (2)	0 (2)	0 (2)	0 (2)	0 (2)	0.016*

*significant at p<0.1, **significant at p<0.01, ***significant at p<0.001

Abbreviations: PHQ-2, Patient Health Questionnaire-2; IQR, interquartile range

Table 3. Robust linear mixed-effects model estimating change in depressive symptoms from pre-program to post-program among individuals who completed cardiac rehabilitation (n=1,808), accounting for clustering by site

Variable	β-Coefficient (95% Confidence Interval)	p-value
Frequent financial strain vs No financial strain	-0.337 (-0.534, -0.140)	0.0207
Occasional financial strain vs No financial strain	-0.168 (-0.289, -0.047)	0.0336
Age group ≤60 years vs >60 years	-0.111 (-0.219, -0.004)	0.0784
Education group ≤12 years vs >12 years	-0.030 (-0.175, 0.115)	0.6986
Full-time or part-time vs unemployed	0.297 (0.104, 0.489)	0.0187
Disability or modified duties vs unemployed	0.102 (-0.037, 0.242)	0.2089
Retired vs unemployed	0.194 (0.022, 0.365)	0.0686
Upper-middle-income country vs low-resource settings within high-income countries	0.303 (-0.237, 0.842)	0.3296
Lower-middle-income country vs low-resource settings within high-income countries	-0.258 (-0.828, 0.313)	0.4297

Model adjusted for pre-program depressive symptoms, financial strain, age group, educational attainment, employment status, and country-income level

Change in quality of life by socioeconomic characteristics

Changes in quality of life were smaller across socioeconomic characteristics (Table 2). While quality of life improved overall, the magnitude of change was modest. Individuals who reported frequent financial strain experienced similar change in quality of life compared with those who did not (median [IQR] change 2 [0] vs. 2 [0], $p<0.001$). Individuals older than 60 years experienced similar change to those aged 60 years or younger (0 [2] vs. 0 [2], $p=0.149$). Compared with individuals who were retired, those who were unemployed experienced the same median change in quality of life scores (0 [2] vs. 0 [2]), despite a statistically significant p-value ($p=0.016$).

In adjusted models, no socioeconomic characteristics were significantly associated with change in quality of life (Table 4). All β coefficients were close to zero, and no associations remained significant after correction for multiple comparisons.

Table 4. Robust linear mixed-effects model estimating change in quality of life from pre-program to post-program among individuals who completed cardiac rehabilitation (n=1,808), accounting for clustering by sites

Variable	β-Coefficient (95% Confidence Interval)	p-value
Frequent financial strain vs No financial strain	-0.267 (-1.030, 0.495)	0.519
Occasional financial strain vs No financial strain	-0.379 (-0.994, 0.237)	0.273
Age group ≤60 years vs >60 years	-0.096 (-0.110, 0.302)	0.388
Education group ≤12 years vs >12 years	0.311 (-0.018, 0.641)	0.104
Full-time or part-time vs unemployed	0.058 (-0.338, 0.453)	0.783
Disability or modified duties vs unemployed	0.190 (-0.192, 0.572)	0.370
Retired vs unemployed	0.123 (-0.163, 0.409)	0.429
Upper-middle-income country vs low-resource settings within high-income countries	0.173 (-0.864, 1.210)	0.759
Lower-middle-income country vs low-resource settings within high-income countries	0.374 (-0.737, 1.485)	0.548

Model adjusted for pre-program quality of life, financial strain, age group, educational attainment, employment status, and country-income level

DISCUSSION

This study used data from the ICRR to examine associations between pre-program characteristics, including socioeconomic characteristics, and outcomes among 3,520 individuals attending 17 cardiac rehabilitation programs across lower-income countries and low-resource settings within high-income countries. Program completion was more common among individuals who reported less financial strain, had >12 years of education, were employed full-time or part-time, were referred after stable coronary disease, or attended programs in upper-middle or high-income countries. Financial strain and employment status were independently associated with change in depressive symptoms. Individuals reporting financial strain experienced greater improvement, while those employed full-time or part-time showed smaller improvement compared with those unemployed. No socioeconomic characteristics were associated with change in quality of life, despite modest overall improvements.

The finding that individuals experiencing financial strain had greater improvement in depressive symptoms was unexpected. Financial strain, often linked with job insecurity, housing instability, or out-of-pocket health costs, is typically associated with poorer mental health and may limit the benefits of cardiac rehabilitation.[41-44] In this study, financial strain reflects self-reported concern about meeting basic needs, rather than objective income, and may capture heightened distress at program entry. It reflects individuals' perceptions of whether their finances and resources are sufficient to meet both current and anticipated needs.[41-44] In this study, those reporting financial strain also had lower functional capacity and more comorbidities at pre-program, indicating greater vulnerability. Greater improvements among this group may therefore reflect a greater scope for psychosocial change over the program period, rather than any protective effect of financial strain. Structured support through cardiac rehabilitation may be associated with meeting previously unmet needs, which could be linked to greater psychosocial improvement.[45]

The finding that individuals with stable employment had smaller improvement in depressive symptoms is also notable. While employment may buffer financial strain, it can introduce competing demands, especially in informal or inflexible work settings where job security,

paid leave, or workplace accommodations may be limited.[46-49] In low-resource settings, employment may more often involve limited flexibility, variable income, and fewer protections, which may reduce engagement with program components and leave less time for recovery. [46-50] Employment-related stress, limited time for sessions, or anxiety about returning to work may be associated with smaller psychosocial improvements.[50] This is consistent with the possibility that individuals without stable employment may have experienced greater improvement alongside the program's structure, peer support, and consistent contact with cardiac rehabilitation staff, who may have offered consistent encouragement, psychosocial support, and help navigating care.[51,52] These findings align with psychosocial models of recovery, which suggest that mental health improvement involves not only symptom reduction but also the re-establishment of meaningful routines and roles.[53,54] When financial strain increases vulnerability and employment introduces competing demands, the extent of improvement may vary according to whether individuals were able to prioritize cardiac rehabilitation and recovery.

Beyond depressive symptoms, these findings contribute to the limited literature on psychosocial outcomes in low-resource settings.[26,55] The high median Cantril's Ladder score at pre-program may reflect sociocultural factors, prosociality, and gratitude, which have been reported to support higher self-reported wellbeing in non-Western or lower-income settings.[56,57] Changes in quality of life were smaller across all socioeconomic characteristics. While quality of life improved overall, the magnitude of change was modest. Although some p-values were statistically significant, the median change scores were similar across groups, suggesting these differences may not be clinically meaningful. Because quality of life was assessed using a single-item measure, smaller changes over the program period may not have been captured. Minimal clinically important change scores have not been established for either the PHQ-2 or the Cantril's Ladder, particularly among diverse individuals in low-resource settings. Changes were therefore interpreted cautiously, focusing on patterns across groups. The self-reported nature of the Cantril's Ladder, including the potential for response bias at both pre- and post-program, may also explain the modest change scores.[35] This contrasts with studies in high-income countries.[27,58-60] The limited improvements may reflect persistent barriers to longer-term support, including financial, social, or health system constraints.[21-23,28-30] In addition, variation in program content, duration, and follow-up timing across sites may have contributed to variability in observed changes. Nevertheless, the

consistent improvements observed may reflect the value of structured care and peer support during recovery.[61,62] Future research could explore how programs can better support individuals managing competing occupational and social demands.

While this study draws on a multi-country registry with detailed individual-level data from underrepresented low-resource settings, several limitations should be considered. First, this study is observational, where associations may reflect natural recovery or other concurrent factors, and causality cannot be established. Second, analyses were limited to individuals who had access to an operational cardiac rehabilitation program and registration capacity. This may introduce selection bias and limit the generalizability to individuals who attend programs with fewer resources or who have no access to cardiac rehabilitation. Restricting outcome analyses to individuals who completed the program may further introduce attrition bias, as those who did not complete may differ in socioeconomic vulnerabilities, health status, competing responsibilities, or motivation. Third, some relevant factors that may influence change in depressive symptoms and quality of life, such as pain, sleep quality, spiritual wellbeing, expectations about recovery, or readiness to return to work, were not routinely collected.[63-67] Fourth, quality of life was assessed using Cantril's Ladder, a general life satisfaction measure, which may not fully capture health-related or domain-specific changes.[68] Finally, variation in program delivery models and follow-up timing across sites and countries may limit the comparability of observed changes in depressive symptoms and quality of life. This may limit the ability to extrapolate findings to other settings and underscores the need for prospective studies with standardized measures and consistent follow-up timing.

CONCLUSION

Individuals with less financial strain, higher educational attainment, stable employment, referral after stable coronary disease, or attendance at programs in higher-income countries were more likely to complete cardiac rehabilitation. Among individuals who completed the program, financial strain and employment status were associated with changes in depressive symptoms, with greater improvement among those reporting financial strain and smaller improvement among those employed full-time or part-time. No socioeconomic characteristic was associated with change in quality of life. These findings suggest that financial and occupational pressures may be associated with differences in the psychosocial burden of cardiac disease and with variation in recovery, supporting the need for delivery models of cardiac rehabilitation that offer greater flexibility, support, and adaptability to local socioeconomic contexts, which may differ from models developed in high-resource settings.

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SUPPLEMENTARY MATERIALS

Supplemental Table 1. Demographic, clinical characteristics, and attendance in supervised exercise sessions among cardiac rehabilitation participants who completed the program (n=2,190) by self-reported financial strain, age, educational attainment, and employment status

Variable	Level	Frequent financial strain n=233 n (%)	Occasional financial strain n=970 n (%)	No financial strain n=981 n (%)	p-value	Age ≤60 years n=1,143 n (%)	Age >60 years n=1,047 n (%)	p-value	Education ≤12 years n=930 n (%)	Education >12 years n=1,209 n (%)	p-value	Full-time or part-time n=864 n (%)	Disability or modified duties n=461 n (%)	Retired n=449 n (%)	Unemployed n=303 n (%)	Other employment n=93 n (%)	p-value
Age	≤60 years	138 (62)	493 (51)	498 (51)	0.007**				449 (48)	666 (55)	0.002**	600 (69)	294 (64)	68 (15)	117 (39)	47 (51)	<0.001***
Sex	Male	170 (76)	732 (76)	851 (87)	<0.001***	953 (83)	816 (78)	0.001**	702 (76)	1023 (85)	<0.001***	779 (90)	435 (94)	397 (88)	64 (21)	75 (81)	<0.001***
Educational attainment	≤12 years	137 (63)	419 (44)	374 (39)	<0.001***	449 (40)	481 (47)	0.002**				184 (34)	161 (35)	212 (48)	209 (70)	62 (99)	<0.001***
Employment status	Full-time or part-time	49 (5.7)	412 (48)	402 (47)	<0.001***	600 (69)	264 (31)	<0.001***	184 (34)	565 (67)	<0.001***						
	Disability or modified duties	66 (14)	159 (35)	236 (51)		294 (64)	167 (36)		161 (35)	295 (65)							
	Retired	38 (9.5)	201 (45)	210 (47)		68 (15)	381 (85)		212 (48)	229 (52)							
	Unemployed	44 (15)	155 (51)	104 (34)		117 (39)	186 (61)		209 (70)	89 (30)							
	Other	26 (28)	40 (43)	27 (29)		47 (51)	46 (50)		62 (99)	28 (31)							
Financial strain	Frequent					138 (12)	483 (8.1)	0.007**	137 (15)	82 (6.8)	<0.001***	49 (5.7)	66 (14)	38 (9.5)	44 (15)	26 (28)	<0.001***
	Occasional					493 (44)	477 (46)		419 (45)	541 (45)		412 (48)	159 (35)	201 (45)	155 (51)	40 (43)	
	No					498 (44.1)	483 (46.2)		374 (40)	586 (49)		402 (47)	236 (51)	210 (47)	104 (34)	27 (29)	
Out-of-pocket cost for heart medications	Yes	175 (79)	867 (90)	686 (70)	<0.001***	841 (75)	887 (85)	<0.001***	711 (77)	988 (82)	0.002**	639 (74)	347 (81)	351 (78)	275 (91)	86 (93)	<0.001***
Have health-related support	Definite	104 (47)	492 (51)	690 (71)	<0.001***	668 (59)	619 (59)	0.375	597 (64)	667 (55)	<0.001***	577 (67)	208 (45)	263 (59)	190 (63)	46 (50)	<0.001***

	Most of the time	64 (29)	365 (38)	198 (20)		320 (28)	307 (30)		217 (23)	403 (33)		228 (27)	167 (36)	117 (26)	82 (27)	31 (33)	
	Some of the time, rarely, or none	55 (25)	112 (12)	91 (9.3)		142 (13)	116 (11)		116 (12)	139 (11)		57 (6.6)	70 (18)	69 (15)	31 (10)	16 (17)	
Country income	Lower-middle-income	107 (48)	268 (28)	546 (56)	<0.001***	456 (40)	466 (46)	<0.001***	361 (39)	540 (45)	<0.001***	182 (21)	369 (80)	193 (43)	136 (45)	40 (43)	<0.001***
	Upper-middle-income	66 (30)	516 (53)	222 (23)		350 (31)	454 (43)		432 (46)	372 (31)		383 (44)	43 (9.3)	193 (43)	141 (47)	42 (42)	
	High-income	50 (22)	186 (19)	213 (22)		337 (30)	127 (12)		167 (18)	297 (25)		299 (35)	49 (11)	63 (14)	26 (6.6)	11 (12)	
Diagnosis at referral	Acute coronary syndrome	126 (60)	387 (46)	514 (56)	<0.001***	587 (56)	44 (48)	<0.001***	462 (55)	552 (50)	0.066*	358 (47)	282 (64)	216 (54)	109 (40)	58 (65)	<0.001***
	Stable coronary artery disease or stable angina	47 (23)	272 (32)	318 (34)	0.004**	303 (29)	344 (37)	<0.001***	245 (29)	376 (34)	0.012*	306 (40)	107 (24)	126 (31)	80 (29)	18 (20)	< 0.001***
	Heart failure	9 (4.3)	61 (7.3)	42 (4.5)	0.032**	49 (4.6)	64 (6.8)	0.035*	44 (5.2)	66 (6.0)	0.435	50 (6.5)	12 (2.7)	23 (5.7)	24 (8.8)	3 (3.4)	0.007**
	Other cardiac	27 (13)	120 (14)	50 (5.4)	<0.001***	115 (11)	83 (8.9)	0.131	95 (11)	101 (9.2)	0.146	54 (7.0)	38 (8.7)	36 (9.0)	59 (22)	10 (11)	<0.001***
Cardiac intervention at referral	Percutaneous coronary intervention	113 (53)	517 (57)	501 (55)	0.444	604 (61)	478 (50)	<0.001***	463 (53)	654 (58)	0.038*	561 (68)	195 (45)	219 (53)	107 (38)	45 (52)	< 0.001***
	Coronary artery bypass surgery	65 (30)	164 (18)	297 (32)	<0.001***	236 (22)	292 (30)	<0.001***	236 (27)	277 (24)	0.186	124 (15)	188 (44)	123 (30)	63 (23)	28 (32)	<0.001***
	Valve surgery	16 (7.4)	4 (5.3)	35 (3.8)	0.061*	56 (5.1)	43 (4.5)	0.486	51 (5.8)	46 (4.1)	0.065*	25 (3)	21 (4.9)	17 (4.1)	29 (10)	7 (8.0)	<0.001***
	Rhythm device	2 (0.9)	17 (1.9)	8 (0.9)	0.205	12 (1.1)	16 (1.7)	0.271	18 (2.1)	9 (0.8)	0.015	4 (0.5)	3 (0.7)	9 (2.2)	11 (3.9)	0 (0.0)	<0.001***
	Ablation	0 (0.0)	2 (0.2)	1 (0.1)	0.730	2 (0.2)	1 (0.1)	1.000	2 (0.2)	1 (0.1)	0.583	1 (0.1)	0 (0.0)	0 (0.0)	2 (0.7)	0 (0.0)	0.226
	Heart Transplant	0 (0.0)	2 (0.2)	5 (0.5)	0.453	5 (0.5)	2 (0.2)	0.459	2 (0.2)	4 (0.4)	0.703	0 (0.0)	4 (0.9)	0 (0.0)	2 (0.7)	1 (1.1)	0.007**
	Mechanical Circulatory Support	0 (0.0)	0 (0)	1 (0.1)	1.000	0 (0.0)	1 (0.1)	0.468	0 (0.0)	1 (0.1)	1.000	0 (0.0)	1 (0.2)	0 (0.0)	0 (0.0)	0 (0.0)	0.597

	Other procedures	7 (3.3)	32 (3.5)	37 (4.0)	0.813	44 (4.0)	32 (3.3)	0.450	26 (3.0)	49 (4.3)	0.116	31 (3.8)	15 (3.5)	14 (3.4)	12 (4.3)	4 (4.6)	0.926
Body mass index category	Underweight	4 (1.8)	13 (1.4)	9 (0.9)	0.593	18 (1.6)	8 (0.8)	0.002**	15 (1.6)	11 (0.9)	0.076*	7 (0.8)	8 (1.7)	2 (0.5)	8 (2.7)	1 (1.1)	<0.001***
	Healthy	77 (35)	304 (32)	337 (35)		349 (31)	373 (36)		297 (32)	409 (34)		269 (32)	185 (40)	169 (38)	66 (22)	30 (32)	
	Overweight	90 (41)	43 (45)	407 (42)		486 (43)	450 (44)		383 (42)	526 (44)		387 (45)	179 (39)	196 (45)	123 (41)	39 (42)	
	Obese	49 (22)	214 (22)	214 (22)		280 (25)	200 (19)		226 (24)	247 (21)		192 (23)	86 (19)	73 (17)	103 (34)	23 (25)	
Systolic blood pressure (mmHg)	Mean (SD)	120 (20)	120 (22)	121 (21)	<0.001***	120 (20)	120 (20)	0.002**	120 (20)	120 (20)	<0.001***	120 (21)	120 (19.5)	120 (21)	120 (19)	120 (20)	Overall=0.001** Fulltime vs retired=0.004** Disability vs retired=0.006**
Diastolic blood pressure (mmHg)	Mean (SD)	72 (14)	70 (18)	70 (14)	0.006 Not at all & sometimes =0.004**	73 (13)	70 (16)	<0.001***	72(14)	70 (16)	<0.001***	74 (15)	70 (15)	70 (16)	70 (17)	74 (11)	Overall=0.001** Fulltime vs disability= 0.034* Fulltime vs unemployed=0.010*
Functional capacity (METs)	Median (IQR)	4.2 (4.7)	4.5 (4.1)	3.3 (4.6)	<0.001*** Not at all & sometimes <0.001***	5.2 (5.1)	3.63 (3.5)	<0.001***	4 (4.3)	4.3(4.8)	0.067*	6.7 (4.3)	2.6 (0.93)	3.9 (3.84)	3.3 (1.9)	5.5 (5.6)	<0.001***
Comorbidity	Stroke	2 (1.8)	4 (0.8)	7 (1.0)	0.478	9 (1.1)	4 (0.8)	0.487	6 (1.1)	6 (0.8)	0.661	6 (1.0)	2 (0.7)	1 (0.5)	1 (0.6)	3 (5.6)	0.069*
	Vascular disease	0 (0.0)	3 (0.6)	3 (0.4)	1.000	5 (0.6)	1 (0.2)	0.411	2 (0.4)	4 (0.6)	0.701	3 (0.5)	0 (0.0)	2 (0.9)	1 (0.6)	0 (0.0)	0.513
	Diabetes	30 (27)	79 (15)	153 (23)	<0.001***	150 (19)	112 (21)	0.341	98 (17)	154 (21)	0.083*	113 (19)	74 (25)	39 (18)	28 (18)	8 (15)	0.133
	Liver disease	0 (0.0)	3 (0.6)	4 (0.6)	1.000	4 (0.5)	3 (0.6)	1.000	3 (0.5)	4 (0.6)	1.000	3 (0.5)	1 (0.3)	2 (0.9)	0 (0.0)	1 (1.9)	0.392
	Kidney disease	2 (1.8)	3 (0.6)	7 (1.0)	0.313	5 (0.6)	7 (1.3)	0.241	4 (0.7)	8 (1.1)	0.465	7 (1.2)	0 (0.0)	3 (1.4)	0 (0.0)	2 (3.7)	0.032*
	Lung disease	1 (0.9)	6 (1.1)	10 (1.5)	0.869	5 (0.6)	12 (2.3)	0.010*	10 (1.8)	6 (0.8)	0.128	8 (1.4)	0 (0.0)	6 (2.8)	3 (1.9)	0 (0.0)	0.011*

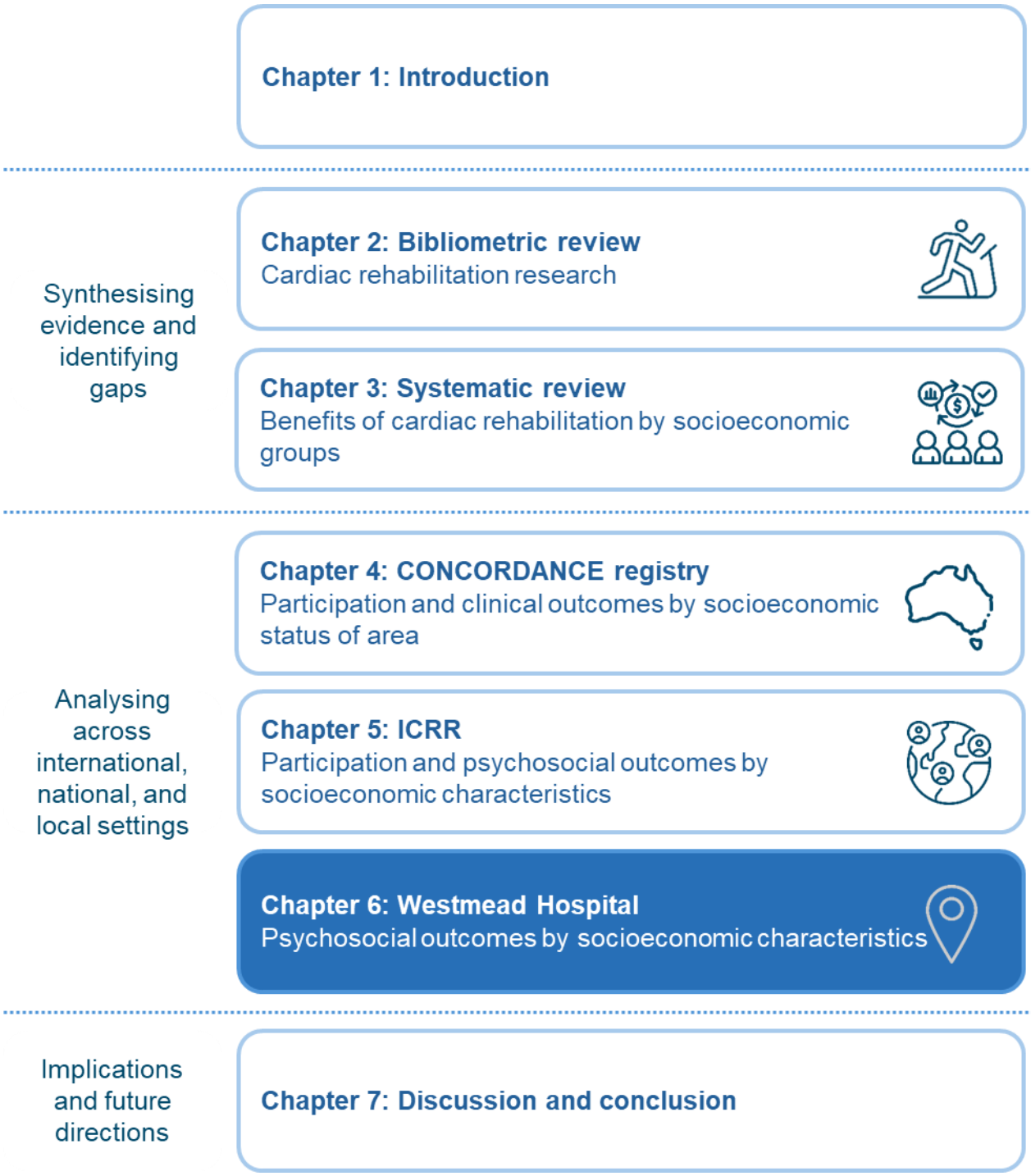
	Musculoskeletal issues	4 (3.5)	16 (3.0)	27 (4.0)	0.658	25 (3.1)	22 (4.2)	0.344	23 (4.1)	24 (3.3)	0.466	19 (3.2)	8 (2.7)	11 (5.1)	8 (5.1)	1 (1.9)	
	Cancer	1 (0.9)	4 (0.8)	3 (0.4)	0.638	2 (0.3)	6 (1.1)	0.097*	3 (0.5)	5 (0.7)	1.000	3 (0.5)	1 (0.3)	3 (1.4)	1 (0.6)	0 (0.0)	0.621
	Human immunodeficiency virus	0 (0.0)	1 (0.2)	0 (0.0)	0.491	1 (0.1)	0 (0.0)	1.000	1 (0.2)	0 (0.0)	0.438	0 (0.0)	1 (0.3)	0 (0.0)	0 (0.0)	0 (0.0)	0.551
	Movement disorder	0 (0.0)	1 (0.2)	2 (0.3)	1.000	1 (0.1)	2 (0.4)	0.566	1 (0.2)	2 (0.3)	1.000	2 (0.3)	0 (0.0)	1 (0.5)	0 (0.0)	0 (0.0)	0.764
	Osteoporosis	1 (0.9)	1 (0.2)	3 (0.4)	0.366	1 (0.1)	4 (0.8)	0.164	3 (0.5)	2 (0.3)	0.659	0 (0.0)	1 (0.3)	4 (1.8)	0 (0.0)	0 (0.0)	0.039*
	Sexual issues	2 (1.8)	1 (0.2)	1 (0.1)	0.039*	3 (0.4)	1 (0.2)	0.653	3 (0.5)	1 (0.1)	0.324	2 (0.3)	1 (0.3)	1 (0.5)	0 (0.0)	0 (0.0)	1.000
	Other	26 (23)	220 (41)	181 (27)	<0.001***	220 (28)	207 (28)	<0.001***	203 (36)	220 (30)	0.032*	137 (23)	101 (34)	102 (47)	72 (46)	14 (26)	<0.001***
	None	44 (39)	189 (36)	267 (40)	0.295	354 (45)	146 (28)	<0.001***	204 (36)	289 (40)	0.176	285 (49)	104 (35)	42 (19)	43 (27)	25 (46)	1.000
Supervised exercise session completed	Median (IQR)	17 (10)	18 (24)	15 (6)	<0.001***	17 (10)	17 (17)	0.001**	17 (18)	17 (9.0)	0.003**	12 (7)	17(5)	17 (18)	17 (24)	12 (I4)	Overall<0.001*** Fulltime vs retired<0.001*** Retired vs unemployed<0.002** Retired vs unemployed=0.002** Retired vs other=0.029**

*significant at p<0.1, **significant at p<0.01, ***significant at p<0.001

Abbreviations: mmHg, millimeters of millimeters of mercury; SD, standard deviation; METs, metabolic equivalent of tasks; IQR, interquartile range.

CHAPTER 6

Psychosocial outcomes after cardiac rehabilitation by socioeconomic characteristics: Analysis of the local Westmead Hospital data



This chapter presents a quantitative analysis of the cardiac rehabilitation program at Westmead Hospital on whether country of birth, employment status, socioeconomic status of area of residence, and remoteness of area of residence are associated with change in health-related quality of life (measured using 36-Item Short Form Health Survey [SF-36]). It builds on Chapter 5 by providing real-world evidence from a culturally and socioeconomically diverse setting in Western Sydney, New South Wales, Australia.

A total of 4,918 individuals who completed pre- and post-program assessments were included. All SF-36 health-related quality of life domains improved overall. However, improvements in several domains were more modest among individuals born overseas, those who were unemployed, retired or on a pension, and those residing in inner or outer regional areas. These findings shape the subsequent Discussion of this thesis.

> **Aim Addressed:** This chapter addresses **Aim 5** – to assess whether socioeconomic characteristics are associated with cardiac rehabilitation psychosocial outcome.

This work, titled *"Differences in post-cardiac rehabilitation quality of life in Western Sydney by country of birth, employment status, socioeconomic status of area of residence, and remoteness of area of residence"*, is currently under review by *Heart, Lung and Circulation*.

PUBLICATION

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STATEMENT OF AUTHORSHIP

Deborah Manandi led the conceptualisation, methodology, formal analysis, and writing – original draft. The roles of co-authors are as follows:

Task	**Role of co-authors**
Conceptualisation	MH, RZ, KH
Methodology	MH, JR, RZ, KH
Formal analysis	KH
Writing – reviewing & editing	MH, JR, QT, NH, RZ, KH

ABSTRACT

Introduction: Cardiac rehabilitation improves recovery after cardiovascular events, but changes in health-related quality of life (HRQoL) may differ by socioeconomic subgroups. This study investigated whether changes in HRQoL differed by country of birth, employment status, socioeconomic status of area of residence, and remoteness.

Methods: Data were analysed from individuals who completed pre- and post-program assessments at a publicly funded cardiac rehabilitation program in Western Sydney, Australia. Changes in domain scores of the 36-Item Short Form Health Survey (SF-36) were assessed using multivariable linear regression with robust standard errors. False discovery rate (FDR) correction was applied across nine models for each socioeconomic characteristic.

Results: Of 11,695 individuals referred (mean age=61 years, Standard Deviation [SD]=12; 78% male), 6,461 (55%) completed the program and 4,918 (42%) completed both HRQoL assessments (mean age=61 years, SD=11; 80% male). Being born overseas (versus Australia) was associated with more modest improvement in *Health Transition*. Being retired or unemployed (versus employed) was associated with more modest improvement across *Physical Functioning*, *Role Physical*, *Bodily Pain*, *General Health*, *Vitality*, *Social Functioning*, *Role Emotional*, and *Mental Health*. Socioeconomic status of area was not associated with differences in change. Residing in inner or outer regional areas (versus major cities) was associated with more modest improvement in *Role Physical*, while residing in remote or very remote areas with *Role Physical* and *Role Emotional*.

Conclusion: HRQoL improved across all domains, but improvements were more modest among individuals born overseas, unemployed or retired, and those residing in regional or remote areas. Programs may need to strengthen culturally adapted resources and extend flexible delivery to support more equitable recovery.

INTRODUCTION

Cardiac rehabilitation is a comprehensive, multidisciplinary intervention that forms the foundation of long-term care after a cardiovascular event. It supports recovery, reduces recurrence, and promotes wellbeing.[1-5] Programs typically begin with physical and psychosocial assessments, followed by structured exercise, education, and counselling tailored to individual needs, and conclude with repeat assessments to evaluate progress.[6-9] Despite strong clinical evidence and endorsement in international guidelines, program completion remains suboptimal, and the extent of benefit varies across individuals and subgroups.[6-9]

Health-related quality of life is recognized as a key outcome of cardiac rehabilitation, with sustained improvements reported up to six years post-program and early evidence of associations with reduced hospital admission and cardiovascular-related death.[10-14] It encompasses capacity to perform daily tasks and roles, physical discomfort, perceptions of health, energy, social participation, and emotional wellbeing.[15-17] These domains broadly reflect physical and mental components of health, corresponding to the Physical Component Summary (PCS) and Mental Component Summary (MCS) of the 36-Item Short Form Health Survey (SF-36).[15-17] Improvements in some domains have been observed following exercise-based cardiac rehabilitation, including median increases of 5.1 points (95% Confidence Interval [CI]=1.0, 9.1) in general health at six months and 9.8 points (95% CI=1.5, 18.2) in physical functioning at twelve months, as measured using the SF-36.[11] Physical health domains tend to improve more consistently than mental health domains, particularly in comprehensive programs.[18] A recent systematic review using the 12-Item Short Form Health Survey (SF-12) reported a pooled improvement of 7.0 points (p=0.040) in the physical component summary score at six months, compared to 1.1 points (p=0.820) in the mental component summary.[18] However, improvements across domains remain variable and uncertain for comprehensive programs.[19]

Emerging evidence suggests that clinical outcomes following cardiac rehabilitation can differ across socioeconomic characteristics. Past cohort studies have reported differences in hospital readmission and death even among individuals completing the same cardiac rehabilitation program, although findings have not been consistent across settings.[2,20,21] These findings

suggest that recovery may not be experienced in the same way across socioeconomic subgroups, and similar differences may be reflected in health-related quality of life. As a patient-reported outcome, health-related quality of life reflects cultural and social perceptions, and may therefore differ across socioeconomic subgroups.[22] Socioeconomic disparities in quality of life have also been reported in broader populations. Individuals born overseas, compared with those born in Australia, may experience better outcomes in some respects but poorer outcomes in others, with findings varying across outcome measures.[23,24] Such differences may further vary by country of birth, and by income or education level, with lower income or lower educational attainment consistently associated with poorer quality of life.[23,25] In addition, residing in more socioeconomically disadvantaged or more remote areas has been associated with poorer outcomes and more limited access to specialised healthcare, independent of individual socioeconomic characteristics.[26,27] Together, these patterns suggest that health-related quality of life after cardiac rehabilitation may not improve equally across all individuals, particularly those with different socioeconomic characteristics.[28]

In Australia, Western Sydney is one of the most culturally and socioeconomically diverse regions, with a population of approximately 1.08 million individuals in 2025.[29] Compared with the New South Wales average, a greater proportion of the population was born overseas (48% vs. 35%), speaks a language other than English at home (54% vs. 27%), and was unemployed (7.2% vs. 6.3%).[30] These proportions were also higher than national averages, where 31% of the population was born overseas, 23% spoke a language other than English at home, and 4.2% were unemployed.[31-33] These characteristics highlight the importance of understanding how individuals experience recovery and improve health-related quality of life through cardiac rehabilitation. Therefore, this study aimed to investigate whether changes in each domain of health-related quality of life differ by country of birth, employment status, socioeconomic status of area of residence, and remoteness of area of residence.

METHODS

This study used routinely collected data from individuals who presented to the publicly funded cardiac rehabilitation program at Westmead Hospital, a tertiary referral centre in Western Sydney, Australia, between 1993 and 2024. The program included a minimum of five structured outpatient exercise training and education sessions focused on lifestyle and behavioural changes, delivered by a multidisciplinary team, generally over a two-week period. Health-related quality of life was assessed routinely from 1995 onwards. Individuals were referred following an acute cardiac event, a diagnosis of coronary heart disease, or a cardiac surgical intervention, with primary diagnoses recorded as free-text descriptors at referral. Ethical approval to analyse the deidentified data was granted by the New South Wales Health Research Ethics and Governance Information System (2022/ETH01373). Individuals were included if they completed both pre-program and post-program health-related quality of life assessments. Measurements recorded as 'unknown' were treated as missing.

The program collected characteristics at pre- and post-program. Pre-program sociodemographic characteristics included age, sex, marital status, country of birth, ethnicity, employment status, socioeconomic status of area of residence, and remoteness. Socioeconomic status of area of residence was assigned using individual's residential postcode and categorised according to the Index of Relative Socioeconomic Advantage and Disadvantage (IRSAD) quintiles from the closest census year (2006, 2011, or 2016).[34] Remoteness of area of residence was assigned using postcode and categorised according to the Accessibility/Remoteness Index of Australia.[35] Pre-program clinical characteristics included body mass index, resting heart rate, blood pressure, hypertension, hypercholesterolemia, diabetes, and smoking status. Additional characteristics included alcohol consumption, lifestyle behaviours measured as binary classification of active or sedentary based on self-reported physical activity, health-related quality of life, and program access such as number of wait days from referral to pre-program assessment, number and type of education sessions, and year of assessment. Post-program characteristics included health-related quality of life.

Health-related quality of life was assessed using the SF-36 Version 1.0 (Australia/New Zealand Acute, English only), scored from 0 to 100 across nine domains. Domains contributing primarily to the PCS include *Physical Functioning* reflecting capacity to carry out daily physical tasks; *Role Physical* reflecting capacity to perform daily roles related to physical health; *Bodily Pain* reflecting physical discomfort; and *General Health* reflecting perceptions of overall health.[15-17] Domains contributing primarily to the MCS include *Vitality* reflecting energy levels; *Social Functioning* reflecting participation in social activities influenced by physical or emotional health; *Role Emotional* reflecting capacity to perform daily roles related to emotional health; and *Mental Health* reflecting emotional wellbeing.[15-17] *Health Transition* reflects perceptions of recent health status.[15-17]

Although *Health Transition* is an additional domain to the core SF-36 domains, it was included in this study as it reflects how individuals felt their health had changed, which is relevant to the program's focus on supporting recovery. Higher scores reflect better health-related quality of life. Outcomes of interest were changes in domain scores, calculated as post-program minus pre-program scores, with positive values reflecting improvement.

Statistical Analyses

Baseline characteristics were stratified by socioeconomic characteristics: country of birth, employment status, socioeconomic status of area of residence, and remoteness of area of residence. Country of birth was categorized as Australia versus overseas. Employment status was categorized as employed versus retired or unemployed versus pensioner. Socioeconomic status of area of residence was categorised as IRSAD 5 (most advantaged) versus IRSAD 4 versus IRSAD 3 versus IRSAD 2 versus IRSAD 1 (most disadvantaged).[34] Remoteness of area of residence was categorised as major cities versus inner or outer regional versus remote or very remote.[35] Categories coded as Overseas/Unknown for remoteness of area of residence (n=4) were excluded from analyses involving this variable. Continuous variables were reported as means and standard deviations when normally distributed, or as medians and interquartile intervals (IQIs) when not normally distributed. Independent t-test was used when comparing normally distributed variables between two categories, and analysis of variance (ANOVA) was used for three categories. For skewed variables, Wilcoxon rank-sum test and Kruskal-Wallis tests were used. Categorical variables were reported as counts and

percentages and compared using Chi-squared tests or Fisher's exact tests when any cell values were fewer than five.

Pre-program, post-program, and change scores for each SF-36 domain were stratified by the socioeconomic characteristics: country of birth (Australia vs. Overseas), employment status (Employed vs. Retired or unemployed vs. Pensioner), socioeconomic status of area of residence (IRSAD 5 vs. IRSAD 4 vs. IRSAD 3 vs. IRSAD 2 vs. IRSAD 1), and remoteness of area of residence (Major cities vs. Inner or outer regional vs. Remote or very remote). Domain scores were reported as medians and IQIs given skewed distributions assessed visually and statistically.

Associations between each socioeconomic characteristic and changes in domain-specific health-related quality of life scores were assessed using nine separate multivariable linear regression (one per SF-36 domain), with robust standard errors estimated using the Heteroskedasticity-Consistent 1 (HC1) method for all models. Each model adjusted for the corresponding pre-program domain score, country of birth, employment status, socioeconomic status of area of residence, remoteness of area of residence, age, sex, body mass index, hypertension, diabetes, smoking status, alcohol consumption, lifestyle behaviours, and year of assessment. These covariates were selected based on clinical relevance to cardiac rehabilitation outcomes and statistical significance ($p<0.05$) in univariable analyses. A positive beta coefficient (β) reflects greater improvement compared to the reference group, while a negative β reflects more modest improvement, after adjusting for covariates. One high-leverage observation was identified during model diagnostics for all nine models, and a sensitivity analysis was conducted with this individual excluded. To account for multiple testing across domains for socioeconomic characteristics only, p-values for each socioeconomic characteristic (country of birth, employment status, socioeconomic status of area of residence, and remoteness of area of residence) were adjusted separately across the nine domain models using the Benjamini-Hochberg method to control for the false discovery rate (FDR). Unadjusted p-values are reported for all covariates. Both unadjusted and FDR-adjusted p-values were reported for socioeconomic characteristics. An FDR-adjusted p-value <0.05 was considered statistically significant for socioeconomic characteristics. All analyses were conducted using RStudio version 2025.05.1+513.

RESULTS

A total of 11,695 individuals presented to the cardiac rehabilitation program at Westmead Hospital in Western Sydney. The mean age was 61 (SD=12), and 9,077 (78%) were male. Of these, 6,461 (55%) individuals completed the program, and 4,918 (42%) completed both pre- and post-program health-related quality of life assessments. Among individuals who completed both assessments, the mean age was 61 (SD=11), and 4,114 (80%) were male. All subsequent analyses were conducted among individuals who completed both assessments.

Pre-program characteristics differed significantly across socioeconomic characteristics (Table 1). Compared to individuals born in Australia, those born overseas were more likely to be male, married, report no or rare alcohol consumption, and less likely to have obesity or diabetes (all unadjusted $p \leq 0.0001$). The most common ethnic backgrounds among individuals born overseas were South or Central Asian (34%), European (34%), and Middle Eastern and North African (12%). Compared to individuals who were employed, those who were retired or unemployed were more likely to be female, older, and have higher rates of hypertension, diabetes, and sedentary lifestyle (all $p<0.0001$). Compared to individuals residing in the most advantaged areas, those in the most disadvantaged areas were more likely to be pensioners and report sedentary lifestyle, hypertension, and diabetes (all unadjusted $p \leq 0.0001$). Compared to individuals residing in major cities, those in remote or very remote areas were more likely to identify as Aboriginal and/or Torres Strait Islander and report hypercholesterolemia ($p \leq 0.0390$). Other characteristics examined did not differ significantly across remoteness of area categories.

Table 1. Baseline characteristics by country of birth, employment status, socioeconomic status of area of residence, and remoteness of area of residence

Variable	Level	Australia n (%) n=2,009	Overseas n (%) n=2,909	p-value	Employed n (%) n=2,278	Retired /Unemployed n (%) n=312	Pensioner n (%) n=1,589	p-value	IRSAD 5 (Most advantaged) n (%) n=1,392	IRSAD 4 n (%) n=1,493	IRSAD 3 n (%) n=683	IRSAD 2 n (%) n=131	IRSAD 1 (Most disadvantaged) n (%) n=513	p-value	Major cities n (%) n=564	Inner/ Outer regional n (%) n=658	Remote/Very remote n (%) n=132	p-value
Sociodemographic characteristics																		
Age	Median (IQI)	62 (55, 70)	61 (52, 68)	<0.0001***	56 (48, 62)	58 (51, 63)	70 (66, 75)	<0.0001***	62 (53, 69)	62 (54, 70)	61 (52, 68)	59 (50, 67)	61 (53, 69)	0.0024**	63 (53, 71)	61 (52, 70)	63 (56, 69)	0.2676
Sex	Male	1,549 (77)	2,402 (83)	<0.0001***	1,981 (87)	185 (59)	1,205 (76)	<0.0001***	1,147 (82)	1,154 (77)	564 (83)	106 (81)	406 (79)	0.0047**	439 (78)	529 (80)	104 (79)	0.5438
Marital status	Married	1,387 (69)	2,343 (81)	<0.0001***	1,775 (78)	172 (55)	1,196 (75)	<0.0001***	1,155 (83)	1,090 (73)	482 (71)	91 (70)	355 (69)	<0.0001***	423 (75)	486 (74)	99 (75)	0.3048
	Partner	72 (3.6)	67 (2.3)		92 (4.0)	7 (2.3)	25 (1.6)		33 (2.4)	51 (3.4)	23 (3.4)	3 (2.3)	15 (2.9)		19 (3.4)	18 (2.7)	7 (5.3)	
	Single	188 (9.4)	138 (4.7)		165 (7.2)	51 (16)	66 (4.2)		52 (3.7)	105 (7.0)	68 (10)	13 (9.9)	52 (10)		44 (7.8)	39 (5.9)	5 (3.8)	
	Divorced	208 (10)	196 (6.7)		188 (8.3)	56 (18)	115 (7.2)		95 (6.8)	125 (8.4)	65 (9.5)	14 (11)	56 (11)		48 (8.5)	63 (9.6)	10 (7.6)	
	Widowed	154 (7.7)	163 (5.6)		58 (8.3)	25 (8.0)	187 (12)		57 (4.1)	122 (8.2)	45 (6.6)	10 (7.6)	34 (6.6)		30 (5.3)	51 (7.8)	11 (8.3)	
Country of birth	Australia				1,013 (45)	143 (46)	824 (52)	<0.0001***	623 (45)	611 (41)	283 (41)	52 (40)	206 (40)	0.1918	226 (40)	276 (42)	50 (38)	0.6227
	Overseas				1,265 (56)	169 (54)	765 (48)		769 (55)	882 (59)	400 (59)	79 (60)	307 (60)		338 (60)	382 (58)	82 (62)	
Ethnicity	Australian (non-Indigenous)	1,799 (90)	0 (0.0)	0.0005***	861 (38)	119 (38)	793 (50)	0.0005***	576 (46)	533 (43)	250 (41)	43 (45)	175 (35)	<0.0001***	185 (33)	228 (35)	44 (33)	0.0390*
	Aboriginal and Torres Strait Islander Peoples	18 (0.9)	47 (2.1)		37 (1.6)	7 (2.2)	19 (1.2)		12 (1.0)	24 (1.8)	14 (2.3)	1 (1.1)	8 (1.6)		8 (1.4)	10 (1.5)	8 (6.1)	
	Oceania/Pacific	1 (0.0)	47 (2.1)		27 (1.2)	7 (2.2)	14 (0.9)		3 (0.2)	19 (1.4)	9 (1.5)	0 (0.0)	13 (2.6)		6 (1.1)	12 (1.8)	1 (0.8)	
	South and	5 (0.2)	757 (34)		529 (23)	49 (16)	172 (11)		233 (19)	299 (23)	111 (18)	9 (9.5)	53 (11)		146 (26)	160 (24)	28 (21)	

	Central Asia																	
	Southeast Asia	5 (0.2)	167 (7.5)			11 (3.5)	43 (2.7)		45 (3.6)	52 (3.9)	22 (3.6)	5 (5.3)	29 (5.8)		27 (4.8)	27 (4.1)	5 (3.8)	
	East Asia	8 (0.4)	121 (5.4)		86 (3.8)	6 (1.9)	37 (2.3)		59 (4.7)	30 (2.3)	16 (2.6)	0 (0.0)	15 (3.0)		31 (5.5)	17 (2.6)	2 (1.5)	
	Middle East and North Africa	42 (2.1)	265 (12)		169 (7.4)	38 (12)	98 (6.2)		57 (4.6)	80 (6.1)	41 (6.6)	7 (7.4)	90 (18)		44 (7.8)	63 (9.6)	12 (9.1)	
	Sub-Saharan Africa	0 (0.0)	18 (0.8)		12 (0.5)	3 (1.0)	3 (0.2)		6 (0.5)	6 (0.5)	1 (0.2)	0 (0.0)	4 (0.8)		3 (0.5)	4 (0.6)	0 (0.0)	
	Europe	127 (6.3)	763 (34)		411 (18)	69 (22)	394 (25)		245 (20)	272 (21)	142 (23)	28 (30)	103 (21)		106 (19)	131 (20)	31 (24)	
	Latin America	3 (0.1)	33 (1.5)		20 (0.9)	1 (0.3)	13 (0.8)		9 (0.7)	3 (0.2)	9 (1.5)	2 (2.1)	9 (1.8)		5 (0.9)	5 (0.8)	1 (0.8)	
	North America	1 (0.0)	14 (0.6)		10 (0.4)	2 (0.6)	3 (0.2)		7 (0.6)	4 (0.3)	2 (0.3)	0 (0.0)	0 (0.0)		3 (0.5)	1 (0.2)	0 (0.0)	
Employment status	Employed	1,013 (51)	1,265 (58)	<0.0001***					721 (59)	679 (52)	332 (55)	60 (63)	246 (50)	<0.0001***	319 (57)	351 (54)	70 (53)	0.4192
	Retired/ Unemployed	143 (7.2)	169 (7.7)						59 (4.8)	109 (8.3)	49 (8.2)	5 (5.3)	71 (15)		43 (7.7)	63 (9.6)	8 (6.1)	
	Pensioner	824 (42)	765 (35)						449 (37)	523 (40)	220 (37)	30 (32)	173 (35)		199 (36)	240 (37)	54 (41)	
Socioeconomic status	IRSAD 5 (Most advantaged)	623 (35)	769 (32)	0.1918	721 (35)	59 (20)	449 (32)	<0.0001***							166 (30)	190 (30)	38 (29)	<0.0001***
	IRSAD 4	611 (34)	882 (36)		679 (33)	109 (37)	523 (38)								245 (44)	256 (40)	50 (39)	
	IRSAD 3	283 (16)	400 (16)		332 (16)	49 (17)	220 (16)								65 (12)	78 (12)	15 (12)	
	IRSAD 2	52 (2.9)	79 (3.2)		60 (2.9)	5 (1.7)	30 (2.2)								11 (2.0)	11 (1.7)	1 (0.8)	
	IRSAD 1 (Most disadvantaged)	206 (12)	307 (13)		246 (12)	71 (24)	173 (12)								73 (13)	109 (17)	25 (19)	
Remoteness	Major cities	226 (41)	338 (42)	0.6227	319 (43)	43 (38)	199 (40)	0.4192	166 (42)	245 (45)	65 (41)	11 (48)	73 (35)	<0.0001***				
	Inner/Outer	276 (5)	382 (48)		351 (47)	63 (55)	240 (49)		190 (48)	256 (47)	78 (49)	11 (48)	109 (53)					

	regional																	
	Remote/Very remote	50 (9.1)	82 (10)		70 (9.5)	8 (7.0)	54 (11)		38 (9.6)	50 (9.1)	15 (9.5)	1 (4.3)	25 (12)					
Clinical characteristics																		
Body mass index category	Underweight	10 (0.5)	9 (0.3)	<0.0001***	9 (0.4)	2 (0.6)	5 (0.3)	<0.0001***	6 (0.4)	4 (0.3)	1 (0.1)	4 (3.1)	2 (0.4)	<0.0001***	3 (0.5)	2 (0.3)	2 (1.5)	0.0040**
	Healthy	420 (21)	833 (29)		567 (25)	79 (25)	393 (25)		391 (28)	403 (27)	151 (22)	28 (21)	108 (21)		161 (29)	167 (25)	31 (24)	
	Overweight	846 (42)	1,331 (46)		1,061 (47)	101 (32)	673 (42)		647 (47)	622 (42)	305 (45)	64 (49)	208 (41)		208 (37)	304 (46)	49 (37)	
	Obese	731 (36)	736 (25)		641 (28)	130 (42)	516 (33)		348 (25)	462 (31)	226 (33)	35 (27)	195 (38)		192 (34)	185 (28)	50 (38)	
Resting heart rate	Median (IQI)	72 (63, 82)	72 (63, 83)	0.6468	71 (63, 81)	74 (65, 82)	71 (62, 82)	0.0768	70 (62, 81)	73 (64, 83)	72 (63, 83)	76 (67, 85)	72 (64, 80)	<0.0001***	70 (62, 80)	71 (63, 80)	69 (63, 81)	0.6053
Resting systolic blood pressure (mmHg)	Median (IQI)	117 (105, 130)	116 (105, 130)	0.4111	110 (100, 120)	110 (100, 125)	120 (110, 130)	<0.0001***	115 (105, 128)	118 (105, 130)	115 (104, 130)	115 (105, 125)	115 (105, 125)	0.3914	118 (105, 126)	112 (102, 125)	115 (105, 130)	0.0455*
Resting diastolic blood pressure (mmHg)	Median (IQI)	70 (60, 80)	70 (63, 80)	0.0020**	70 (60, 80)	70 (60, 75)	70 (60, 80)	0.0030***	70 (60, 80)	70 (60, 80)	70 (60, 80)	70 (65, 80)	70 (60, 80)	0.0415*	70 (60, 80)	70 (60, 78)	70 (60, 80)	0.3127
Hypertension	Yes	1,150 (57)	1,636 (56)	<0.0001***	1,133 (50)	167 (54)	1,100 (69)	<0.0001***	775 (56)	871 (58)	388 (57)	68 (52)	303 (59)	<0.0001***	321 (57)	369 (56)	88 (67)	0.0758
Hypercholesterolemia	Yes	1,799 (90)	2,599 (90)	<0.0001***	2,062 (91)	266 (85)	1,471 (93)	0.0015**	1,258 (91)	1,348 (91)	611 (90)	111 (85)	470 (92)	<0.0001***	510 (90)	598 (91)	130 (99)	0.0027**
Diabetes	Yes	405 (20)	817 (28)	<0.0001***	526 (23)	97 (31)	473 (30)	<0.0001***	309 (22)	423 (28)	171 (25)	32 (24)	131 (26)	<0.0001***	163 (29)	189 (29)	36 (27)	0.9317
Smoking status	Yes	378 (19)	525 (18)	0.8068	506 (22)	89 (29)	141 (8.9)	<0.0001***	197 (14)	274 (18)	157 (23)	30 (23)	116 (23)	<0.0001***	85 (15)	113 (17)	28 (21)	0.3558
	Ex-smoker	669 (33)	973 (33)		628 (28)	80 (26)	624 (39)		438 (32)	483 (32)	221 (32)	49 (37)	165 (32)		163 (29)	184 (28)	42 (32)	
	No	954 (48)	1,401 (48)		1,133 (50)	142 (46)	818 (52)		753 (54)	732 (49)	305 (45)	51 (39)	229 (45)		316 (56)	360 (55)	62 (47)	

Alcohol consumption	Nil or rare	702 (36)	1,278 (45)	<0.0001***	885 (39)	185 (60)	678 (43)	<0.0001***	510 (38)	668 (45)	286 (42)	46 (37)	251 (49)	0.0002***	277 (49)	302 (46)	61 (46)	0.6697
	Occasional and social	1,038 (53)	1,300 (46)		1,177 (52)	99 (32)	750 (48)		701 (52)	666 (45)	326 (48)	60 (49)	212 (41)		247 (44)	307 (47)	58 (44)	
	Light to moderate regularly	40 (2.0)	111 (3.9)		24 (1.1)	2 (0.7)	42 (2.7)		40 (2.9)	46 (3.1)	13 (1.9)	6 (4.9)	8 (1.6)		5 (0.9)	7 (1.1)	3 (2.3)	
	Heavy or binge	197 (10)	156 (5.5)		159 (7.1)	21 (6.8)	98 (6.2)		109 (8.0)	95 (6.4)	50 (7.4)	11 (8.9)	41 (8.0)		34 (6.0)	40 (6.1)	10 (7.6)	
Lifestyle behaviors	Active	1,020 (51)	1,505 (52)	0.5247	1,194 (52)	115 (37)	841 (53)	<0.0001***	756 (54)	730 (49)	338 (50)	69 (53)	231 (45)	0.0027**	269 (48)	326 (50)	65 (49)	0.8065
	Sedentary	989 (49)	1,404 (48)		1,084 (48)	197 (63)	748 (47)		636 (46)	763 (51)	345 (51)	62 (47)	282 (55)		295 (52)	332 (51)	67 (51)	
Program access characteristics																		
Wait days (from discharge or referral to pre-program assessment)	Median (IQI)	18 (12, 27)	18 (11, 25)	0.1274	16 (10, 22)	19 (12, 27)	21 (14, 29)	<0.0001***	17 (12, 26)	18 (12, 26)	17 (11, 24)	18 (13, 23)	19 (12, 26)	0.6851	18 (11, 28)	17 (11, 25)	19 (17, 27)	0.0339*
Number of education session participated in	Median (IQI)	8 (5, 12)	8 (5, 13)	0.1086	7 (5, 11)	7 (5, 11)	8 (5, 12)	<0.0001***	7 (5, 12)	8 (5, 12)	7 (5, 12)	8 (6, 13)	7 (5, 11)	0.0095**	6 (5, 10)	7 (5, 10)	7 (5, 10)	0.6484
Type of education session participated in	All groups and all talks	140 (7.1%)	161 (5.6%)	0.0001***	160 (7.1%)	27 (8.7%)	106 (6.7%)	0.0375*	95 (6.9)	92 (6.2)	44 (6.6)	12 (9.2)	35 (7.0)	0.8181	29 (5.1%)	64 (9.8%)	10 (7.6%)	<0.0001***
	Diet	217 (11)	305 (11)		210 (9.3)	32 (10)	190 (12)		148 (11)	162 (11)	63 (9.4)	9 (6.9)	49 (9.8)		51 (9.0)	28 (4.3)	15 (11)	

	Diet and psychosocial support	119 (6.0)	277 (9.7)		154 (6.8)	9 (2.9)	100 (6.3)		91 (6.7)	119 (8.1)	48 (7.2)	13 (9.9)	32 (6.4)		21 (3.7)	25 (3.8)	10 (7.6)	
	Only psychosocial support	126 (6.4)	182 (6.4)		141 (6.2)	24 (7.7)	101 (6.4)		93 (6.8)	82 (5.6)	41 (6.1)	8 (6.1)	32 (6.4)		12 (2.1)	44 (6.7)	12 (9.1)	
Year	1995-1999	0 (0.0)	385 (16)	<0.0001***	0 (0.0)	0 (0.0)	0 (0.0)	<0.0001***	128 (9.2)	153 (10)	57 (8.3)	33 (25)	13 (2.5)	<0.0001***	0 (0.0)	0 (0.0)	0 (0.0)	<0.0001***
	2000-2004	161 (9.1)	160 (6.6)		169 (8.3)	7 (2.4)	103 (7.4)		119 (8.5)	123 (8.2)	44 (6.4)	28 (21)	7 (1.4)		0 (0.0)	0 (0.0)	0 (0.0)	
	2005-2009	439 (25)	360 (15)		412 (20)	51 (17)	289 (21)		319 (23)	191 (13)	192 (28)	21 (16)	76 (15)		1 (0.2)	0 (0.0)	0 (0.0)	
	2010-2014	491 (28)	510 (21)		486 (24)	104 (36)	408 (29)		306 (22)	294 (20)	206 (30)	23 (18)	172 (34)		66 (12)	141 (22)	82 (64)	
	2015-2019	401 (23)	508 (21)		501 (25)	66 (23)	337 (24)		284 (20)	396 (27)	81 (12)	18 (14)	130 (25)		155 (28)	279 (43)	34 (26)	
	2020-2024	285 (16)	514 (21)		472 (23)	65 (22)	258 (19)		236 (17)	335 (23)	103 (15)	8 (6.1)	115 (22)		339 (60)	224 (35)	13 (10)	

*significant at $p<0.05$, **significant at $p<0.01$, ***significant at $p<0.001$

Abbreviations: IRSAD, Index of Relative Socio-economic Advantage and Disadvantage; IQI, Interquartile Interval

Overall, changes in health-related quality of life scores varied across domains. The largest median improvements were observed in the *Role Physical* domain (25 [IQI=0, 75]) and in the *Physical Functioning* domain (20 [IQI=5, 35]). These were followed by improvements in the *Social Functioning* domain (13 [IQI= 0, 38]), the *Bodily Pain* domain (10 [IQI=0, 28]), and the *Vitality* domain (10 [IQI=0, 25]). More modest improvements were observed in the *General Health* domain (5 [IQI=-5, 15]) and in the *Mental Health* domain (4 [IQI=-4, 16]). Median changes were minimal, but distributions of the change were wider in the *Role Emotional* domain (0 [IQI=0, 67]), and the *Health Transition* domain (0 [IQI=0, 25]).

Physical Functioning **by socioeconomic characteristics**

Individuals who were retired or unemployed improved in *the Physical Functioning* domain, but to a more modest extent than those who were employed (Table 2). Median improvement among pensioners was the same as those who were employed. Individuals who were residing in the most disadvantaged areas (IRSAD 1) improved in the *Physical Functioning* domain, but to a more modest extent than those who were residing in the most advantaged areas (IRSAD 5). The magnitude of improvement did not differ across country of birth or remoteness of area. After adjustment, being retired or unemployed was associated with more modest improvement in *Physical Functioning* compared to being employed (Table 3). Pensioner status was associated with more modest improvement in the unadjusted analyses, but this did not remain significant after FDR correction. Residing in areas of moderate advantage (IRSAD 4) was associated with greater improvement in the unadjusted analyses, but this did not remain significant after FDR correction. No significant differences were observed by country of birth or remoteness of area.

Table 2. Median (IQI) change in SF-36 domains by country of birth, employment status, socioeconomic status of area of residence, and remoteness of area of residence

Variable	Level	Australia n (%) n=2,009	Overseas n (%) n=2,909	p-value	Employed n (%) n=2,278	Retired /Unemployed n (%) n=312	Pensioner n (%) n=1,589	p-value	IRSAD 5 (Most advantaged) n (%) n=1,392	IRSAD 4 n (%) n=1,493	IRSAD 3 n (%) n=683	IRSAD 2 n (%) n=131	IRSAD 1 (Most disadvantaged) n (%) n=513	p-value	Major cities n (%) n=564	Inner/ Outer regional n (%) n=658	Remote/Very remote n (%) n=132	p-value
Pre-program General Health n=4,918	Median (IQI)	67 (52, 82)	67 (52, 82)	0.7487	70 (55, 82)	57 (42, 72)	67 (52, 82)	<0.0001***	70 (55, 82)	67 (52, 82)	67 (52, 82)	67 (50, 82)	67 (52, 82)	0.02443*	67 (52, 77)	67 (52, 82)	67 (51.5, 82)	0.9219
Post-program General Health n=4,918	Median (IQI)	72 (57, 87)	72 (57, 87)	0.1781	77 (62, 87)	62 (47, 77)	72 (57, 82)	<0.0001***	77 (62, 87)	72 (57, 87)	72 (57, 82)	72 (57, 82)	72 (57, 82)	<0.0001***	72 (57, 82)	67 (52, 82)	73.5 (56, 82)	0.8207
Change in General Health	Median (IQI)	5 (-5, 15)	5 (-5, 15)	0.0812	5 (-5, 15)	2.5 (-5, 15)	5 (-5, 15)	0.02208 *	5 (-5, 15)	5 (-5, 15)	5 (-5, 15)	5 (-5, 15)	5 (-5, 15)	0.03939	5 (-5, 15)	5 (-5, 15)	2 (-5.8, 12)	0.4191
Pre-program Physical Functioning n=4,918	Median (IQI)	65 (45, 80)	65 (45, 80)	0.6024	65 (50, 80)	55 (35, 70)	55 (40, 75)	<0.0001***	65 (45, 80)	60 (45, 75)	60 (45, 80)	70 (50, 85)	60 (40, 80)	0.00013***	60 (44, 76)	60 (45, 80)	65 (45, 80)	0.9107
Post-program Physica	Median (IQI)	85 (70, 95)	85 (70, 95)	0.9016	90 (80, 95)	75 (60, 90)	80 (65, 90)	<0.0001***	90 (75, 95)	85 (70, 95)	85 (70, 95)	85 (75, 95)	85 (65, 95)	<0.0001***	85 (70, 95)	85 (70, 95)	85 (70, 95)	0.6669

l Functioning n=4,918																		
Change in Physical Functioning	Median (IQI)	15 (5, 30)	20 (5, 35)	0.7864	20 (5, 35)	15 (5, 30)	20 (5, 35)	0.3552	20 (5, 35)	20 (5, 35)	15 (5, 35)	15 (5, 30)	15 (5, 30)	0.03077*	20 (5, 30)	20 (5, 35)	15 (5, 30)	0.5555
Pre-program Role Physical n=4,918	Median (IQI)	0 (0, 50)	25 (0, 75)	0.0802	25 (0, 75)	0 (0, 50)	0 (0, 50)	0.0020**	0 (0, 75)	0 (0, 50)	25 (0, 50)	25 (0, 75)	25 (0, 75)	0.5307	25 (0, 75)	0 (0, 50)	25 (0, 75)	0.6893
Post-program Role Physical n=4,918	Median (IQI)	100 (50, 100)	100 (50, 100)	0.0823	100 (50, 100)	75 (25, 100)	100 (25, 100)	<0.0001***	100 (50, 100)	100 (50, 100)	100 (25, 100)	100 (50, 100)	100 (25, 100)	0.0009***	100 (50, 100)	100 (50, 100)	100 (50, 100)	0.0192*
Change in Role Physical	Median (IQI)	50 (0, 75)	25 (0, 75)	0.0040**	50 (0, 75)	25 (0, 75)	25 (0, 75)	0.0001***	50 (0, 75)	50 (0, 75)	25 (0, 75)	25 (0, 75)	25 (0, 75)	0.0004***	50 (0, 75)	25 (0, 75)	25 (0, 75)	0.1015
Pre-program Bodily Pain n=4,918	Median (IQI)	72 (51, 84)	62 (42, 84)	0.0002***	64 (42, 84)	62 (41, 74)	72 (42, 84)	<0.0001***	72 (51, 84)	62 (42, 84)	64 (42, 84)	62 (42, 84)	64 (42, 84)	0.01624*	64 (41, 84)	64 (42, 84)	72 (51, 84)	0.5094
Post-program Bodily Pain n=4,918	Median (IQI)	84 (64, 100)	84 (62, 100)	0.0307*	84 (72, 100)	74 (52, 100)	84 (62, 100)	<0.0001***	84 (72, 100)	84 (62, 100)	84 (62, 100)	84 (62, 100)	80 (62, 100)	<0.0001***	84 (62, 100)	84 (62, 100)	84 (62, 100)	0.1859

Change in Bodily Pain	Median (IQI)	10 (0, 28)	11 (0, 30)	0.0915	12 (0, 31)	10 (-9, 26)	10 (0, 26)	<0.0001***	11 (0, 29)	11 (0, 28)	10 (0, 28)	10 (0, 31)	10 (0, 26)	0.176	10 (0, 28)	11 (0, 30)	10 (0, 23)	0.2184
Pre-program Vitality n=4,918	Median (IQI)	55 (40, 70)	60 (45, 75)	<0.0001***	60 (45, 75)	50 (35, 65)	55 (40, 70)	<0.0001***	55 (45, 75)	55 (40, 70)	60 (45, 75)	55 (40, 70)	55 (45, 70)	0.8966	60 (44, 70)	55 (40, 75)	60 (50, 75)	0.0910
Post-program Vitality n=4,918	Median (IQI)	70 (60, 80)	75 (60, 85)	0.0036**	75 (60, 85)	65 (50, 75)	70 (55, 80)	<0.0001***	75 (60, 85)	70 (60, 85)	70 (55, 80)	70 (60, 80)	70 (55, 80)	0.0018**	70 (60, 80)	75 (55, 85)	72.5 (60, 80)	0.3044
Change in Vitality	Median (IQI)	15 (0, 25)	10 (0, 25)	0.0003***	10 (0, 25)	10 (0, 25)	10 (0, 25)	0.9283	10 (0, 25)	10 (0, 25)	10 (0, 25)	15 (3, 25)	10 (0, 25)	0.0037**	10 (0, 25)	10 (0, 25)	10 (0, 20)	0.0563
Pre-program Social Functioning n=4,918	Median (IQI)	75 (50, 100)	75 (50, 88)	0.0745	75 (50, 88)	62.5 (38, 88)	75 (50, 100)	<0.0001***	75 (50, 100)	75 (50, 100)	75 (50, 100)	75 (50, 88)	75 (50, 100)	0.732	75 (50, 88)	75 (50, 88)	75 (50, 100)	0.0581
Post-program Social Functioning n=4,918	Median (IQI)	100 (75, 100)	100 (75, 100)	<0.0001***	100 (75, 100)	81.2 (63, 100	100 (75, 100)	<0.0001***	100 (75, 100)	100 (75, 100)	100 (75, 100)	88 (75, 100)	100 (75, 100)	0.0022**	100 (75, 100)	100 (75, 100)	100 (75, 100)	0.6320
Change in Social Functioning	Median (IQI)	13 (0, 38)	13 (0, 38)	0.1181	13 (0, 38)	13 (0, 38)	13 (0, 38)	0.0133*	13 (0, 38)	13 (0, 38)	13 (0, 38)	13 (0, 38)	13 (0, 25)	0.0088**	13 (0, 38)	13 (0, 38)	0 (0, 25)	0.04038*
Pre-program Role	Median (IQI)	100 (0, 100)	67 (0, 100)	<0.0001***	67 (0, 100)	33 (0, 100)	67 (0, 100)	<0.0001***	100 (0, 100)	67 (0, 100)	67 (0, 100)	100 (0, 100)	67 (0, 100)	0.0074**	67 (0, 100)	67 (0, 100)	67 (0, 100)	0.9123

Emotional n=4,918																	
Post-program Role Emotional n=4,918	Median (IQI)	100 (100, 100)	100 (67, 100)	<0.0001***	100 (100, 100)	100 (33, 100)	100 (67, 100)	<0.0001***	100 (100, 100)	100 (67, 100)	100 (67, 100)	100 (67, 100)	100 (67, 100)	0.0007***	100 (67, 100)	100 (67, 100)	100 (33, 100)	0.0662
Change in Role Emotional	Median (IQI)	0 (0, 67)	0 (0, 67)	0.1558	0 (0, 67)	0 (0, 67)	0 (0, 67)	0.3980	0 (0, 67)	0 (0, 67)	0 (0, 67)	0 (0, 67)	0 (0, 67)	0.2732	0 (0, 67)	0 (0, 67)	0 (0, 67)	0.1517
Pre-program Mental Health n=4,918	Median (IQI)	80 (64, 88)	76 (60, 88)	0.0020**	76 (64, 88)	68 (52, 84)	80 (64, 88)	<0.0001***	80 (64, 88)	76 (60, 88)	76 (64, 88)	76 (60, 88)	76 (60, 88)	0.1681	76 (64, 88)	76 (60, 88)	80 (64, 88)	0.5407
Post-program Mental Health n=4,918	Median (IQI)	84 (72, 92)	84 (72, 92)	0.0001***	84 (72, 92)	76 (60, 88)	84 (72, 92)	<0.0001***	84 (72, 92)	84 (72, 92)	84 (72, 92)	84 (72, 92)	84 (68, 92)	0.0002***	84 (72, 92)	84 (72, 92	84 (72, 92)	0.7803
Change in Mental Health	Median (IQI)	4 (0, 16)	4 (-4, 16)	0.6995	4 (0, 16)	4 (-4, 16)	4 (-4, 16)	0.5183	4 (-4, 16)	4 (0, 16)	4 (-4, 16)	8 (-4, 20)	4 (-4, 16)	0.0471*	4 (-4, 12)	4 (-4, 16)	4 (-4, 16)	0.5326
Pre-program Health Transition n=4,918	Median (IQI)	25 (0, 50)	25 (0, 50)	<0.0001***	25 (0, 50)	25 (25, 50)	25 (0, 50)	<0.0001***	25 (0, 50)	25 (0, 50)	25 (0, 50)	25 (0, 50)	25 (0, 50)	0.9768	25 (0, 50)	25 (0, 50)	25 (0, 50)	0.9713
Post-progra	Median (IQI)	50 (25, 50)	25 (0, 50)	<0.0001***	25 (25, 50)	25 (25, 50)	25 (25, 50)	0.1077	50 (25, 50)	25 (25, 50)	25 (25, 50)	25 (25, 50)	25 (0, 50)	0.0284 1*	25 (25, 50)	25 (25, 50)	38 (25, 50)	0.4389

m Health Transition n=4,918																		
Change in Health Transition	Median (IQI)	0 (0, 25)	0 (0, 25)	<0.0001***	0 (0, 25)	0 (-25, 25)	0 (0, 25)	0.0102*	0 (0, 25)	0 (0, 25)	0 (0, 25)	0 (0, 25)	0 (0, 25)	0.2492	0 (0, 25)	0 (0, 25)	0 (0, 25)	0.6297

*significant at p<0.05, **significant at p<0.01, ***significant at p<0.001

Abbreviations: IRSAD, Index of Relative Socio-economic Advantage and Disadvantage; IQI, Interquartile Interval

Table 3. Adjusted associations between individual socioeconomic characteristics and change in SF-36 Physical Functioning domain, a Physical Component Summary (PCS) domain

Variable	β-Coefficient (Robust Standard Error)	p-value	FDR-adjusted p-value
Pre Physical Functioning	-0.6832 (0.0191)	<0.0010	
Country of birth (Overseas vs. Australia)	-0.1506 (0.9218)	0.8703	0.9791
Employment status (Retired/Unemployed vs. Employed)	-4.8872 (1.8925)	0.0099	0.0112*
Employment status (Pensioner vs. Employed)	-2.8545 (1.1464)	0.0129	0.1162
Socioeconomic status of area (IRSD 4 vs. IRSD 5)	2.6722 (1.1918)	0.0251	0.0783
Socioeconomic status of area (IRSD 3 vs. IRSD 5)	1.1329 (1.3628)	0.4059	0.8100
Socioeconomic status of area (IRSD 2 vs. IRSD 5)	-0.5799 (1.3460)	0.6667	0.7719
Socioeconomic status of area (IRSD 1 vs. IRSD 5)	-1.8459 (1.3531)	0.1727	0.2084
Remoteness of area (Inner/Outer regional vs. Major cities)	0.2059 (0.8858)	0.8162	0.8162
Remoteness of area (Remote/Very remote vs. Major cities)	0.8886 (1.6573)	0.5919	0.7611
Age	-0.1759 (0.0450)	<0.0010	
Sex (Female vs. Male)	-4.8063 (1.0813)	<0.0010	
Body mass index category (Obese vs. Healthy)	-4.6597 (1.1494)	<0.0010	
Body mass index category (Overweight vs. Healthy)	-1.0689 (1.0376)	0.3032	
Body mass index category (Underweight vs. Healthy)	-5.3964 (5.5842)	0.3341	
Hypertension (Yes vs. No)	-1.0151 (0.8969)	0.2579	
Diabetes (Yes vs. No)	-2.8844 (0.9475)	0.0024	
Smoking status (Former vs. Never)	-0.0126 (0.9863)	0.9898	
Smoking status (Current vs. Never)	-3.0644 (1.3273)	0.0211	
Alcohol consumption (Occasional and social vs. Nil or rare)	2.0906 (0.8813)	0.0178	
Alcohol consumption (Light to moderate regularly vs. Nil or rare)	1.6802 (4.2644)	0.6936	
Alcohol consumption (Heavy or binge vs. Nil or rare)	3.8971 (1.8646)	0.0368	
Lifestyle behaviours (Sedentary vs. Active)	-3.3490 (0.8750)	0.0001	
Year (2015-2019 vs. 2005-2009)	2.8323 (1.3212)	0.0323	
Year (2020-2024 vs. 2005-2009)	1.8720 (1.2970)	0.1492	

*significant at p<0.05, **significant at p<0.01, ***significant at p<0.001

Abbreviations: FDR, False Discovery Rate; IRSAD, Index of Relative Socio-economic Advantage and Disadvantage

Role Physical by socioeconomic characteristics

Individuals who were born overseas improved in the *Role Physical* domain, but to a more modest extent than those born in Australia (Table 2). Individuals who were retired or unemployed improved to a more modest extent compared to those who were employed. Individuals who were residing in the most disadvantaged areas (IRSAD 1) improved in the *Role Physical* domain, but to a more modest extent than those who were residing in the most advantaged areas (IRSAD 5). Individuals who were residing in inner or outer regional areas improved to a more modest extent compared to those who were residing in major cities. After adjustment, being retired or unemployed was associated with more modest improvement in *Role Physical* compared to being employed (Table 4). Pensioner status was also associated with more modest improvement in unadjusted analyses, but this did not remain significant after FDR correction. Residing in the most disadvantaged areas (IRSAD 1) was associated with more modest improvement in unadjusted analyses, but this did not remain significant after FDR correction. Residing in inner or outer regional areas was associated with more modest improvement compared to residing in major cities. Residing in remote or very remote areas was also associated with more modest improvement. No significant differences were observed by country of birth.

Table 4. Adjusted associations between individual socioeconomic characteristics and change in SF-36 Role Physical domain, a Physical Component Summary (PCS) domain

Variable	β-Coefficient (Robust Standard Error)	p-value	FDR-adjusted p-value
Pre Role Physical	-0.7080 (0.0245)	<0.0010	
Country of birth (Overseas vs. Australia)	-2.2604 (2.0101)	0.2610	0.3915
Employment status (Retired/Unemployed vs. Employed)	-11.9142 (3.7735)	0.0016	0.0024**
Employment status (Pensioner vs. Employed)	-5.0174 (2.6452)	0.0581	0.1307
Socioeconomic status of area (IRSD 4 vs. IRSD 5)	5.0623 (2.8900)	0.0801	0.1802
Socioeconomic status of area (IRSD 3 vs. IRSD 5)	1.6271 (3.1868)	0.6097	0.8100
Socioeconomic status of area (IRSD 2 vs. IRSD 5)	-2.8862 (3.1879)	0.3655	0.7719
Socioeconomic status of area (IRSD 1 vs. IRSD 5)	-6.6533 (3.2254)	0.0393	0.0708
Remoteness of area (Inner/Outer regional vs. Major cities)	-6.1554 (2.0355)	0.0025	0.0229*
Remoteness of area (Remote/Very remote vs. Major cities)	-9.4829 (3.6020)	0.0086	0.0386*
Age	-0.1588 (0.1032)	0.1239	
Sex (Female vs. Male)	-0.8653 (2.4704)	0.7262	
Body mass index category (Obese vs. Healthy)	-2.2706 (2.6352)	0.3890	
Body mass index category (Overweight vs. Healthy)	3.5480 (2.3747)	0.1354	
Body mass index category (Underweight vs. Healthy)	-20.5651 (12.7973)	0.1083	
Hypertension (Yes vs. No)	-2.4652 (2.0459)	0.2285	
Diabetes (Yes vs. No)	-5.9185 (2.1658)	0.0064	
Smoking status (Former vs. Never)	1.1123 (2.2616)	0.6229	
Smoking status (Current vs. Never)	-2.7070 (3.0449)	0.3742	
Alcohol consumption (Occasional and social vs. Nil or rare)	2.1997 (2.0094)	0.2739	
Alcohol consumption (Light to moderate regularly vs. Nil or rare)	-3.5213 (9.7770)	0.7188	
Alcohol consumption (Heavy or binge vs. Nil or rare)	1.3378 (4.2708)	0.7542	
Lifestyle behaviours (Sedentary vs. Active)	-4.9325 (1.9826)	0.0130	
Year (2015-2019 vs. 2005-2009)	-0.4055 (3.0309)	0.8936	
Year (2020-2024 vs. 2005-2009)	-1.8490 (2.9718)	0.5339	

*significant at p<0.05, **significant at p<0.01, ***significant at p<0.001

Abbreviations: FDR, False Discovery Rate; IRSAD, Index of Relative Socio-economic Advantage and Disadvantage

Bodily Pain by socioeconomic characteristics

Individuals who were retired or unemployed improved in the *Bodily Pain* domain, but to a more modest extent than those who were employed (Table 2). The magnitude of improvement did not differ across country of birth, socioeconomic status of area, or remoteness of area. After adjustment, being retired or unemployed was associated with more modest improvement in *Bodily Pain* compared to being employed (Table 5). No significant differences were observed by country of birth or remoteness of area.

Table 5. Adjusted associations between individual socioeconomic characteristics and change in SF-36 Bodily Pain domain, a Physical Component Summary (PCS) domain

Variable	β-Coefficient (Robust Standard Error)	p-value	FDR-adjusted p-value
Pre Bodily Pain	-0.6991 (0.0203)	<0.0010	
Country of birth (Overseas vs. Australia)	-1.6165 (1.1440)	0.1579	0.3211
Employment status (Retired/Unemployed vs. Employed)	-7.3392 (2.2463)	0.0011	0.0020**
Employment status (Pensioner vs. Employed)	-2.1714 (1.4315)	0.1296	0.2332
Socioeconomic status of area (IRSD 4 vs. IRSD 5)	0.9965 (1.6154)	0.5374	0.6046
Socioeconomic status of area (IRSD 3 vs. IRSD 5)	-3.4790 (1.8238)	0.0567	0.5101
Socioeconomic status of area (IRSD 2 vs. IRSD 5)	-2.3512 (1.7335)	0.1752	0.7719
Socioeconomic status of area (IRSD 1 vs. IRSD 5)	-3.7641 (1.6896)	0.0261	0.0708
Remoteness of area (Inner/Outer regional vs. Major cities)	0.5322 (1.1274)	0.6369	0.8162
Remoteness of area (Remote/Very remote vs. Major cities)	-1.1125 (1.9594)	0.5703	0.7611
Age	-0.1186 (0.0577)	0.0400	
Sex (Female vs. Male)	-4.5978 (1.3737)	0.0008	
Body mass index category (Obese vs. Healthy)	-2.9123 (1.4652)	0.0471	
Body mass index category (Overweight vs. Healthy)	0.4661 (1.3210)	0.7243	
Body mass index category (Underweight vs. Healthy)	2.9024 (7.1148)	0.6834	
Hypertension (Yes vs. No)	-0.9044 (1.1376)	0.4268	
Diabetes (Yes vs. No)	-1.9135 (1.2051)	0.1126	
Smoking status (Former vs. Never)	0.7434 (1.2587)	0.5549	
Smoking status (Current vs. Never)	-0.2544 (1.6928)	0.8806	
Alcohol consumption (Occasional and social vs. Nil or rare)	0.0009 (1.1202)	0.9994	
Alcohol consumption (Light to moderate regularly vs. Nil or rare)	0.4447 (5.4376)	0.9348	
Alcohol consumption (Heavy or binge vs. Nil or rare)	2.7064 (2.3754)	0.2548	
Lifestyle behaviours (Sedentary vs. Active)	-2.6249 (1.1034)	0.0175	
Year (2015-2019 vs. 2005-2009)	3.6217 (1.6844)	0.0317	
Year (2020-2024 vs. 2005-2009)	-0.8719 (1.6545)	0.5983	

*significant at p<0.05, **significant at p<0.01, ***significant at p<0.001

Abbreviations: FDR, False Discovery Rate; IRSAD, Index of Relative Socio-economic Advantage and Disadvantage

General Health by socioeconomic characteristics

Individuals who were retired or unemployed improved in the *General Health* domain, but to a more modest extent than those who were employed (Table 2). Median improvement among individuals who were residing in the most disadvantaged areas was the same as those residing in the most advantaged areas (IRSAD 5). The magnitude of improvement did not differ across country of birth or remoteness of area. After adjustment, being retired or unemployed was associated with more modest improvement in *General Health* compared to being employed (Table 6). Residing in the most disadvantaged areas (IRSAD 1) was associated with more modest improvement in the unadjusted analyses, but this did not remain significant after FDR correction. No significant differences were observed by country of birth, socioeconomic status of area, or remoteness of area.

Table 6. Adjusted associations between individual socioeconomic characteristics and change in SF-36 General Health domain, a Physical Component Summary (PCS) domain

Variable	β-Coefficient (Robust Standard Error)	p-value	FDR-adjusted p-value
Pre General Health	-0.3505 (0.0214)	<0.0010	
Country of birth (Overseas vs. Australia)	1.4549 (0.8549)	0.0890	0.3211
Employment status (Retired/Unemployed vs. Employed)	-4.9817 (1.5239)	0.0011	0.0020**
Employment status (Pensioner vs. Employed)	-1.0383 (1.0715)	0.3328	0.4742
Socioeconomic status of area (IRSD 4 vs. IRSD 5)	0.9702 (1.1667)	0.4058	0.5842
Socioeconomic status of area (IRSD 3 vs. IRSD 5)	-1.9828 (1.3494)	0.1420	0.6389
Socioeconomic status of area (IRSD 2 vs. IRSD 5)	-0.8899 (1.2140)	0.4637	0.7719
Socioeconomic status of area (IRSD 1 vs. IRSD 5)	-3.0189 (1.2793)	0.0184	0.0708
Remoteness of area (Inner/Outer regional vs. Major cities)	-0.2383 (0.8232)	0.7723	0.8162
Remoteness of area (Remote/Very remote vs. Major cities)	-1.3474 (1.6436)	0.4125	0.7611
Age	-0.0424 (0.0429)	0.3226	
Sex (Female vs. Male)	-1.6947 (1.0256)	0.0987	
Body mass index category (Obese vs. Healthy)	-2.0384 (1.0930)	0.0624	
Body mass index category (Overweight vs. Healthy)	0.5165 (0.9849)	0.6001	
Body mass index category (Underweight vs. Healthy)	10.3856 (5.3071)	0.0506	
Hypertension (Yes vs. No)	0.3153 (0.8508)	0.7110	
Diabetes (Yes vs. No)	-1.3568 (0.9021)	0.1328	
Smoking status (Former vs. Never)	0.2456 (0.9384)	0.7936	
Smoking status (Current vs. Never)	-1.0069 (1.2625)	0.4253	
Alcohol consumption (Occasional and social vs. Nil or rare)	0.6392 (0.8356)	0.4444	
Alcohol consumption (Light to moderate regularly vs. Nil or rare)	6.2739 (4.0553)	0.1221	
Alcohol consumption (Heavy or binge vs. Nil or rare)	3.1590 (1.7716)	0.0748	
Lifestyle behaviours (Sedentary vs. Active)	0.8163 (0.8293)	0.3251	
Year (2015-2019 vs. 2005-2009)	1.8964 (1.2563)	0.1314	
Year (2020-2024 vs. 2005-2009)	-0.7017 (1.2337)	0.5696	

*significant at $p<0.05$, **significant at $p<0.01$, ***significant at $p<0.001$

Abbreviations: FDR, False Discovery Rate; IRSAD, Index of Relative Socio-economic Advantage and Disadvantage

Vitality by socioeconomic characteristics

Individuals who were born overseas improved in the *Vitality* domain, but to a more modest extent than those who were born in Australia (Table 2). The magnitude of improvement did not differ across employment status, socioeconomic status of area, or remoteness of area. However, after adjustment, being retired or unemployed was associated with more modest improvement in *Vitality* compared to being employed (Table 7). No significant differences were observed by country of birth or remoteness of area.

Table 7. Adjusted associations between individual socioeconomic characteristics and change in SF-36 Vitality domain, a Mental Component Summary (MCS) domain

Variable	β-Coefficient (Robust Standard Error)	p-value	FDR-adjusted p-value
Pre Vitality	-0.5349 (0.0208)	<0.0010	
Country of birth (Overseas vs. Australia)	0.0138 (0.9111)	0.9879	0.9879
Employment status (Retired/Unemployed vs. Employed)	-6.1439 (1.8097)	0.0007	0.0020**
Employment status (Pensioner vs. Employed)	-0.4377 (1.1759)	0.7098	0.7985
Socioeconomic status of area (IRSD 4 vs. IRSD 5)	0.9800 (1.3096)	0.4544	0.5842
Socioeconomic status of area (IRSD 3 vs. IRSD 5)	-0.5408 (1.4724)	0.7135	0.8100
Socioeconomic status of area (IRSD 2 vs. IRSD 5)	0.0948 (1.3682)	0.9448	0.9448
Socioeconomic status of area (IRSD 1 vs. IRSD 5)	-1.8515 (1.4021)	0.1869	0.2084
Remoteness of area (Inner/Outer regional vs. Major cities)	0.3917 (0.9098)	0.6669	0.8162
Remoteness of area (Remote/Very remote vs. Major cities)	-0.6282 (1.5707)	0.6893	0.7754
Age	-0.0509 (0.0458)	0.2658	
Sex (Female vs. Male)	-1.4646 (1.1007)	0.1836	
Body mass index category (Obese vs. Healthy)	-4.0928 (1.1691)	0.0005	
Body mass index category (Overweight vs. Healthy)	-0.5921 (1.0542)	0.5745	
Body mass index category (Underweight vs. Healthy)	5.4192 (5.6762)	0.3399	
Hypertension (Yes vs. No)	-0.5490 (0.9087)	0.5458	
Diabetes (Yes vs. No)	-2.0280 (0.9616)	0.0352	
Smoking status (Former vs. Never)	-0.0932 (1.0035)	0.9260	
Smoking status (Current vs. Never)	-1.9163 (1.3506)	0.1562	
Alcohol consumption (Occasional and social vs. Nil or rare)	1.4130 (0.8924)	0.1136	
Alcohol consumption (Light to moderate regularly vs. Nil or rare)	3.6946 (4.3394)	0.3947	
Alcohol consumption (Heavy or binge vs. Nil or rare)	3.3618 (1.8953)	0.0764	
Lifestyle behaviours (Sedentary vs. Active)	-0.2217 (0.8879)	0.8029	
Year (2015-2019 vs. 2005-2009)	1.8000 (1.3439)	0.1807	
Year (2020-2024 vs. 2005-2009)	-0.6735 (1.3186)	0.6096	

*significant at p<0.05, **significant at p<0.01, ***significant at p<0.001

Abbreviations: FDR, False Discovery Rate; IRSAD, Index of Relative Socio-economic Advantage and Disadvantage

Social Functioning by socioeconomic characteristics

Individuals who were retired or unemployed improved in the *Social Functioning* domain, the same as those who were employed, although the difference in distributions was statistically significant (p=0.0133) (Table 2). Median improvement among individuals who were residing in the most disadvantaged areas (IRSAD 1) was the same as those who were residing in the most advantaged areas (IRSAD 5). The magnitude of improvement did not differ across country of birth or remoteness of area. After adjustment, being retired or unemployed was associated with more modest improvement in *Social Functioning* compared to being employed (Table 8). No significant differences were observed by country of birth or remoteness of area.

Table 8. Adjusted associations between individual socioeconomic characteristics and change in SF-36 Social Functioning domain, a Mental Component Summary (MCS) domain

Variable	β-Coefficient (Robust Standard Error)	p-value	FDR-adjusted p-value
Pre Social Functioning	-0.7216 (0.0197)	<0.0010	
Country of birth (Overseas vs. Australia)	-1.5776 (1.1377)	0.1658	0.3211
Employment status (Retired/Unemployed vs. Employed)	-8.3038 (2.3484)	0.0004	0.0019**
Employment status (Pensioner vs. Employed)	-1.3265 (1.4754)	0.3688	0.4742
Socioeconomic status of area (IRSD 4 vs. IRSD 5)	1.9668 (1.7361)	0.2575	0.4634
Socioeconomic status of area (IRSD 3 vs. IRSD 5)	-0.4694 (1.8561)	0.8004	0.8100
Socioeconomic status of area (IRSD 2 vs. IRSD 5)	0.7038 (1.7554)	0.6885	0.7719
Socioeconomic status of area (IRSD 1 vs. IRSD 5)	-2.2293 (1.7711)	0.2084	0.2084
Remoteness of area (Inner/Outer regional vs. Major cities)	0.8741 (1.1647)	0.4531	0.8162
Remoteness of area (Remote/Very remote vs. Major cities)	-1.3292 (2.0812)	0.5232	0.7611
Age	0.1084 (0.0584)	0.0637	
Sex (Female vs. Male)	-0.8189 (1.3949)	0.5573	
Body mass index category (Obese vs. Healthy)	-1.3731 (1.4879)	0.3563	
Body mass index category (Overweight vs. Healthy)	0.8813 (1.3409)	0.5112	
Body mass index category (Underweight vs. Healthy)	5.6636 (7.2258)	0.4333	
Hypertension (Yes vs. No)	0.7638 (1.1545)	0.5084	
Diabetes (Yes vs. No)	-3.1128 (1.2241)	0.0111	
Smoking status (Former vs. Never)	-0.0839 (1.2774)	0.9476	
Smoking status (Current vs. Never)	-2.2505 (1.7197)	0.1909	
Alcohol consumption (Occasional and social vs. Nil or rare)	1.3842 (1.1385)	0.2243	
Alcohol consumption (Light to moderate regularly vs. Nil or rare)	0.2330 (5.5219)	0.9663	
Alcohol consumption (Heavy or binge vs. Nil or rare)	0.3422 (2.4121)	0.8872	
Lifestyle behaviours (Sedentary vs. Active)	-0.6543 (1.1189)	0.5588	
Year (2015-2019 vs. 2005-2009)	0.3669 (1.7109)	0.8302	
Year (2020-2024 vs. 2005-2009)	-1.4110 (1.6788)	0.4008	

*significant at p<0.05, **significant at p<0.01, ***significant at p<0.001

Abbreviations: FDR, False Discovery Rate; IRSAD, Index of Relative Socio-economic Advantage and Disadvantage

Role Emotional by socioeconomic characteristics

The magnitude of improvement in the *Role Emotional* domain did not differ across country of birth, employment status, socioeconomic status of area, or remoteness of area (Table 2). However, after adjustment, being retired or unemployed was associated with more modest improvement in *Role Emotional* compared to being employed (Table 9). Pensioner status was associated with more modest improvement in unadjusted analyses, but this did not remain significant after FDR correction. Residing in the most disadvantaged areas (IRSAD 1) was associated with more modest improvement in unadjusted analyses, but this was not significant after FDR correction. Residing in remote or very remote areas was associated with more modest improvement compared to residing in major cities. No significant differences were observed by country of birth.

Table 9. Adjusted associations between individual socioeconomic characteristics and change in SF-36 Role Emotional domain, a Mental Component Summary (MCS) domain

Variable	β-Coefficient (Robust Standard Error)	p-value	FDR-adjusted p-value
Pre Role Emotional	-0.7650 (0.0205)	<0.0010	
Country of birth (Overseas vs. Australia)	-2.5573 (1.8993)	0.1784	0.3211
Employment status (Retired/Unemployed vs. Employed)	-10.9861 (3.9315)	0.0053	0.0068**
Employment status (Pensioner vs. Employed)	-5.3208 (2.4612)	0.0308	0.1307
Socioeconomic status of area (IRSD 4 vs. IRSD 5)	5.6530 (2.5377)	0.0261	0.0783
Socioeconomic status of area (IRSD 3 vs. IRSD 5)	-1.0431 (2.9903)	0.7273	0.8100
Socioeconomic status of area (IRSD 2 vs. IRSD 5)	-1.6059 (2.7473)	0.5590	0.7719
Socioeconomic status of area (IRSD 1 vs. IRSD 5)	-6.4732 (3.0993)	0.0370	0.0708
Remoteness of area (Inner/Outer regional vs. Major cities)	-2.5844 (1.8423)	0.1609	0.7242
Remoteness of area (Remote/Very remote vs. Major cities)	-10.8607 (3.5627)	0.0023	0.0211*
Age	0.0310 (0.0973)	0.7500	
Sex (Female vs. Male)	-0.6571 (2.3291)	0.7779	
Body mass index category (Obese vs. Healthy)	-1.7412 (2.4876)	0.4841	
Body mass index category (Overweight vs. Healthy)	1.9060 (2.2378)	0.3945	
Body mass index category (Underweight vs. Healthy)	1.1617 (12.0670)	0.9233	
Hypertension (Yes vs. No)	2.0827 (1.9284)	0.2803	
Diabetes (Yes vs. No)	-1.6917 (2.0458)	0.4085	
Smoking status (Former vs. Never)	-0.4276 (2.1366)	0.8414	
Smoking status (Current vs. Never)	-4.3081 (2.8705)	0.1337	
Alcohol consumption (Occasional and social vs. Nil or rare)	3.3464 (1.8948)	0.0776	
Alcohol consumption (Light to moderate regularly vs. Nil or rare)	-6.6676 (9.2191)	0.4697	
Alcohol consumption (Heavy or binge vs. Nil or rare)	-3.4584 (4.0274)	0.3907	
Lifestyle behaviours (Sedentary vs. Active)	-1.0620 (1.8702)	0.5702	
Year (2015-2019 vs. 2005-2009)	-7.2703 (2.8562)	0.0110	
Year (2020-2024 vs. 2005-2009)	-8.2324 (2.8028)	0.0034	

*significant at p<0.05, **significant at p<0.01, ***significant at p<0.001

Abbreviations: FDR, False Discovery Rate; IRSAD, Index of Relative Socio-economic Advantage and Disadvantage

Mental Health by socioeconomic characteristics

The magnitude of improvement in the *Mental Health* domain did not differ across country of birth, employment status, socioeconomic status of area, or remoteness of area (Table 2). However, after adjustment, being retired or unemployed was associated with more modest improvement in *Mental Health* compared to being employed (Table 10). No significant differences were observed by country of birth, socioeconomic status of area, or remoteness of area.

Health Transition by socioeconomic characteristics

Although not a core domain of the SF-36, median improvement in the *Health Transition* domain was similar for individuals who were born overseas and those born in Australia, although distributions differed in unadjusted analyses ($p<0.001$) (Table 2). The magnitude of improvement did not differ across employment status, socioeconomic status of area, or remoteness of area. After adjustment, being born overseas was associated with more modest improvements in *Health Transition* compared to being born in Australia (Table 11). Residing in most disadvantaged areas (IRSAD 1) was associated with more modest improvement in unadjusted analyses, but this did not remain significant after FDR correction. No significant differences were observed by country of birth or remoteness of area.

Across all models, baseline domain score was associated with change (Table 3-11). Age, sex, and comorbidities such as diabetes, obesity, and smoking status were also significantly associated in some domains.

Table 10. Adjusted associations between individual socioeconomic characteristics and change in SF-36 Mental Health domain, a Mental Component Summary (MCS) domain

Variable	β-Coefficient (Robust Standard Error)	p-value	FDR-adjusted p-value
Pre Mental Health	-0.5420 (0.0218)	<0.0010	
Country of birth (Overseas vs. Australia)	0.8046 (0.8083)	0.3197	0.4110
Employment status (Retired/Unemployed vs. Employed)	-7.0260 (1.7526)	<0.0010	0.0006***
Employment status (Pensioner vs. Employed)	-0.0118 (1.0540)	0.9911	0.9911
Socioeconomic status of area (IRSD 4 vs. IRSD 5)	-0.4665 (1.2103)	0.7000	0.7000
Socioeconomic status of area (IRSD 3 vs. IRSD 5)	-0.3219 (1.3387)	0.8100	0.8100
Socioeconomic status of area (IRSD 2 vs. IRSD 5)	-0.5123 (1.2053)	0.6709	0.7719
Socioeconomic status of area (IRSD 1 vs. IRSD 5)	-2.0110 (1.2349)	0.1037	0.1555
Remoteness of area (Inner/Outer regional vs. Major cities)	0.6236 (0.8157)	0.4447	0.8162
Remoteness of area (Remote/Very remote vs. Major cities)	-2.0163 (1.4759)	0.1721	0.5164
Age	0.0377 (0.0420)	0.3696	
Sex (Female vs. Male)	0.3157 (1.0035)	0.7531	
Body mass index category (Obese vs. Healthy)	-1.5793 (1.0689)	0.1398	
Body mass index category (Overweight vs. Healthy)	0.7350 (0.9638)	0.4458	
Body mass index category (Underweight vs. Healthy)	4.1223 (5.1929)	0.4274	
Hypertension (Yes vs. No)	-0.0290 (0.8297)	0.9721	
Diabetes (Yes vs. No)	-0.0651 (0.8789)	0.9410	
Smoking status (Former vs. Never)	0.0334 (0.9176)	0.9710	
Smoking status (Current vs. Never)	-0.7341 (1.2358)	0.5526	
Alcohol consumption (Occasional and social vs. Nil or rare)	2.4323 (0.8152)	0.0029	
Alcohol consumption (Light to moderate regularly vs. Nil or rare)	-1.0002 (3.9666)	0.8010	
Alcohol consumption (Heavy or binge vs. Nil or rare)	2.1037 (1.7326)	0.2249	
Lifestyle behaviours (Sedentary vs. Active)	0.1015 (0.8083)	0.9001	
Year (2015-2019 vs. 2005-2009)	-1.6697 (1.2290)	0.1745	
Year (2020-2024 vs. 2005-2009)	-3.4124 (1.2059)	0.0047	

*significant at p<0.05, **significant at p<0.01, ***significant at p<0.001

Abbreviations: FDR, False Discovery Rate; IRSAD, Index of Relative Socio-economic Advantage and Disadvantage

Table 11. Adjusted associations between individual socioeconomic characteristics and change in SF-36 Health Transition domain

Variable	β-Coefficient (Robust Standard Error)	p-value	FDR-adjusted p-value
Pre Health Transition	-0.7484 (0.0259)	<0.0010	
Country of birth (Overseas vs. Australia)	-5.4197 (1.1670)	<0.0010	<0.0010***
Employment status (Retired/Unemployed vs. Employed)	3.2716 (2.1009)	0.1197	0.1197
Employment status (Pensioner vs. Employed)	3.0996 (1.5477)	0.0454	0.1307
Socioeconomic status of area (IRSD 4 vs. IRSD 5)	-4.2048 (1.8121)	0.0205	0.0783
Socioeconomic status of area (IRSD 3 vs. IRSD 5)	-2.3501 (1.9847)	0.2366	0.7098
Socioeconomic status of area (IRSD 2 vs. IRSD 5)	-3.8471 (1.7623)	0.0292	0.2630
Socioeconomic status of area (IRSD 1 vs. IRSD 5)	-4.3342 (1.8130)	0.0170	0.0708
Remoteness of area (Inner/Outer regional vs. Major cities)	-0.4873 (1.1855)	0.6811	0.8162
Remoteness of area (Remote/Very remote vs. Major cities)	-0.4671 (2.1359)	0.8269	0.8269
Age	0.0138 (0.0600)	0.8184	
Sex (Female vs. Male)	0.8564 (1.4368)	0.5513	
Body mass index category (Obese vs. Healthy)	0.8881 (1.5374)	0.5636	
Body mass index category (Overweight vs. Healthy)	-3.9462 (1.3803)	0.0043	
Body mass index category (Underweight vs. Healthy)	-4.8545 (7.4429)	0.5144	
Hypertension (Yes vs. No)	-0.4824 (1.1900)	0.6853	
Diabetes (Yes vs. No)	-1.5518 (1.2603)	0.2185	
Smoking status (Former vs. Never)	-0.9097 (1.3157)	0.4894	
Smoking status (Current vs. Never)	-0.5421 (1.7708)	0.7596	
Alcohol consumption (Occasional and social vs. Nil or rare)	2.3859 (1.1692)	0.0415	
Alcohol consumption (Light to moderate regularly vs. Nil or rare)	8.3082 (5.6875)	0.1443	
Alcohol consumption (Heavy or binge vs. Nil or rare)	-1.8241 (2.4892)	0.4638	
Lifestyle behaviours (Sedentary vs. Active)	-1.4605 (1.1504)	0.2045	
Year (2015-2019 vs. 2005-2009)	-3.6555 (1.7619)	0.0382	
Year (2020-2024 vs. 2005-2009)	0.4447 (1.7289)	0.7971	

*significant at p<0.05, **significant at p<0.01, ***significant at p<0.001

Abbreviations: FDR, False Discovery Rate; IRSAD, Index of Relative Socio-economic Advantage and Disadvantage

DISCUSSION

This study examined whether changes in SF-36 health-related quality of life domains following completion of a publicly funded cardiac rehabilitation program in Western Sydney differed by individuals' country of birth, employment status, socioeconomic status of area of residence, and remoteness of area of residence. Improvements were observed across all domains, with the largest improvements observed within the PCS, particularly *Physical Functioning* and *Role Physical*, while more modest improvements were observed within the MCS, particularly *Social Functioning*, *Role Emotional*, and *Mental Health*. After correction for multiple testing, being born overseas was associated with more modest improvement in *Health Transition* only. Being retired or unemployed was associated with more modest improvements across all eight core domains, excluding *Health Transition*. Pensioner status showed associations within the PCS, particularly *Physical Functioning*, and within the MCS, particularly *Role Emotional*, but these did not remain significant after correction. Socioeconomic status of area was not associated with differences in change in any domain. Residing in inner or outer regional areas was associated with more modest improvement within the PCS, particularly *Role Physical*, while residing in remote or very remote areas was associated with more modest improvement within the PCS, particularly *Role Physical*, and within the MCS, particularly Role *Emotional*.

The more modest improvement in *Health Transition* among individuals born overseas may reflect differences in how recovery is perceived following a cardiac event.[32,36,37] Country of birth, as commonly recorded in Australian health data, does not capture duration of residence in Australia, age at migration, English-language proficiency, or familiarity with the healthcare system.[38] Health literacy may be relevant for some individuals, and cultural beliefs may also shape how recovery and health are understood and reported, such that perceived change in health may differ even when functional capacity improves.[32,36-38] Offering culturally adapted materials and enhancing engagement with community-based providers may help ensure individuals recognise progress and feel supported.[39,40] Future registry-based research may benefit from collecting and exploring migration history, health literacy, or health-seeking behaviours to better understand variations in perceived change in health following cardiac rehabilitation.[41]

The more modest improvements across multiple domains among individuals who were retired or unemployed suggest persistent socioeconomic inequities in recovery.[2,20,21] While the largest improvements were observed within the PCS, particularly *Physical Functioning* and *Role Physical*, which may reflect the exercise training component of cardiac rehabilitation, these same domains showed more modest improvements among those without stable employment, suggesting a gap in recovery. Although cardiac rehabilitation was publicly funded with minimal expected out-of-pocket costs, indirect costs related to transport, parking, and the logistical burden of completing sessions may have posed greater barriers for individuals who were unemployed, pensioners, or more reliant on caregivers.[42] In contrast, supports that may benefit outcomes within the MCS, including Employee Assistance Programs commonly offered through workplaces, may facilitate recovery for individuals who are employed but are typically unavailable to those who are unemployed or pensioners.[43,44]

By contrast, postcode-based indicators of area-level socioeconomic characteristic showed different patterns: socioeconomic status of area was not associated with differences in change in any domain, whereas remoteness of area was associated with more modest improvement within the PCS, particularly *Role Physical*, and within the MCS, particularly *Role Emotional*. This suggests that equity in recovery may be shaped less by neighbourhood disadvantage and more by geographic access.

Tailored support, such as more frequent one-on-one counselling, referrals to external services, encouragement to use Australia's Medicare-subsidized mental health treatment plan (which assists up to 10 psychologist sessions per year), or peer support from individual with shared concerns, may be needed to achieve comparable outcomes among those without workplace-based resources, particularly when compounded by caregiving responsibilities or financial strain.[45-47] Associations with employment status within the MCS, particularly *Social Functioning*, *Role Emotional*, and *Mental Health*, were observed only in multivariable models, suggesting that adjustment for factors such as age, comorbidities, or number of sessions participated in revealed more subtle effects of socioeconomic characteristics. For instance, individuals who were older and retired may have reported higher baseline mental health, while those who were younger and unemployed may have had greater capacity for improvement but continued to face external stressors during the program, participated in

fewer sessions, or lacked the confidence to resume previous roles. Beyond structural support, personal factors such as self-efficacy and optimism about returning to work may also contribute to psychosocial recovery, consistent with past studies showing that individuals who are unemployed face greater challenges in psychosocial outcomes compared to those who are employed or retired, even after completing cardiac rehabilitation.[48,49]

The more modest improvement within the PCS, particularly *Role Physical*, among individuals residing in inner or outer regional areas may reflect structural barriers to returning to physically demanding roles, such as reduced availability of local specialists or allied health services, and limited transport options.[50-52] The finding of more modest improvements within the PCS, particularly *Role Physical*, and within the MCS, particularly *Role Emotional*, among individuals residing in remote or very remote areas highlights the impact of geographic barriers. Even when physical symptoms improve, the capacity to return to usual daily roles may remain restricted. Addressing these challenges may require strengthening the flexibility already offered through the program, which includes face-to-face, home walking, and telehealth options, by ensuring that each mode is accessible and supported according to individual need. Additional strategies such as transport assistance or closer coordination with primary care providers may further reduce barriers.[53-57] These findings confirm patterns in past studies on health equity, where socioeconomic context, including migration background, employment status, and geographic access, has been linked not only to differences in participation, but also to the extent of benefit from cardiac rehabilitation. Flexible delivery and support may therefore be needed to achieve more equitable recovery.

Several limitations remain of consideration. This study used data from a single, publicly funded cardiac rehabilitation program in Western Sydney, which may limit the transferability of findings to other programs, regions, or healthcare systems. However, this setting offers valuable insight into a culturally and socioeconomically diverse population, with program completion rates (55%) higher than those reported in Queensland (44%), South Australia (28%), and international studies.[58-62] It also represents one of the largest continuous datasets collected using the same SF-36 version for over more than 30 years. In addition, postcodes were based on individuals' usual place of residence, although some may have temporarily stayed closer to hospital during recovery, and others may travel frequently between

metropolitan and remote areas. The smaller number of individuals with recorded remoteness of area of residence and the exclusion of Overseas/Unknown categories may have limited the ability to detect differences. This study also included only individuals who completed both pre- and post-program health-related quality of life assessments, which may introduce selection bias by excluding those who dropped out early, were in poor health, or were unable to complete the SF-36 due to literacy or language barriers. Outcomes were based on self-reported health-related quality of life, which may be subject to recall bias and did not allow assessment of whether improvements were sustained over time. Health-related quality of life was measured using the SF-36 Version 1.0 (Australia/New Zealand Acute, English only). Neither the SF-36 instrument nor individual country of birth captured cultural or social differences in how individuals interpreted and reported their health-related quality of life. Although Version 2.0 exists with updated wording and response options to improve precision, Version 1.0 was used to maintain comparability with earlier program data.[63] Lastly, the proportion of participants born overseas increased over time, and no analyses accounted for this temporal change, which may have influenced findings as cardiac rehabilitation has evolved with population and program changes.

CONCLUSION

Health-related quality of life improved across all domains following a publicly funded cardiac rehabilitation program in a culturally and socioeconomically diverse region of Australia. Individuals born overseas reported more modest improvements in perceived health changes, while those unemployed or retired reported more modest improvements across all eight domains. Associations for pensioner status were less consistent and did not remain significant after correction. Socioeconomic status of area was not associated with change, suggesting equity may be shaped more by individual circumstances than by area-level disadvantages. Individuals in regional areas reported more modest improvements in physically demanding roles, while those in remote areas reported more modest improvements in both physical and emotional role functioning. To support equitable recovery, programs may need culturally adapted materials, support for those without workplace-based resources, and flexible delivery through digital or home-based options.

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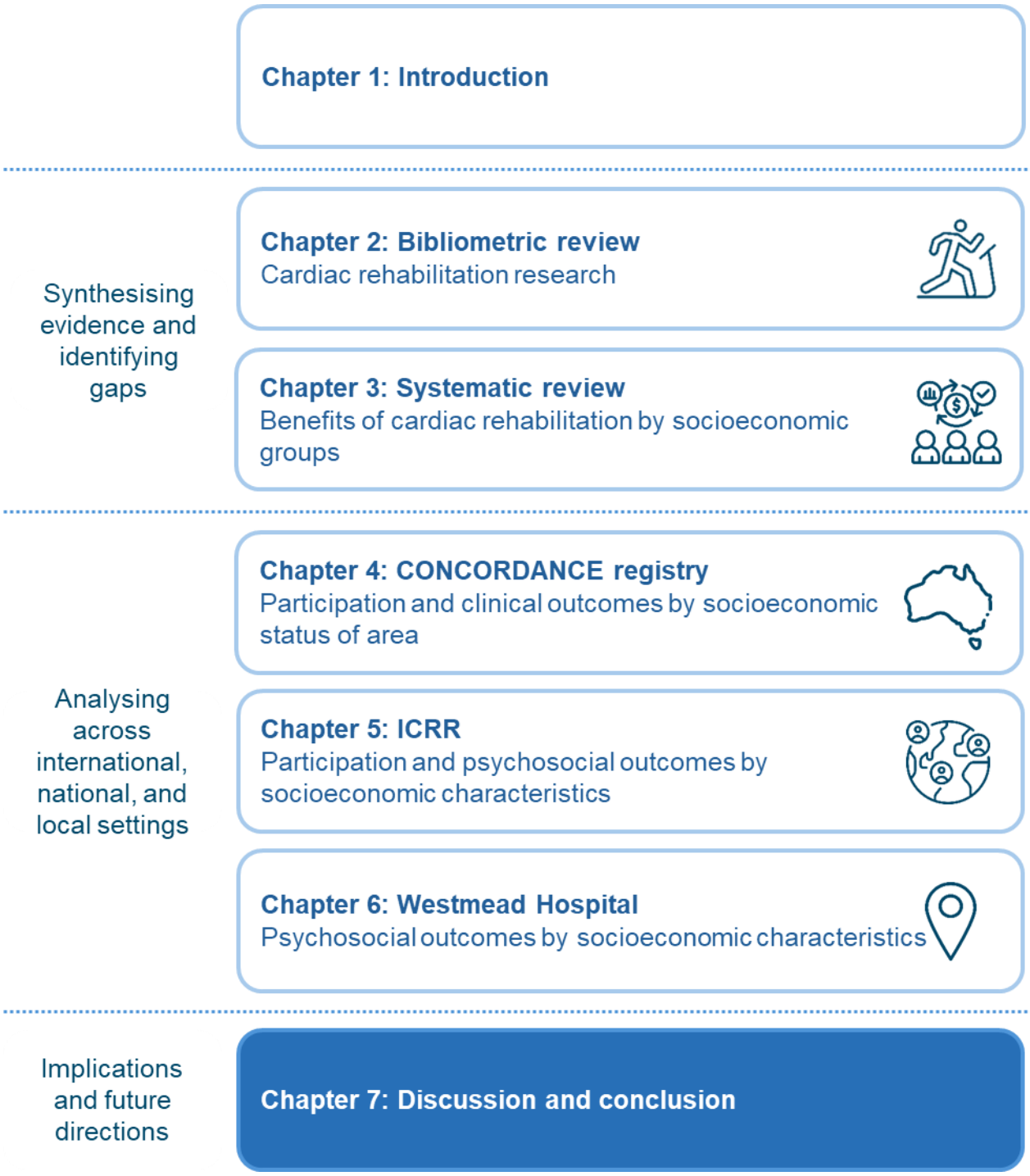
CHAPTER 7

Discussion and conclusion



Cardiac rehabilitation is a core secondary prevention strategy that supports recovery after a cardiac or vascular event, reduces the risk of recurrence, and alleviates pressure on healthcare systems. This thesis examined how socioeconomic characteristics, measured at both area and individual levels, were associated with participation, completion, and outcomes of cardiac rehabilitation across international, national, and local settings. Despite differences in setting and study design, a consistent pattern was observed. Individuals residing in areas of lower socioeconomic status, those residing in more remote areas, reporting lower educational attainment, experiencing financial strain, those who were unemployed or retired, and those born overseas rather than in country of residence were less likely to participate or complete programs. Among those who completed cardiac rehabilitation, clinical outcomes were comparable across socioeconomic groups, including reduced risk of major adverse cardiac events and mortality. Psychosocial outcomes also improved overall, but improvements in depressive symptoms and health-related quality of life were more modest among individuals from disadvantaged subgroups.

The key findings can be summarised as follows:

1. **Socioeconomic characteristics are underrepresented in the cardiac rehabilitation literature:** Chapter 2 showed that socioeconomic characteristics remain underrepresented in the global literature, with low-resource settings largely absent. Chapter 3 confirmed that few studies examined participation or outcomes by socioeconomic subgroup.
2. **Participation and completion are consistently lower among disadvantaged groups:** Across Chapters 3-6, lower socioeconomic status of area, greater remoteness of area, lower educational attainment, financial strain, unemployment or retirement, and being born overseas were associated with lower participation and completion.
3. **Clinical outcomes are comparable once completion is achieved:** Chapters 3 and 4 showed that participation was associated with lower all-cause mortality and reduced risk of major adverse CVD events, with no evidence of differences across socioeconomic groups.
4. **Return to work is less common among disadvantaged groups:** Chapter 3 found that lower socioeconomic status of area and lower educational attainment were

associated with lower return to work rates, even when clinical outcomes were comparable.

5. **Psychosocial improvements are more modest among disadvantaged groups:** Chapters 5 and 6 showed that while psychosocial outcomes improved overall, improvements in depressive symptoms and health-related quality of life were smaller among individuals reporting financial strain, those unemployed or retired, those born overseas, and those residing in more remote areas.

Together, these findings show that while cardiac rehabilitation delivers comparable clinical benefits across socioeconomic groups, inequities remain in referral, participation, completion, and psychosocial recovery. Addressing these disparities will require strategies that are targeted, context-specific, and sustainable. For example, adapting program delivery to different health literacy levels and cultural backgrounds, strengthening integration with primary care, community-based, and financial services, and collaborating with lower-income countries to enhance program capacity and research. The sections that follow expand on each of these findings in detail.

Socioeconomic characteristics are underrepresented in the cardiac rehabilitation literature

Socioeconomic characteristics remain poorly represented in cardiac rehabilitation research, which may reflect the limited attention to equity highlighted in some previous reviews.[1-4] Publications have predominantly focused on exercise, recurrent cardiac events, and biomedical risk factor, with far fewer studies examining participation, completion, or outcomes stratified by socioeconomic subgroup.[1-4] The bibliometric review in Chapter 2 showed how persistent this imbalance has been across almost a century of research, and the systematic review in Chapter 3 confirmed that only a small proportion of studies analysed participation or outcomes according to these characteristics.

This lack of evidence may have several implications. Without routine reporting by socioeconomic status of area, remoteness of area, educational attainment, financial strain, employment status, or country of birth, it may not be possible to monitor who is excluded

from cardiac rehabilitation and at what point along the referral, enrolment, completion pathway. As a result, interventions may not be directed toward those most at risk of dropping out, and disparities could widen.[5-7] When registries are used for quality improvement or innovation, the findings may reflect individuals who are already advantaged, such as those with higher literacy, English fluency, or more familiarity with navigating services, while those with fewer resources are less visible.

The gap appears most evident in low- and middle-income countries, where the availability and density of cardiac rehabilitation programs are lowest relative to disease burden.[8] Although research output from these regions is increasing, it remains sparse compared with high-income countries. Several factors may contribute to this. Limited access to research training reduces opportunities for clinicians and academics to design studies, analyse data, and prepare manuscripts for publication.[9-11] Even when studies are conducted, many may be published in institutional or national repositories that are not indexed in international databases, meaning they are not captured in bibliometric analyses, systematic reviews, or guideline development.[9-11] Publication fees may also be unaffordable, discouraging submissions to international journals and further limiting the visibility of work local research.[9-11] As a result, cardiac rehabilitation delivery models that could be effective in constrained contexts may remain invisible in international reviews and guidelines. Addressing these barriers would require targeted strategies, including expansion of training in scientific analysis and writing, indexing of local repositories and theses, and subsidisation or waiver of publication fees.[12] Stronger collaboration between high- and lower-income countries could also support shared data infrastructure, co-authorship, and greater visibility for research emerging from low-resource settings.

There may also be missed opportunities to learn from delivery models developed in lower-income countries. Community-based rehabilitation for physical disabilities, although different from cardiac rehabilitation, has been successfully delivered in schools, private residences, retirement homes, and community halls.[13-15] Some of these approaches have already been adapted in high-income settings, including Canada, where they were used to promote independence in daily activities.[13-15] While cardiac rehabilitation requires disease-specific components, it could build on these examples by adapting nurse- and community healthcare

worker-led group education and low-cost exercise delivered in existing clinics or community spaces.[8,16] These adaptations may also provide lessons for improving efficiency and reach in high-income countries.

As outputs from low- and middle-income countries become more visible, the global literature may be better balanced by documenting pragmatic and scalable delivery models. This could provide room for research in high-income countries to focus more on newer outcomes and technologies, such as the management of postural orthostatic tachycardia syndrome (POTS), which shares several symptoms with CVD conditions, and is increasingly discussed in more recent cardiac rehabilitation research.[17-2] Additionally, innovations in 360-degree virtual reality and motion capture technologies are expanding the scope of cardiac rehabilitation, enabling more precise tailoring of exercise training to each individual.[17-24] A combined agenda of simple and practical models from low-resource settings and technological advances and innovative delivery methods from high-income countries may broaden the scope of cardiac rehabilitation research and reduce the current disproportionate focus on exercise or biomedical outcomes.

Participation and completion are consistently lower among disadvantaged groups

Participation in cardiac rehabilitation was consistently lower among individuals from socioeconomically disadvantaged backgrounds, which is consistent with earlier studies that have reported lower participation among these groups.[25-28] This included those residing in areas of lower socioeconomic status or greater remoteness, reporting lower educational attainment, experiencing financial strain, being unemployed or retired, or being born overseas. This pattern was observed across the international literature in Chapter 3, the national CONCORDANCE registry in Chapter 4, the international ICRR in Chapter 5, and the local Westmead study in Chapter 6 These findings mirror inequities across the continuum of CVD care, from timely management of acute events through to adherence with secondary prevention interventions.[29-34]

At the individual-level, multiple barriers may contribute to this disparity. Individuals residing in disadvantaged or remote areas may face long travel distances, fewer transport options, and

reduced program availability.[35-37] Those with lower educational attainment may have lower health literacy, which could limit their ability to understand the purpose of cardiac rehabilitation sessions or to seek clarifying information outside the program.[38,39] Unemployment or retirement may be associated with financial strain, poorer mental health, and indirect costs, all of which could reduce participation.[36,40-43] For individuals born overseas, unfamiliarity with healthcare systems and limited English proficiency may make navigation more difficult, while the absence of family or community support may further reduce engagement.[44-49] Self-efficacy barriers, such as low motivation to change lifestyle, may compound these challenges.[37,50-52] Even with universal healthcare systems, competing responsibilities such as caregiving or paid employment may limit access.[53] These barriers may be exacerbated in low- and middle-income countries, where reliance on out-of-pocket costs or private insurance is greater and where universal coverage is absent.[8,37,50]

At the program-level, structural barriers reinforce disadvantage. In the ICRR study in Chapter 5, program-level differences in session number were associated with completion, suggesting that limited intensity can compound individual barriers. Programs serving disadvantaged areas may be less comprehensive, have weaker leadership, fewer training opportunities, and more constrained resources, all of which can affect quality.[35,54,55] While telehealth and hybrid models may extend access, participation could still be limited by the digital divide.[56-59] The availability of culturally adapted materials is often limited, and programs may lack staff with varied cultural or linguistic backgrounds. In some settings, healthcare systems may not be adequately prepared to integrate cultural practices or family involvement, which are central to participation in certain communities.[44-49]

Because these barriers overlap, strategies may need to operate at both the individual and system level. Automatic referral, whether electronic or paper-based, can reduce reliance on clinician discretion and ensure consistent offers of rehabilitation.[60,61] Printed information provided before discharge, reinforced by cardiologists, nurses, or allied health professionals, may improve understanding, particularly when adapted to different levels of health literacy.[62,63] Follow-up phone calls or text reminders could help reinforce these referrals. Cardiac rehabilitation programs can also strengthen partnerships with community services, for example, linking with subsidised transport, loaned exercise equipment, or digital literacy

training, although these supports depend on available resources.[37,64] Financial incentives have been tested, including co-payment removal, lotteries, or stipends linked to outcomes, and while they may improve participation and outcomes in the short-term, sustainability remains uncertain. Positioning cardiac rehabilitation as part of lifelong CVD management may also improve uptake and maintenance by linking lifestyle change to ongoing care, especially when delivered in collaboration with primary care providers who are trusted sources of support.[65-69]

Across all these approaches, culturally adapted materials, providers with similar backgrounds, and involvement of family or community support remain important.[70-73] Heart2Heart provides one example of a digital program that integrates language adaptations, cultural tailoring, and peer support to improve accessibility, social connectedness and psychosocial outcomes in cardiac rehabilitation.[74,75] Lower participation among socioeconomically disadvantaged groups remains a persistent challenge in cardiac rehabilitation.

Clinical outcomes are comparable once completion is achieved

Participation in cardiac rehabilitation was associated with lower all-cause mortality and reduced risk of major adverse CVD events, with comparable benefits across individuals residing in areas of lower socioeconomic status, those residing in areas of greater remoteness, those with different levels of educational attainment, and those reporting financial strain. The evidence was consistent across settings: the systematic review in Chapter 3 and the national CONCORDANCE study in Chapter 4 both confirmed that observed equity gaps appear to arise mainly from access and completion, with limited evidence of differential effectiveness once completion was achieved. Major adverse CVD event rates, however, were comparable across these groups, indicating that the benefits of cardiac rehabilitation in reducing major adverse CVD events were not significantly different across socioeconomic subgroups.

This trend aligns with systematic reviews of the effectiveness of cardiac rehabilitation on clinical outcomes. Earlier reviews reported significant reductions in all-cause mortality, whereas recent updates have found this effect to be statistically non-significant.[76-79] This shift may reflect advances in the broader context of CVD care, where timely acute management

and the widespread use of cardioprotective medications have improved early survival and reduced long-term risk. As a result, baseline survival is now higher, leaving less scope for cardiac rehabilitation to demonstrate additional effects on all-cause mortality. Despite this, cardiac rehabilitation remains effective for cardiovascular-specific outcomes, including reducing recurrent events, CVD mortality, and hospitalisation.[76-79] The findings of this thesis confirm that these benefits are consistent across socioeconomic subgroups, supporting the conclusion that programs are sufficiently structured and standardised to deliver equitable clinical outcomes once accessed. Communicating that cardiac rehabilitation offers meaningful benefits regardless of background may also help strengthen individual self-efficacy, while encouraging family and community support for participation and adherence to secondary prevention strategies.[51,52,72,73]

Return to work is less common among disadvantaged groups

While clinical outcomes were comparable once participation in cardiac rehabilitation was achieved, individuals residing in areas of lower socioeconomic status and those with lower educational attainment were less likely to return to work. The systematic review in Chapter 3 suggested this disparity, although the evidence was drawn from only a few studies and may have been limited by statistical power. Return to work may be shaped not only by medical recovery but also by workplace conditions, financial pressures, and broader socioeconomic resources, even when clinical recovery was otherwise comparable.

One possible explanation is that individuals from areas of lower socioeconomic status may present to cardiac rehabilitation at a later or more severe stage of disease, which could make return to work more difficult. Return to work also often requires employment environments that provide flexibility for gradual reintegration, modified duties, and access to paid sick leave.[80,81] These supports may be less available in areas with fewer secure jobs, or among individuals with lower educational attainment who may face greater difficulty negotiating workplace accommodations or navigating compensations.[38,39,82]

To address these inequities, collaboration between cardiac rehabilitation and external services could be expanded to include vocational counsellors, financial assistance providers, and

workplaces that support safe reintegration into employment.[83,84] In this way, programs can continue to deliver the core components of cardiac rehabilitation while complementary vocational and financial supports are provided through partnerships, although adherence to these external services is not guaranteed.[83,84]

Psychosocial improvements are more modest among disadvantaged groups

Participation in cardiac rehabilitation was associated with improvements in depressive symptoms, quality of life, and health-related quality of life. These findings, however, varied by group and setting. In the international ICRR study in Chapter 5, individuals reporting financial strain experienced greater improvements in depressive symptoms, while those employed full- or part-time showed smaller improvements compared with those unemployed or retired. No socioeconomic characteristics were associated with change in quality of life in this dataset. In contrast, the local Westmead program study in Chapter 6 showed that improvements in health-related quality of life were smaller among individuals who were unemployed or retired, those born overseas, and those residing in areas of lower socioeconomic status or greater remoteness. Together, these findings suggest that psychosocial recovery, like return to work, may be shaped not only by participation in cardiac rehabilitation but also by broader financial, social, and cultural circumstances.

These differences may reflect worse baseline depressive symptoms and health-related quality of life among disadvantaged groups, which could require longer time or additional counselling beyond the scope of standard cardiac rehabilitation to show significant improvement. Some patterns were unexpected. For example, individuals who were employed showed more modest improvements in depressive symptoms compared with those who were unemployed, which may reflect the stress or anxiety of returning to work or the time constraint of balancing employment with recovery.[85] A similar finding was described in a study conducted in a low- and middle-income country.[85]

Quality of life improved overall regardless of socioeconomic characteristics. However, because quality of life was assessed with a single-item measure, it may be less sensitive to inequities than multi-domain measures such as health-related quality of life, which capture

broader aspects of psychosocial recovery. This distinction is important, as while clinical outcomes were comparable once participation was achieved, efforts to reduce inequities in functional and psychosocial outcomes may be equally important, since they could shape longer-term recovery.[86,87]

Strengths and limitations

A strength of this thesis is its comprehensive design, with multiple study approaches brought together to examine socioeconomic disparities in cardiac rehabilitation. Bibliometric mapping, systematic review, and registry analyses were conducted across international, national, and local settings. Looking across these different contexts showed the value of triangulating evidence, where findings from one approach could reinforce or expand those from another. Another strength is the scale and diversity of the datasets analysed, which provided statistical power and the opportunity to test whether socioeconomic disparities persisted across different socioeconomic measures, outcomes, and healthcare systems. This thesis also extended beyond clinical outcomes to focus on equity and psychosocial outcomes, which are both crucial aspects of recovery but have been underexplored in past studies. Finally, the registry-based analyses in Chapters 4, 5, and 6 demonstrated that routine collection of socioeconomic and clinical data in cardiac rehabilitation is feasible and could be used to inform program improvement and guide relevant policy.

There are, however, limitations to consider. All studies in this thesis were observational, which means causality could not be established. Reviews of published evidence in Chapters 2 and 3 were likely affected by publication bias. Chapter 2 relied on a single database, and excluded non-English publications, which might overstate the underrepresentation of studies from low-income settings. Socioeconomic measures also varied between studies, limiting direct comparability. Some studies examined area-level socioeconomic status, while others examined individual characteristics such as educational attainment, employment status, or financial strain. Even within a single characteristic, definitions and categories differed depending on context. Selection bias may also have arisen, since registry analyses only included individuals who were already referred to cardiac rehabilitation programs. In addition, program-level differences in duration, intensity, workforce capacity, and delivery models could not be fully accounted for. Finally, confounding from factors such as social

support, caregiving responsibilities, or familiarity with navigating healthcare systems may have contributed to the associations, yet were left unmeasured.

Future cardiac rehabilitation research, practice and policy

Building on these findings, future directions can be considered across research, practice, and policy. The underrepresentation of socioeconomic characteristics highlighted in Chapters 2 and 3 shows the need for more consistent and standardised measures of socioeconomic status, educational attainment, employment status, financial strain, and cultural background across studies and registries. Standardisation would allow equity to be monitored and compared more consistently across settings. While additional measures such as social support, caregiving responsibilities, familiarity with navigating healthcare systems, and financial or digital literacy could be included to explain associations that are not captured in current datasets, they may be most valuable once core socioeconomic characteristics are routinely reported. Bibliometric mapping could be used alongside systematic review and registry analyses to track gaps in evidence and ensure that equity remains a routinely measured outcome.[3,88-92] Registry data provide opportunities to monitor access, completion, and outcomes in real-world settings, but they may still need to be complemented by qualitative and implementation studies to capture barriers to participation and challenges in program delivery. Co-design with individuals and the workforce may be central to this, ensuring that new models, materials, and strategies are relevant, feasible, and acceptable across diverse groups.[93]

While early uses of co-design largely focused on research processes, where advisory groups contributed to the framing and relevance of research questions, later applications extended this involvement into how care is structured and delivered, with individuals and healthcare professionals contributing alongside researchers.[94,95] In several non-cardiovascular chronic disease settings, including rheumatology and nephrology care, co-design has been used to improve continuity of care and to reshape outcome priorities, increasing attention to functional capacity and quality of life outcomes that were underrepresented in clinician-led models.[96-99] In applied health and rehabilitation contexts, similar co-design approaches have informed changes to educational session content and delivery, including adaptation to different levels of health literacy, return to work commitments, caregiving responsibilities,

and local service capacity.[100,101] Viewed alongside the findings of this thesis, these examples suggest that co-design may have been primarily applied to reducing barriers to referral, participation, and completion, but with more limited application to addressing socioeconomic disparities in clinical or psychosocial outcomes once enrolled.

Findings from Chapter 3 to 6 showed that individuals from disadvantaged groups are less likely to participate and complete cardiac rehabilitation. Addressing this requires wider implementation of strategies already shown to increase participation, such as automatic referral, consistent discharge education, and follow-up reminders to reinforce the importance of cardiac rehabilitation as part of lifelong chronic disease management.[66] Workforce and program accreditation could help ensure that educational sessions, vocational support, and psychosocial care are delivered consistently.[102,103] Digital and hybrid programs could extend access and peer support, but healthcare professionals may need to play a larger role in promoting these options and integrating them with primary care and community services. Community organisations may also help provide complementary components when program capacity is constrained, ensuring that individuals are aware of available services and that secondary prevention continues to be prioritised within busy clinical settings. The Lions Club in Singapore is one example of a successful partnership between researchers, government, residential care facilities, and specialists such as prosthetists and vision care providers to extend rehabilitation for other chronic conditions; a similar approach could be adapted for cardiac rehabilitation to support disadvantaged groups.[104]

The finding that clinical outcomes were comparable across socioeconomic groups once completion was achieved, as shown in Chapters 3 to 4, suggests that equity gaps may lie more in access and participation than in the effectiveness of programs themselves. Policy efforts could therefore focus on embedding cardiac rehabilitation as part of lifelong CVD management. National audits and registries already show how routine data can be used to identify inequities and guide improvement. In the United Kingdom, the National Audit of Cardiac Rehabilitation identified post-COVID-19 declines in participation among females (-5.9%), males (-8.1%), and culturally and linguistically diverse individuals (-11%), prompting staff training and the expansion of hybrid and home-based delivery models.[105,106] In Australia, the QUICR trial is testing whether a collaborative, data-driven quality improvement approach

can increase completion and strengthen adherence to guidelines.107 In the United States, the CDC's Health Equity Indicators Toolkit provides a framework to identify disadvantaged areas and direct resources using measures such as overcrowded housing, spending more than 50% of household income on housing, and inadequate facilities.[108] Internationally, the ICRR demonstrates that collection socioeconomic data across countries is feasible and useful for monitoring.[109] Broader initiatives from the World Heart Federation (WHF) and the National Heart Foundation of Australia emphasise equity, sustainability, and alignment across systems. Linking future projects with the WHF Cardiac Rehabilitation Roadmap may help scale effective strategies internationally and embed equity as a central measure of program quality.

Conclusion

This thesis demonstrates that cardiac rehabilitation delivers consistent clinical benefits across socioeconomic groups, but participation and psychosocial recovery remain unequally distributed. Over nearly a century, cardiac rehabilitation has grown, predominantly driven by high-income countries, with limited focus on socioeconomic status (Chapter 2). Participation in cardiac rehabilitation was associated with lower mortality and hospital readmissions across socioeconomic subgroups (Chapter 3). Participation was also associated with reduced risk of major adverse CVD events, with no variation by area-level socioeconomic status (Chapter 4). This shows that effectiveness is consistent once accessed. Depressive symptoms improved more among those reporting financial strain but less among those employed full- or part-time, with no socioeconomic variation in quality of life (Chapter 5). Health-related quality of life improved overall but to a smaller extent among those unemployed or retired, born overseas, or residing in remote areas (Chapter 6). These disparities appear to arise primarily from barriers to completion rather than program effectiveness. Addressing them will require embedding socioeconomic considerations in research, program delivery, and policy through strategies such as automatic referral, culturally adapted materials, workforce training, integration with primary care and community services, and collaboration between higher- and lower-income countries. Implementing these strategies would enable cardiac rehabilitation to contribute more fully to reducing health inequities.

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APPENDICES

APPENDIX 1

APPENDIX 1.1

Generative AI was used to assist with copyediting. Generative AI was employed to improve sentence structure, clarity, and grammatical consistency. The AI tool used was GPT-4 and GPT-5 (Open AI), and the prompt was: *"Check grammar, improve clarity, while making minimal changes."*

APPENDIX 1.2 (Chapter 2, Page 55, line 55-58)

Generative AI was used to assist with debugging R error messages. The AI tool used was GPT-4 (OpenAI), and the prompt was: *"I need the graph to show ..., fix this error ... accordingly."* Outputs were validated by running the code in RStudio to confirm alignment with the dataset.

APPENDIX 1.3 (Chapter 6, Page 160, line 6-8)

Generative AI was used to assist in statistical analysis for the regression model. The AI tool used was GPT-45 (OpenAI), and the prompt was: *"Has this model been coded correctly? Optimise if not."* Suggestions to optimise model parameters were implemented and validated by running the code in RStudio to confirm alignment with the protocol.

CONCORDANCE

Cooperative National Registry of Acute Coronary care, Guideline Adherence and Clinical Events.

Patient Initials
(First 2 letters of the patients First Name and the First 2 letters of the patients Last Name)

ABBR_NAME
___ ___ /___ ___

Registration number

REG_NUM
___ ___ ___ - ___ ___ ___

The purpose of the registry is to report observations regarding this patient's entire episode of care. Therefore, the information entered on this form should reflect the treatment received and clinical events that occurred from the time the patient was admitted until the time they left the health care system for this event.

This detail is required in order calculate the report items returned to your site and facilitate descriptive analyses on service provision.

This requires the collection of some information from hospitals the patient may have been transferred to. To assist in the completion of this questionnaire, please refer to the detailed completion notes.

The required responses include all Yes/No variables and those variables that are needed to calculate site reports items..

Eligibility Criteria Check List

Symptoms of ACS*	Yes ☐	No ☐
ECG changes	Yes ☐	No ☐
Increase in Biomarkers	Yes ☐	No ☐
Previous History of IHD/New documentation of CAD	Yes ☐	No ☐
Two high risk (adverse prognostic) features of ACS	Yes ☐	No ☐

Note: In order to be eligible for the study symptoms of ACS must be selected as 'yes' plus at least one other criterion. **This check list is not a required field** it is here to assist you with verifying the eligibility of the patient before the CRF is completed.

1. Admission details

1.01	**Patient initials**	**First Name** |___|___| **FIRST_NAME** **Last Name** |___|___| **LAST_NAME**
1.02	**Date of birth**	___ ___/___ ___/___ ___ ___ ___ **DOB** (dd/ mm/ yyyy)**AGE**
1.03	**Sex**	Male ☐ Female ☐ **SEX**
1.04	**Was an ambulance called for this episode?**	Yes ☐ No ☐ **AMBULANCE** Unknown ☐
1.05	**If *Yes*, what date was the ambulance called?**	___ ___/___ ___/___ ___ ___ ___ (dd/ mm/ yyyy) **AMBULANCE_DATE** **AMBULANCE_DATETIME**
1.06	**What time was the ambulance called?**	___ ___ : ___ ___ (use 24 hr clock, 12:00 = midday, 00:00 = midnight) **AMBULANCE_TIME**
1.07	**What date did the ambulance reach the patient?**	___ ___/___ ___/___ ___ ___ ___ (dd/ mm/ yyyy) **AMBULANCE_ARRIVAL_DATE** **AMBULANCE_ARRIVAL_DATETIME**
1.08	**What time did the ambulance reach the patient?**	___ ___ : ___ ___ (use 24 hr clock, 12:00 = midday, 00:00 = midnight) **AMBULANCE_ARRIVAL_TIME**
1.09	**Date of arrival at hospital #1**	___ ___/___ ___/___ ___ ___ ___ (dd/ mm/ yyyy) **HOSPITAL_ARRIVAL_DATE**
1.10	**Time of arrival at hospital #1**	___ ___ : ___ ___ (use 24 hr clock, 12:00 = midday, 00:00 = midnight) **HOSPITAL_ARRIVAL_TIME** **HOSPITAL_ARRIVAL_DT**
1.11	**Name of Hospital #1**	_____ **HOSPITAL**
1.12	**Was the patient transferred to another facility?**	Yes ☐ No ☐ Unknown ☐ **HOSPTAL_TRANSFER**
	If *Yes*,	
1.13	**Name of hospital #2**	_____ **HOSPITAL_TRANSFER_NAME**
1.14	**Date of arrival at hospital #2**	**HOSPITAL/___TRANSFER/___DATE**___ (dd/ mm/ yyyy)
1.15	**Time of arrival at hospital #2**	**HOSPITAL**:_**TRANSFER**(use_24**TIME**hrclock, 12:00 = midday, 00:00 = midnight) **HOSPITAL_TRANSFER_DT**
1.16	**Admission point at hospital #2**	ED ☐ Cath Lab ☐ Ward ☐ unknown ☐ **ADMISSION_POINT**
1.17	**Was the patient transferred to a third facility?**	Yes ☐ No ☐ Unknown ☐ **HOSP_TRANSFER_THIRD**
1.18	**If *Yes*, reason for transfer*:***	PCI ☐ CABG ☐ Other ☐ **HOSP_TRANSFER_THIRD_REASON**
1.19		Specify: **HOSP_TRANSFER_THIRD_SPECIFY**
1.20	**Name of Hospital #3**	**HOSP_TRANSFER_THIRD_NAME**

2. Demographic information and past medical history

2.01	**Patient's residential postcode**	___ ___ ___ ___ POST_CODE
2.02	**Does the patient have a regular GP/health care provider?**	☐ Yes ☐ No Unknown ☐ REGULAR_GP
2.03	**Does the patient have private health insurance?**	☐ Yes ☐ No Unknown ☐ PRIVATE_INSURANCE
2.04	**Indigenous Status**	☐ Not Aboriginal or Torres Strait Islander ☐ Aboriginal but not Torres Strait Islander ☐ Torres Strait Islander but not Aboriginal ☐ Both Torres Strait Islander and Aboriginal ☐ Maori/ Pacific Islander ☐ not stated/unknown INDIGENOUS_STATUS
2.05 2.06	**Country of birth**	☐ Australia ☐ New Zealand ☐ Pacific Islands ☐ Great Britain ☐ Other European ☐ African ☐ US/Canada ☐ South Asian (India, Sri Lanka, Pakistan, Bangladesh) ☐ China ☐ Other Asian ☐ Middle Eastern ☐ Other BIRTH_COUNTRY BIRTH_COUNTRY_OTHER Specify: _____
2.07	**Language**	☐ English is the first language ☐ English is the second language ☐ Unknown/not documented LANGUAGE
2.08	**Previous myocardial infarction**	Yes ☐ PREVIOUS_MYO ☐ No
2.09	**Exertional angina pectoris**	Yes ☐ EXERTIONAL_ANGINA ☐ No
2.10	**Congestive heart failure**	Yes ☐ CHRONIC_HEART_FAILURE ☐ No
2.11	**Previous coronary angiogram positive for coronary artery disease**	Yes ☐ PREVIOUS_ANGIOGRAM ☐ No
2.12	**Previous percutaneous coronary intervention**	Yes ☐ PREV_CORONARY_INTERV ☐ No
2.13a	**If *Yes*, enter the date of most recent intervention, or only the year if this is known.**	___ ___/___ ___/___ ___ ___ ___ (dd/ mm/ yyyy) PREV_CORONARY_INTERV_DATE
2.13b	**Or, if *Yes* enter only the year if this is known**	___ ___ ___ ___ (yyyy) PREV_CORONARY_INTERV_YEAR
2.14	**Previous coronary artery bypass graft (CABG)**	Yes ☐ PREVIOUS_CORONARY_GRAFT ☐ No

2.14a	**If *Yes*, enter year of CABG**	___ ___ ___ ___ (yyyy) **PREVIOUS_CORONARY_GRAFT_YEAR**		
2.15	**Previous positive stress test**	☐ Yes **PREVIOUS_STRESS_TEST**		☐ No
2.16	**Previous atrial fibrillation**	☐ Yes **PREVIOUS_ATRIAL**		☐ No
2.17	**Previous deep vein thrombosis/pulmonary embolism**	☐ Yes **PREVIOUS_DVT**		☐ No
2.18	**Previous major bleed**	☐ Yes **PREVIOUS_BLEED**		☐ No
2.19	**Previous metal valve replacement**	☐ Yes **PREVIOUS_VALVE**		☐ No
2.20	**Permanent pacemaker**	☐ Yes **PERMANENT_PACEMAKER**		☐ No
2.21	**Implantable defibrillator**	☐ Yes **IMPLANTABLE_DEFIBRILLATOR**		☐ No
2.22	**Chronic Renal Failure**	☐ Yes **CHRONIC_RENAL_FAILURE**		☐ No
2.23	**If *Yes*, is the patient on dialysis?**	☐ Yes **ON_DIALYSYS**		☐ No
2.24	**Previous stroke or transient ischemic attack diagnosed by a doctor**	☐ Yes **PREVIOUS_STROKE**		☐ No
2.25a	**If *Yes*, enter the date of the most recent stroke/TIA. If only the year is known, go to 2.25b.**	___ ___/___ ___/___ ___ ___ ___ **PREVIOUS_STROKE_DATE**		(dd/ mm/ yyyy)
2.25b	**If *Yes*, enter the year of the most recent stroke/TIA if it is known.**	___ ___ ___ ___ (yyyy) **PREVIOUS_STROKE_YEAR**		
2.26	**Diabetes**	☐ Yes **DIABETES**		☐ No
2.27	**If *Yes*, what treatment is the patient receiving?**	☐ Insulin requiring ☐ Oral hypoglycaemic medication ☐ Both insulin requiring and oral medication ☐ Not requiring medication **DIABETES_TREATMENT**		
2.28	**Hypertension**	☐ Yes **HYPERTENSION**		☐ No
2.29		If *Yes*, ☐ Treated **HYPERTENSION_TREATED** ☐ Non-treated		
2.30	**Dyslipidaemia**	☐ Yes	☐ No **DYSLIPIDAEMIA**	
2.31	If *Yes*	☐ Treated ☐ Non-Treated **DYSLIPIDAEMIA_TREATED**		
2.32	**Smoking History**	☐ Never smoked	☐ Ex Smoker **SMOKING_HISTORY**	☐ Current Smoker
2.33	**Family history of coronary heart disease**	☐ Yes **CHD**		☐ No
2.34	**Peripheral arterial disease**	☐ Yes **PAD**		☐ No

2.35	**Dementia/cognitive impairment**	Yes ☐	**DEMENTIA**	☐No
2.36	**Impaired mobility**	Yes ☐	**IMPAIRED_MOBILITY**	☐No
2.37	**Incontinence**	Yes ☐	**INCONTINENCE**	☐No
2.38	**Liver disease**	Yes ☐	**LIVER_DISEASE**	☐No
2.39	**Lung disease**	Yes ☐	**LUNG_DISEASE**	☐No
2.40	**Cancer limiting life expectancy**	Yes ☐	No ☐ **CANCER**	Unknown ☐
2.41	**Documented not for resuscitation**	Yes ☐	**NOT_FOR_RESUSCITATION**	☐No

3. Initial assessment and investigations.

Please enter the FIRST blood pressure and the FIRST heart rate recorded on admission to hospital.
The date and time of symptom onset is also required. Please enter the most recent episode of ACS symptoms that occurred within the 24hrs prior to hospital arrival, this is most likely to be the episode of symptoms that lead the patient to seek medical attention. If an estimate is required due to poor documentation in the medical record, record that it is an estimated time on the CONCORDANCE Patient Contact Sheet.

3.01	**Height**		__ __ __ cm	**HEIGHT**
3.02	**Weight**		__ __ __ kg	**WEIGHT**
3.03	**Blood pressure**	**SBP**	__ __ __ mmHg (Systolic)	First on admission to hospital
3.04		**DBP**	__ __ __ mmHg (Diastolic)	First on admission to Hospital
3.05	**Heart rate**	**HR**	__ __ __ / min	First on admission to Hospital
3.06	**Killip class *(select one)***		1☐ ☐ 2 ☐3 4☐	**KILLIP**
3.07	**Date of symptom onset**		__ __/__ __/__ __ __ __ (dd /mm/ yyyy)	**ONSET_DATE**
3.08	**Time of symptom onset**		**ONSET_TIME** __ __:__ __ (use 24 hr clock, 12:00 = midday, 00:00 = midnight)	**ONSET_DATETIME**
3.09	Number of episodes of angina in the previous 24 hrs including the presenting episode (Therefore, minimum of 1 episode should be recorded here). _____			**NUMBER_EPISODE_ANGINA**
3.10	**Cardiac arrest on admission?**		Yes ☐	**ADMISSION_CARDIAC_ARREST** ☐ No

4. Initial diagnosis

4.01	**Initial presumptive diagnosis**	STEMI/New LBBB NSTEACS or unstable angina Chest pain	**INITIAL_DIAGNOSIS**
4.02		If *Yes*, was risk stratification documented on admission Yes ☐ No	**RISK_STRATIFICATION_YN**
4.03		High risk Intermediate risk Low risk	**RISK_STRATIFICATION**
4.04		Other Specify _____	**INITIAL_DIAGNOSIS_SPECIFY**
4.05	**Was the index ECG indicative of ischaemia?**	Yes ☐ No ☐	**INDEX_ECG**
4.06		If *Yes,* Index ECG Date __ __/__ __/__ __ __ __	**INDEX_ECG_DATE**
4.07		Index ECG time ___ ___ : ___ ___	**INDEX_ECG_TIME** **INDEX_ECG_DATETIME**
4.08		Type of change on index ECG: ST elevation ST depression T wave inversion New Q wave New LBBB	**INDEX_ECG_ST_ELEVATION** **INDEX_ECG_ST_DEPRESSION** **INDEX_ECG_TYPE_T_WAVE** **INDEX_ECG_NEW_Q** **INDEX_ECG_NEW_LBBB**
4.09		Position of change: Anterior Inferior Lateral Posterior	**INDEX_ECG_POSITION_ANTERIOR** **INDEX_ECG_POSITION_INFERIOR** **INDEX_ECG_POSITION_LATERAL** **INDEX_ECG_POSITION_POSTERIOR**
4.10	**Other changes noted on index ECG**	Yes ☐ No ☐	**INDEX_ECG_CHANGES_YN**
4.11		If *Yes,* ☐ Non-specific ST/T wave change ☐ Atrial fibrillation ☐ Other	**INDEX_ECG_CHANGES**
4.12		Specify: _____	**INDEX_ECG_SPECIFY**

5. Investigations after admission

5.01	**Serum Creatine phosphokinase (CK)**	Yes ☐ No ☐	**CK**
5.02		If *Yes,* Peak value _____ U/L (within first 24 hrs)	**CK_PEAK_VALUE**
5.03		Upper limit of normal _____U/L	**CK_UPPER_LIMIT**

5.04	**Serum Troponin measured on admission**	Yes ☐ **TROPONIN**	No ☐
		If *Yes*, was a high sensitivity (HS) Troponin assay used?	
5.05		Yes ☐ **TN_HS**	No ☐
5.06/5.07		If *Yes*, select either HS TnT or HS TnI	
		☐ HSTnT **TN_HS_ASSAY**	☐ HSTnI
5.08		Troponin HS Peak value: _____ (within first 24 hrs)	☐ ng/L **TN_HS_PEAK_VALUE**
5.09		**TN_HS_ULN** Upper limit of normal _____	
5.09a		Lowest value **TN_HS_LV**	

If the troponin HS assay was not used enter the troponin value below. Only one peak value is required:

5.10/5.11	**TROPONIN_TNT**	TnT Peak value: _____ (within first 24 hrs)	☐ µg/ L ☐ U/L **TROPONIN_TNT_UM**
5.12		Upper limit of normal _____ **TROPONIN_TNT_UPPER_LIMIT**	
5.12a		Lowest value **TROPONIN_TNT_LV**	
5.13/5.14	**TROPONIN_TNL**	TnI Peak value: _____ (within first 24 hrs)	☐ µg/ L ☐ U/L **TROPONIN_TNL_UM**
5.15		Upper limit of normal **TROPONIN_TNL_UPPER_LIMIT**	
5.15a		Lowest value **TROPONIN_TNL_LV**	
		OR	
5.16		☐ positive ☐ negative **TROPONIN_TYPE**	

5.17	**Serum Creatinine**	Yes ☐ **CREATININE**	No ☐
		If *Yes* ,	**CREATININE_PEAK_DATETIME**
5.18		Value on admission **SERUM_CREATININE_ADMISSION**	
5.19		Peak value _____ (during hospitalisation)	**SERUM_CREATININE_PEAK**
5.20		Peak date __ __/__ __/__ __ __ __ (dd /mm/ yyyy)	**CREATININE_PEAK_DATE**
5.21		Peak time ___ ___ : ___ ___	**CREATININE_PEAK_TIME**
5.22		Upper limit of normal **SERUM_CREATININE_UPPER_LIMIT**	

5.23	**Serum lipid measured during admission.**	Total Cholesterol	☐ Yes ☐ No	**LIPID_TOTAL**
5.24			Value _____ mmol/ L	**LIPID_TOTAL_MMOL**
5.25		LDL Cholesterol	Yes ☐ No ☐	**LIPID_LDL**
5.26			Value _____ mmol/ L	**LIPID_LDL_MMOL**
5.27		HDL Cholesterol	☐ Yes ☐ No	**LIPID_HDL**
5.28			Value _____ mmol/ L	**LIPID_HDL_MMOL**
5.29		Triglyceride	Yes ☐ No ☐	**LIPID_TRIG**
5.30			Value _____ mmol/ L	**LIPID_TRIG_MMOL**

5.31	**Serum glucose**	Yes SERUM_GLUCOSE ☐ No If *Yes*, First measurement value:
5.32		_____ mmol/L SERUM_MMOL
5.33		Fasting? Yes No SERUM_FASTING Unknown
5.34	**HbA1c**	Yes HBA No☐
5.35		If *Yes*, First measured value: _____ % HBA_MEASUREMENT
5.36	**White Cell**	Yes WCC No☐
5.37	**Count**	If *Yes*, First measured value: _____ x10^9/L WCC_MEASUREMENT
5.38	**Haemoglobin measured during admission**	Yes HAEMOGLOBIN No☐ If *Yes*,
5.39		Initial Hb: _____ g/L HAEMOGLOBIN_HB HAEMOGLOBIN_HB_DATETIME
5.40		Initial Hb Date: __ __/__ __/__ __ __ __ (dd /mm/ yyyy) HAEMOGLOBIN_HB_DATE
5.41		Initial Hb Time: ___ ___ : ___ ___ (24 hr clock) HAEMOGLOBIN_HB_TIME
5.42		Lowest Hb: _____ g/L HAEMOGLOBIN_LOW HAEMOGLOBIN_LOW_DATETIME
5.43		Lowest Hb Date: __ __/__ __/__ __ __ __ (dd /mm/ yyyy) HAEMOGLOBIN_LOW_DATE
5.44		Lowest Hb Time: ___ ___ : ___ ___ (24 hr clock) HAEMOGLOBIN_LOW_TIME
5.45	**Platelets (Plt) measured during admission**	Yes PLATELETS No☐ If *Yes*, PLATELETS_HB
5.46/5.47		Initial Plt: _____ ☐ g/L or ☐ x10^9/L PLATELETS_HB_UM
5.48		Initial Plt Date: __ __/__ __/__ __ __ __ (dd /mm/ yyyy) PLATELETS_HB_DATE
5.49		Initial Plt Time: ___ ___ : ___ ___ PLATELETS_HB_TIME PLATELETS_HB_DATETIME
5.50/5.51	PLATELETS_LOW	Lowest Plt: _____ ☐ g/L or ☐ x10^9/L PLATELETS_LOW_UM
5.52		Lowest Plt Date: __ __/__ __/__ __ __ __ (dd /mm/ yyyy) PLATELETS_LOW_DATE
5.53		Lowest Plt Time: ___ ___ : ___ ___ (24 hr clock) PLATELETS_LOW_TIME PLATELETS_LOW_DATETIME
5.54	**Echocardiogram performed**	Yes ☐ ECHOCARDIOGRAM No☐
5.55		Date __ __/__ __/__ __ __ __ (dd /mm/ yyyy) ECHOCARDIOGRAM_DATE
5.56		Yes ☐ LV_FUNCTION No☐
5.57	**Left ventricular ejection fraction(LVEF) determined**	☐ Normal ☐ Mild impairment LV_FUNCTION_GRADE
5.58		☐ Moderate impairment OR _____ % LV_FUNCTION_PERCENT ☐ Severe impairment
5.59		Obtained via: ☐ Echo ☐ Nuclear Medicine Scan/MRI/CT or other imaging LV_FUNCTION_OBTAIN ☐ Ventriculogram

5.60	**Stress test performed**	☐ Yes ☐ No	**STRESS_TEST**
		If *Yes*, please specify	
5.61		Exercise test	
		Yes ☐ ☐ No	**EXERCISE_TEST**
5.62		Date __ __/__ __/__ __ __ __	**EXERCISE_TEST_DATE**
5.63		Result ☐ Positive for ischaemia ☐ Negative for ischaemia ☐ Indeterminate	**EXERCISE_TEST_RESULT**
5.64		Radionuclide study	
5.65		Yes ☐ ☐ No	**RADIONUCLIDE_STUDY**
5.66		Date __ __/__ __/__ __ __ __	**RADIONUCLIDE_STUDY_DATE**
		Result ☐ Positive for ischaemia ☐ Negative for ischaemia ☐ Indeterminate	**RADIONUCLIDE_STUDY_RESULT**
5.67		Stress echocardiography	
5.68		Yes ☐ ☐ No	**STRESS_ECHOCARDIOGRAPHY**
5.69		Date __ __/__ __/__ __ __ __	**STRESS_ECHOCARDIOGRAPHY_DATE**
		Result ☐ Positive for ischaemia ☐ Negative for ischaemia ☐ Indeterminate	**STRESS_ECHOCARDIOGRAPHY_RESULT**
5.70	**Electrophysiology study performed**	Yes ☐ No ☐	**ELECTROPHYSIOLOGY**
5.71	**Pacemaker inserted**	Yes ☐ No ☐	**PACEMAKER_INSERTED**
		If *Yes*, select one only;	
5.72		Temporary ☐ Permanent ☐ AICD ☐	**PACEMAKER_INSERTED_STATUS**
Refer to Completion Guidelines for protocol in the event the pacemaker falls into more than one of these options			
5.73	**Intra-aortic balloon pump required**	Yes ☐ No ☐	**INTRA_AORTIC_BALLOON**
5.74	**Mechanical Ventilation requiring invasive intubation?**	Yes ☐ No ☐	**VENTILATION**
		NB: If non invasive ventilation was used (eg: CPAP or BiPAP) for the treatment of heart failure enter this in section 11. (Major In-hospital Events)	

			CARDI_CATHETER_REFUSE
5.75/5.76 5.77 5.78 5.79 5.80 5.81 5.82 5.83 5.84	**Cardiac catheterisation performed**	Yes ☐ CARDI_CATHETERISATION If *Yes,* CARDI_CATHETER_DATETIME CARDI_CATHETER_DATE Date __ __/__ __/__ __ __ __ (dd /mm/ yyyy) Time ___ ___ : ___ ___ CARDI_CATHETER_TIME CARDI_CATHETER_REFUSE_SPECIFY Performed at ☐ Hospital #1 ☐ Hospital # 2 CARDI_CATHETER_HOSPITAL ☐ Hospital # 3 If a cardiac cath was performed at a facility not listed above, please enter the name of the hospital (this may include patients who were transported to another hospital for a day procedure) CARDI_CATHETER_OTHER_HOSP_SPEC (Hospital name)_____ Cardiac vessel/s with ≥ 50% stenosis: Left main CARDI_CATHETER_LEFT_MAIN LAD CARDI_CATHETER_LAD RCA CARDI_CATHETER_RCA LCX CARDI_CATHETER_LCX Vein graft CARDI_CATHETER_VEIN IMACARDI_CATHETER_IMA Angiography performed via Femoral access Radial Access CARDI_CATHETER_ANGIO Other CARDI_CATHETER_ANGIO_SPECIFY Specify _____	No ☐ If *No*, why? Patient refused ☐ Not documented ☐ Other ☐ Specify _____

5.85	**Cardiac CT angiography performed**	Yes CARDIAC_CT No If *Yes,*
5.86		Date __ __/__ __/__ __ __ __ (dd /mm/ yyyy) CARDIAC_CT_DATE
5.87		Time ___ ___ : ___ ___ CARDIAC_CT_TIME
5.88		Performed at ☐ Hospital #1 ☐ Hospital # 2__ CARDIAC_CT_HOSPITAL ☐ Hospital # 3__
5.89		If cardiac CT angiography was performed at a facility not listed above, please enter the name of the hospital (this may include patients who were transported to another hospital for a day procedure) CARDIAC_CT_OTHER_HOSPITAL_SPECIFY (Hospital name)_____
5.90		Cardiac vessel/s with ≥ 50% stenosis Left main CARDIAC_CT_LEFT_MAIN LAD CARDIAC_CT_LAD RCA CARDIAC_CT_RCA LCX CARDIAC_CT_LCX Vein graft CARDIAC_CT_VEIN_GRAFT IMA CARDIAC_CT_IMA

6. Reperfusion therapy and/or revascularisation procedure

6.01	**Thrombolytic therapy given**	Yes ☐ THROMB No ☐
6.02/6.03	THROMB_GIVEN	If *Yes,* Given Pre-hospital In-hospital
	THROMB_NON_TYPE	If *No,* ☐ Contraindication ☐ Patient refused ☐ Primary PCI ☐ Not indicated ☐ Unknown
6.04	THROMB_TYPE	Thrombolytic type Streptokinase Reteplase (rPA) Tenecteplase (TNK) Other
6.05		Specify THROMB_SPECIFY
6.06		Date started __ __/__ __/__ __ __ __ THROMB_DATE
6.07		Time started __ __:__ __ (24 hr clock) THROMB_TIME THROMB_DATETIME

6.08/6.11 **Percutaneous coronary intervention (PCI) performed?** ☒Yes **PCI** ☐No

If *No*, **PCI_NON_TYPE**

6.09 If *Yes*,

PCI_TYPE

First procedure was (select one only)
- ☒Primary(Emergency)
- ☐Rescue
- ☐Other

PCI_TYPE_SPECIFY
Specify _____

6.10/6.12

- ☐Patient refused
- ☐Not documented
- ☐Other

Specify _____
PCI_NON_TYPE_SPECIFY

6.13 Date of first PCI __ __/__ __/__ __ __ __ **PCI_DATE**

6.14 Time of first PCI __ __:__ __ **PCI_TIME** **PCI_DATETIME**

6.15 Vessel Treated:
- ☐Left Main **VESSEL_TREATED_LEFT_MAIN**
- ☐LAD **VESSEL_TREATED_LAD**
- ☐LCX **VESSEL_TREATED_LCX**
- ☐RCA **VESSEL_TREATED_RCA**
- ☐Vein graft **VESSEL_TREATED_VEIN_GRAFT**
- ☐IMA **VESSEL_TREATED_LEFT_IMA**
- ☐Not reported **VESSEL_TREATED_NOT_REPORTED**
- ☐Attempted, not successful **VESSEL_TREATED_ATTEMPTED**

6.16 # of stents used ☐Bare metal stent (BMS) **STENTS_BMS**

6.17 ☐Drug eluting stent (DES) **STENTS_DES**

(Bio-absorbable stents should be entered as DES)

6.18 Specify: DES /Bio stent tradename #1: **STENTS_DES_SPECIFY1**

6.19 DES/Bio stent tradename #2: **STENTS_DES_SPECIFY2**

6.20 Performed at:
- ☒Hospital #1
- ☐Hospital #2 __
- ☐Hospital #3 __

PCI_PERFORMED

6.21 If a PCI was performed at another facility not listed above, please enter the name of the hospital (this may include patients who were transported to another hospital for a day procedure)

PCI_PERFORMED_SPECIFY

(Hospital name)_____

6.22 PCI performed via
- ☒Femoral access
- ☒Radial Access
- ☐Other

PCI_VIA

Specify **PCI_VIA_SPECIFY**

6.23 _____

6.24	**Coronary artery bypass grafting (CABG) performed**	Yes ☐ **CABG**	☐ No
6.25		If *Yes,* Date of CABG __ __/__ __/__ __ __ __ **CABG_DATE**	
6.26	Performed at	☐ Hospital #1 ☐ Hospital #2 **CABG_PERFORMED** ☐ Hospital #3	

7. Medical treatment before arrival at hospital

Select *Yes* if the patient has routinely taken any one of the medical therapies listed below within the last 4 weeks. If the medical record indicates that the patient was taking the medical therapy as listed but does not specify the length of time, select *Yes*. If any of the medications listed below were given in the ambulance do not enter them here, enter them in section 8 of this form under 'Medical treatment received during hospitalisation'.

7.01	**Aspirin**	Yes **CHR_ASPIRIN**	No
7.02		Dose _____ mg/ day **CHR_ASPIRIN_DOSE**	
7.03	**Clopidogrel**	Yes **CHR_CLOPIDOGREL**	No
7.04		Dose _____ mg/ day **CHR_CLOPIDOGREL_DOSE**	
7.05	**Coplavix**	Yes **CHR_COPLAVIX**	No
7.06		Dose _____ mg/ day **CHR_COPLAVIX_DOSE**	
7.07	**Prasugrel**	Yes **CHR_PRASUGREL**	No
7.08		Dose _____ mg/ day **CHR_PRASUGREL_DOSE**	
7.09	**Ticagrelor**	Yes **CHR_TICAGRELOR**	No
7.10		Dose _____ mg/ day **CHR_TICAGRELOR_DOSE**	
7.11	**Apixaban**	Yes **CHR_APIXABAN**	No
7.12		Dose _____ mg/ day **CHR_APIXABAN_DOSE**	
7.13	**Rivaroxaban**	Yes **CHR_RIVAROXABAN**	No
7.14		Dose _____ mg/ day **CHR_RIVAROXABAN_DOSE**	
7.15	**Dabigatran**	Yes **CHR_DABIGATRAN**	No
7.16		Dose _____ mg/ day **CHR_DABIGATRAN_DOSE**	
7.17	**Warfarin**	Yes	No **CHR_WARFARIN**
7.18	**Beta-blocker**	Yes	No **CHR_BETABLOCKER**
7.19		If *Yes* Generic/trade name **CHR_BETABLOCKER_TRADENAME** _____	
7.20	**ACE-inhibitor**	Yes	No **CHR_ACEI**
7.21		If *Yes* Generic/trade name **CHR_ACEI_TRADENAME**	
7.22	**Angiotensin receptor blocker**	Yes	No **CHR_ARB**
7.23		If *Yes* Generic/trade name **CHR_ARB_TRADENAME** _____	
7.24	**Statin**	Yes	No **CHR_STATIN**
7.25		If *Yes*	
7.26		Generic/trade name **CHR_STATIN_TRADENAME** Dose _____ mg/ day **CHR_STATIN_DOSE**	

7.27	**Other lipid-lowering drug**	Yes ☐ No ☐ **CHR_OCD** If *Yes,* 1. Generic/trade name	
7.28		**CHR_OCD_SPEC1** _____	
7.29		Dose: _____ mg/day **CHR_OCD_DOSE1**	
7.30		2.Generic/trade name **CHR_OCD_SPEC2** _____	
7.31		Dose: _____ mg/day **CHR_OCD_DOSE2**	
8. Medical treatment received during hospitalisation.			
8.01	**Aspirin**	☐ Yes **IH_ASPIRIN** No ☐ If *Yes,*	
8.02		Maintenance dose _____ mg/ day **IH_ASPIRIN_DOSE**	
8.03	**Clopidogrel**	☐ Yes **IH_CLOPIDOGREL** No ☐ If *Yes,* **IH_CLOPIDOGREL_DATETIME**	
8.04		First in-hospital dose _____ mg **IH_CLOPIDOGREL_DOSE**	
8.05		Date commenced __ __/__ __/__ __ __ __ **IH_CLOPIDOGREL_DATE**	
8.06		Time commenced __ __:__ __ **IH_CLOPIDOGREL_TIME**	
8.07		Maintenance dose _____ mg/ day **IH_CLOPIDOGREL_MAINTENANCE_DOSE**	
8.08	**Coplavix**	☐ Yes **IH_COPLAVIX** No ☐ If *Yes,* **IH_COPLAVIX_DATETIME**	
8.09		First in-hospital dose _____ mg **IH_COPLAVIX_DOSE**	
8.10		Date commenced __ __/__ __/__ __ __ __ **IH_COPLAVIX_DATE**	
8.11		Time commenced __ __:__ __ **IH_COPLAVIX_TIME**	
8.12		Maintenance dose _____ mg/ day **IH_COPLAVIX_MAINTENANCE_DOSE**	
8.13	**Prasugrel**	☐ Yes **IH_PRASUGREL** No ☐ If *Yes,* **IH_PRASUGREL_DATETIME**	
8.14		First in-hospital dose _____ mg **IH_PRASUGREL_DOSE**	
8.15		Date commenced __ __/__ __/__ __ __ __ **IH_PRASUGREL_DATE**	
8.16		Time commenced __ __:__ __ **IH_PRASUGREL_TIME**	
8.17		Maintenance dose _____ mg/ day **IH_PRASUGREL_MAINTENANCE_DOSE**	
8.18	**Ticagrelor**	☐ Yes **IH_TICAGRELOR** No ☐ If *Yes,* **IH_TICAGRELOR_DATETIME**	
8.19		First in-hospital dose _____ mg **IH_TICAGRELOR_DOSE**	
8.20		Date commenced __ __/__ __/__ __ __ __ **IH_TICAGRELOR_DATE**	
8.21		Time commenced __ __:__ __ **IH_TICAGRELOR_TIME**	
8.22		Maintenance dose _____ mg/ day **IH_TICAGRELOR_MAINTENANCE_DOSE**	
8.23	**Apixaban**	☐ Yes **IH_APIXABAN** No ☐ If *Yes,* **IH_APIXABAN_DATETIME**	
8.24		First in-hospital dose _____ mg **IH_APIXABAN_DOSE**	
8.25		Date commenced __ __/__ __/__ __ __ __ **IH_APIXABAN_DATE**	
8.26		Time commenced __ __:__ __ **IH_APIXABAN_TIME**	
8.27		Maintenance dose _____ mg/ day **IH_APIXABAN_MAINTENANCE_DOSE**	

8.28	**Rivaroxaban**	☐Yes IH_RIVAROXABAN	No ☐
		If *Yes,*	IH_RIVAROXABAN_DATETIME
8.29		First in-hospital dose _____ mg	IH_RIVAROXABAN_DOSE
8.30		Date commenced __ __/__ __/__ __ __ __	IH_RIVAROXABAN_DATE
8.31		Time commenced __ __:__ __	IH_RIVAROXABAN_TIME
8.32		Maintenance dose _____ mg/ day	IH_RIVAROXABAN_MAINTENANCE_DOSE
8.33	**Dabigatran**	☐Yes IH_DABIGATRAN	No ☐
		If *Yes,*	IH_DABIGATRAN_DATETIME
8.34		First in-hospital dose _____ mg	IH_DABIGATRAN_DOSE
8.35		Date commenced __ __/__ __/__ __ __ __	IH_DABIGATRAN_DATE
8.36		Time commenced __ __:__ __	IH_DABIGATRAN_TIME
8.37		Maintenance dose _____ mg/ day	IH_DABIGATRAN_MAINTENANCE_DOSE
8.38	**Warfarin**	☐Yes IH_WARFARIN	No ☐
8.39	**Glycoprotein IIb/ IIIa receptor antagonist**	☐Yes IH_GLYCOPROTEIN	No ☐
		If *Yes,*	
8.40		Abciximab ☐ Eptifibitide ☐ IH_GLYCOPROTEIN_TYPE Tirofiban ☐	
			IH_GLYCOPROTEIN_DATETIME
8.41		Date commenced __ __/__ __/__ __ __ __	IH_GLYCOPROTEIN_DATE
8.42		Time commenced __ __:__ __	IH_GLYCOPROTEIN_TIME
8.43		GPIIb/IIIa receptor antagonist given during angiographic procedure? ☐ Yes ☐ No	IH_GLYCOPROTEIN_ANGO
8.44		Infusion Yes ☐ No ☐	IH_GLYCOPROTEIN_INFUSION
8.45	**Heparin (unfractionated)**	☐Yes IH_HEPARIN	No ☐
		If *Yes,*	IH_HEPARIN_DATETIME
8.46		Date commenced __ __/__ __/__ __ __ __	IH_HEPARIN_DATE
8.47		Time commenced __ __:__ __	IH_HEPARIN_TIME
8.48		Heparin given during angiographic procedure? Yes ☐ ☐ No	IH_HEPARIN_ANGIO
8.49	**Low MW Heparin**	☐Yes IH_LOW_HEPARIN	No ☐
		If *Yes,*	IH_LOW_HEPARIN_TRADENAME
8.50		Generic/trade name _____	
8.51		Maintenance dose _____	IH_LOW_HEPARIN_DOSE
8.52		Unit ☐ mg/day ☐ U/day ☐ ml/day	IH_LOW_HEPARIN_DOSE_UNIT
8.53		Date commenced __ __/__ __/__ __ __ __	IH_LOW_HEPARIN_DATE
8.54		Time commenced __ __:__ __	IH_LOW_HEPARIN_TIME
8.55		LMW Heparin given during angiographic procedure ☐Yes No	IH_LOW_HEPARIN_DATETIME IH_LOW_HEPARIN_ANGIO

8.56	**Bivalirudin**	Yes IH_BIVALIRUDIN	No
		If *Yes,*	IH_BIVALIRUDIN_DATETIME
8.57		Date commenced __ __/__ __/__ __ __ __	IH_BIVALIRUDIN_DATE
8.58		Time commenced __ __:__ __	IH_BIVALIRUDIN_TIME
8.59		Bivalirudin given during angiographic procedure Yes No	IH_BIVALIRUDIN_ANGIO
8.60	**Beta-blockers**	Yes IH_BETA_BLOCKER	No
		If *Yes,*	IH_BETA_BLOCKER_DATETIME
8.61		Generic/trade name _____	IH BETA_BLOCKER_TRADENAME
8.62		Date commenced in-hospital __ __/__ __/__ __	IH_BETA_BLOCKER_DATE
8.63		Time commenced in-hospital__ __:__ __	IH_BETA_BLOCKER_TIME
8.64	**ACE-inhibitor**	Yes IH_ACE	No
		If *Yes,*	IH_ACE_DATETIME
8.65		Generic/trade name	IH_ACE_TRADENAME
8.66		Date commenced in-hospital __ __/__ __/__ __	IH_ACE_DATE
8.67		Time commenced in-hospital __ __:__ __	IH_ACE_TIME
8.68	**Angiotensin receptor blocker**	Yes IH_ARB	No
		If *Yes,*	IH_ARB_DATETIME
8.69		Generic/trade name _____	IH_ARB_TRADENAME
8.70		Date commenced in-hospital __ __/__ __/__ __	IH_ARB_DATE
8.71		Time commenced in-hospital __ __:__ __	IH_ARB_TIME
8.72	**Statin**	Yes IH_STATIN	No
		If *Yes,*	IH_STATIN_DATETIME
8.73		Generic/trade name	IH_STATIN_TRADENAME
8.73a		Dose _____ mg/day	IH_STATIN_DOSE
8.74		Date commenced __ __/__ __/__ __ __ __	IH_STATIN_DATE
8.75		Time commenced __ __:__ __	IH_STATIN_TIME
8.76	**Other lipid lowering drug (see completion notes for details)**	Yes IH_OCD If *Yes,*	No ☐
8.77		1.Generic/trade name _____	IH_OCD_SPEC1
8.77a		Dose:_____ mg/day	IH_OCD_DOSE1
8.78		2.Generic/trade name _____	IH_OCD_SPEC2
8.78a		Dose:_____ mg/day	IH_OCD_DOSE2

9. Medical treatment at discharge or death			
9.01 9.02 9.03	**Aspirin**	Yes ☐ **DC_ASPIRIN** If *Yes,* Dose _____ mg/day **DC_ASPIRIN_DOSE**	No ☐ If *No*, is there a documented contraindication to aspirin in the medical record? Yes ☐ No ☐ **DC_ASPIRIN_CONTRA**
9.04 9.05 9.06	**Clopidogrel**	Yes ☐ **DC_CLOPIDOGREL** If *Yes,* Dose _____ mg/day **DC_CLOPIDOGREL_DOSE**	No ☐ If *No*, is there a documented contraindication to clopidogrel in the medical record? Yes ☐ No ☐ **DC_CLOPIDOGREL_CONTRA**
9.07 9.08 9.09	**Coplavix**	Yes ☐ **DC_COPLAVIX** If *Yes,* Dose _____ mg/day **DC_COPLAVIX_DOSE**	No ☐ If *No*, is there a documented contraindication to coplavix in the medical record? Yes ☐ No ☐ **DC_COPLAVIX_CONTRA**
9.10 9.11 9.12	**Prasugrel**	Yes ☐ **DC_PRASUGREL** If *Yes,* Dose _____ mg/day **DC_PRASUGREL_DOSE**	No ☐ If *No*, is there a documented contraindication to prasugrel in the medical record? Yes ☐ No ☐ **DC_PRASUGREL_CONTRA**
9.13 9.14 9.15	**Ticagrelor**	Yes ☐ **DC_TICAGRELOR** If *Yes,* Dose _____ mg/day **DC_TICAGRELOR_DOSE**	No ☐ If *No*, is there a documented contraindication to ticagrelor in the medical record? Yes ☐ No ☐ **DC_TICAGRELOR_CONTRA**
9.16 9.17 9.18	**Apixaban**	Yes ☐ **DC_APIXABAN** If *Yes* Dose _____ mg/ day **DC_APIXABAN_DOSE**	No ☐ If *No*, is there a documented contraindication to apixaban in the medical record? Yes ☐ No ☐ **DC_APIXABAN_CONTRA**
9.19 9.20 9.21	**Rivaroxaban**	Yes ☐ **DC_RIVAROXABAN** If *Yes* Dose _____ mg/day **DC_RIVAROXABAN_DOSE**	No ☐ If *No*, is there a documented contraindication to rivaroxaban in the medical record? Yes ☐ No ☐ **DC_RIVAROXABAN_CONTRA**
9.22 9.23 9.24	**Dabigatran**	Yes ☐ **DC_DABIGATRAN** If *Yes* Dose _____ mg/day **DC_DABIGATRAN_DOSE**	No ☐ If *No*, is there a documented contraindication to dabigatran in the medical record? Yes ☐ No ☐ **DC_DABIGATRAN_CONTRA**
9.25	**Warfarin**	Yes ☐ **DC_WARFARIN**	No ☐

9.26 9.27	**Beta-blockers**	Yes If *Yes*	**DC_BETABLOCKER**	No If *No*, is there a documented contraindication to beta-blockers in the medical record? Yes No **DC_BETABLOCKER_CONTRA**
9.28 9.29	**ACE-inhibitor**	Yes If *Yes*	**DC_ACEI**	No If *No*, is there a documented contraindication to ACE-inhibitors in the medical record? Yes No **DC_ACEI_CONTRA**
9.30 9.31	**Angiotensin receptor blocker**	Yes If *Yes,*	**DC_ARB**	No If *No*, is there a documented contraindication to angiotensin receptor blockers in the medical record? Yes No **DC_ARB_CONTRA**
9.32 9.33 9.34 9.35	**Statin**	Yes If *Yes,* **DC_STATIN_TRADENAME** Generic/tradename_____ Dose _____ mg/ day **DC_STATIN_DOSE**	**DC_STATIN**	No If *No*, is there a documented contraindication to statin therapy in the medical record? Yes No **DC_STATIN_CONTRA**
9.36 9.37 9.38 9.39 9.40	**Other lipid lowering drug**	Yes **DC_OCD** If *Yes,* 1.Generic/tradename _____ Dose_____ mg/day 2. Generic/trade name _____ Dose _____ mg/day	**DC_OCD_SPEC1** **DC_OCD_DOSE1** **DC_OCD_SPEC2** **DC_OCD_DOSE2**	No

10. Final diagnosis

Please review the medical record for the discharge diagnosis. If 'other' is selected and the patient had an elevated cardiac biomarker and/or ST elevation on their ECG you may need to confirm this is the correct option

10.01 10.02	ST-elevation MI	Non ST-elevation MI **DIAGNOSIS**	Unstable angina	Other **DIAGNOSIS_OTHER** Specify: _____
10.03	**Stent Thrombosis**	Yes	**STENT**	No	

11. Major in-hospital events and hospitalisation outcome (Please refer to the completion guidelines for definitions)

11.01	**Congestive heart failure (new or worsening)** Congestive heart failure is defined as symptoms of heart failure supported by objective or clinical evidence of heart failure. In the medical record this may be noted as the patients having received any of the following treatments, **IV diuretics** and/or **inotropes /CPAP** or **BiPAP** **Note:** a more detailed definition is provided in the completion note. **CONGESTIVE_FAILURE** Yes No Unknown

11.02	**Cardiogenic shock** CARDIO_SHOCK	☐ Yes	☐ No	☐ Unknown	
11.03	**Acute renal failure** RENAL_FAILURE	☐ Yes	☐ No	☐ Unknown	
11.04	**Recurrent ischaemia** ISCHAEMIA	☐ Yes	☐ No		
11.05	**Myocardial Infarction or re-infarction****	☐ Yes MYOCARDIAL	☐ No	☐ Unknown	
11.06	***MI: in patients admitted with UAP* MYOCARDIAL_DATE MYOCARDIAL_TIME	If *Yes,* MYOCARDIAL_DATETIME Date of onset of symptoms __ __/__ __/__ __ __ __ (dd/ mm/ yyyy) Time of onset of symptoms __ __: __ __ (24 hr clock)			
11.07	*Re-MI: in patients admitted with MI*	Select the cardiac marker measured prior to the chest pain event. Select one only;			
11.08		☐ TnT (HS) ☐ TnI (HS) ☐ TnT ☐ TnI MI_BIOMARKER			
11.09		Enter the troponin value **prior** to the event_____ TROPONIN_PRIOR			
11.10		Enter the troponin peak value **after** the event_____ TROPONIN_POST			
11.11		Specify the basis for diagnosis (select all that apply)			
	MI_DIAG_BASE_1	☐ Symptoms of ischaemia			
	MI_DIAG_BASE_2	☐ New ischaemic ST or T wave changes on ECG			
	MI_DIAG_BASE_3	☐ New Q wave on ECG			
	MI_DIAG_BASE_4	☐ Coronary thrombus on angiography			
	MI_DIAG_BASE_5	☐ Angiographic finding of procedural complication following PCI			
	MI_DIAG_BASE_6	☐ Imaging demonstrating loss of viable myocardium or wall motion abnormality following PCI			
	MI_DIAG_BASE_7	☐ New ischaemic changes on ECG following PCI			
	MI_DIAG_BASE_8	☐ New graft or native graft occlusion following CABG			
	MI_DIAG_BASE_9	☐ New Q wave or LBBB on ECG following CABG			
11.12	**Atrial Fibrillation/flutter**	☐ Yes ATRIAL	☐ No	☐ Unknown	
11.13	**Sustained VT**	☐ Yes SUSTAINED_VT	☐ No	☐ Unknown	
11.14	**AV Block 2^o, 3^o**	☐ Yes AV_BLOCK	☐ No	☐ Unknown	
11.15	**Cardiac Arrest or VF**	☐ Yes CARDIAC_ARREST	☐ No	☐ Unknown	
		If *Yes*			
11.16		Date: __ __/__ __ /__ __ ___ __CARDIAC_ARREST_DATE			
11.17		Time: __ __: __ __ CARDIAC_ARREST_TIME CARDIAC_ARREST_DATETIME			

11.18	**Stroke**	Yes ☐	STROKE	☐ No	Unknown ☐
11.19		If *Yes* Date of onset of symptoms		STROKE_DATE __ __/__ __/__ __ __ __ (dd/ mm/ yyyy)	
11.20		Stroke confirmed on CT/MRI		Yes ☐	No ☐ STROKE_CONFIRM
11.21		Type of stroke		Ischaemic ☐ Haemorrhagic ☐ STROKE_TYPE Unknown ☐	
11.22	**Bleeding event and/ or transfusion**	Yes ☐	MAJOR_BLEEDING	No ☐	
		If *Yes,*		MAJOR_BLEEDING_DATETIME	
11.23		Date: __ __/__ __/__ __ __ __		MAJOR_BLEEDING_DATE	
11.24		Time: __ __: __ __		MAJOR_BLEEDING_TIME	
11.25	MAJOR_BLEEDING_EVENT	Type of event (select one only)		Intercranial ☐ Retroperitoneal ☐ Intraocular ☐ Gastrointestinal/genitourinary bleeding requiring intervention(endoscopy/transfusion) or cessation of therapies ☐ CABG related ☐ Vascular Access ☐ Unknown ☐ Other ☐	
11.26				MAJOR_BLEEDING_SPECIFY Specify _____	
11.27	MAJOR_BLEEDING_HAEMATOMA	Consequence of event		Haematoma ≥ 5cm ☐	
	MAJOR_BLEEDING_REOPERATION			Reoperation for bleeding ☐	
	MAJOR_BLEEDING_TRANSFUSION			Blood product transfusion ☐	
	MAJOR_BLEEDING_REDUCTION			Hb (g/dL) reduction ☐	
	MAJOR_BLEEDING_ENDOSCOPY_THERAPI			Endoscopy Therapies ☐	
	MAJOR_BLEEDING_RADIO_SURG_INTERV			Radio Surg Intervention ☐	
	MAJOR_BLEEDING_REHOSP_PROLONGED_			Prolonged hospitalisation ☐	
11.29		No of units transfused _____		MAJOR_BLEEDING_TRANSF_UNITS	
11.30	MAJOR_BLEEDING_REDUC_LOWEST	Lowest Hb post event_____ g/dL			
11.31	**Patient enrolled in clinical trial?**	Yes ☐	ENROLLED	No ☐	
11.32	**Discharged alive**	Yes ☐	DISCHARGED_ALIVE	No ☐	
11.33		If *Yes,*		If *No,* DEATH_DATE	
11.34	DISCHARGED_DATE	Date: __ __/__ __/__ __ __ __		Date of death ___/___/_____	
11.35		Mode of Separation: Home ☐ Rehabilitation centre ☐ Other: ☐		MODE_SEPARATION	
11.36		MODE_SEPARATION_SPECIFY Specify: _____			

	DEATH_CARDIAC	Did the patient die of cardiac causes (if available)?	DEATH_NON_CARDIAC_REASON	
		Yes(select one only)		No (select one only)
DEATH_CARDIAC_REASON		MI ☐ Arrhythmia ☐ Cardiac rupture ☐ Cardiogenic shock ☐ Other ☐		Infection ☐ Major bleeding ☐ Stroke ☐ Other ☐
DEATH_CARDIAC_REASON_SPECIFY		Specify _____		Specify _____ DEATH_NON_CARDIAC_REASON_SPECIFY
Referred to Cardiac Rehabilitation program? Yes No **11.37**	CARDIAC_REHAB_REFERRAL ☐ ☐			

12.01	**This patient is enrolled in TEXTMED**	Yes ☐	No ☐	**ENROLLED_TEXTMED**
12.02	**This patient is enrolled in the AGRIS-GRACE Risk Study**	Yes ☐	No ☐	**ENROLLED_GRACE**
12.03	**This patient is enrolled in the AF Registry**	Yes ☐	No ☐	**ENROLLED_AF**

ANNOTATED CRF

CONCORDANCE

Cooperative National Registry of Acute Coronary care, Guideline Adherence and Clinical Events.

Patient Initials
(First 2 letters of the patients First Name and the First 2 letters of the patients Last Name)
___ ___ -___ ___

Registration number
REG_NUM
___ ___ ___ - ___ ___ ___

Time after initial visit
___ ___ months
(6 month follow-up)

Patient Hospital File Number
___ ___ ___ ___ ___ ___

To assist in the completion of this questionnaire, please refer to the detailed completion notes.

Section 1: Admission details

1.00a	Follow-up conducted	FOLLOWUP_DONE6	Yes ☐ No ☐
1.00b 1.00c		FOLLOWUP_NONREASON6	If *No* Patient refused ☐ Other ☐ FOLLOWUP_NONREASON_SPECIFY6 Specify: _____
1.01	Mode of follow-up (select all applicable options) MOD_GP_PRIMARYCARE6		☐ Letter MOD_LETTER6 ☐ Telephone MOD_TELEPHONE6 ☐ GP/primary care provider ☐ Hospital database MOD_HOSPDATA6 ☐ Other: MOD_OTHER_YN6
1.02	Other mode of follow-up	MOD_OTHER6	Specify: _____
1.03	Date of follow-up	FOLLOWUP_DATE6	___ ___/___ ___/___ ___ ___ ___ (dd/ mm/ yyyy)

Vital Status

1.04	Was the patient alive at follow-up?	ALIVE6	Yes ☐ No ☐
1.05		DEATH_DATE6	Date of death: __ __/__ __/__ __ __ __ (dd/mm/yyyy)
1.06		CARDIAC_CAUSE6	If *No*, did the patient die of a cardiac cause? ☐ Yes ☐ No ☐ Unknown

Hospitalisation since index admission (or up until date of patient's death). If the patient was readmitted to hospital with heart disease, enter the details for up to 3 admissions.

1.07 1.08	Has the patient been re-hospitalised for heart disease (including heart failure and/or atrial fibrillation) or a bleeding event since hospital discharge?	HD_ADMISSION6	☐ Yes ☐ No If *Yes* Total number of admissions |___|___| TOTAL_ADMISSION6
1.09	What was the time frame from index admission to first re-hospitalisation for heart disease?	TF16	☐ within 1 month ☐ between 1 and 6 months

1.10	**What was the time frame from index admission to second re-hospitalisation for heart disease?**	within 1 month between 1 and 6 months	TF26
1.11	**What was the time frame from index admission to the third re-hospitalisation for heart disease?**	within 1 month between 1 and 6 months	TF36

[redacted]

If CHF1="Y" or CHF2="Y" or CHF3="Y" then CHF6=1; Else CHF6=0;
The other variables follow the same pattern.

2.1.01	**Has the patient been hospitalised because of congestive heart failure (new or worsening)?**	Yes	No	Unknown	CHF1 CHF6
2.1.02	**Has the patient been hospitalised because of atrial fibrillation?**	Yes	No	Unknown	AF1 AF6
2.1.03	**Has the patient been hospitalised because of myocardial infarction/re-infarction?**	Yes	No	Unknown	MIR1 MIR6
2.1.04	**Has the patient been hospitalised because of stroke, including a transient ischaemic attack (TIA)?**	Yes	No	Unknown	STROKE1 STROKE6
2.1.05	**Has the patient been hospitalised because of recurrent angina?**	Yes	No	Unknown	RA1 RA6
2.1.06	**Has the patient been hospitalised because of a bleeding event?**	Yes	No	Unknown	MBE1 MBE6
2.1.07	**Has the patient been hospitalised because of stent thrombosis?**	Yes	No	Unknown	ST1 ST6
2.1.08	**Has a planned cardiac catheterisation been performed?**	Yes	No	Unknown	CC1 CC6
2.1.09	**Has an unplanned cardiac catheterisation been performed?**	Yes	No	Unknown	UCC1 UCC6
2.1.10	**Has a planned PCI been performed?**	Yes	No	Unknown	PPCI1 PPCI6
2.1.11	**Has an unplanned PCI been performed?**	Yes	No	Unknown	UPPCI1 UPCI6
2.1.12	**Has a planned coronary artery bypass graft been performed?**	Yes	No	Unknown	PCABG1 PCAGB6
2.1.13	**Has an unplanned coronary artery bypass graft**	Yes	No	Unknown	UCABG1 UCABG6

[redacted]

2.2.01	**Has the patient been hospitalised because of congestive heart failure (new or worsening)?**	Yes	No CHF2	Unknown
2.2.02	**Has the patient been hospitalised because of atrial fibrillation?**	Yes	No AF2	Unknown
2.2.03	**Has the patient been hospitalised because of myocardial infarction/re-infarction?**	Yes	No MIR2	Unknown

2.2.04	Has the patient been hospitalised because of stroke, including a transient ischaemic attack (TIA)?	☒Yes	☐No STROKE2	☐Unknown
2.2.05	Has the patient been hospitalised because of recurrent angina?	☒Yes	☐No RA2	☐Unknown
2.2.06	Has the patient been hospitalised because of a bleeding event?	☒Yes	☐No MBE2	☐Unknown
2.2.07	Has the patient been hospitalised because of stent thrombosis?	☒Yes	☐No ST2	☐Unknown
2.2.08	Has a planned cardiac catheterisation been performed?	☒Yes	☐No CC2	☐Unknown
2.2.09	Has an unplanned cardiac catheterisation been performed?	☒Yes	☐No UCC2	☐Unknown
2.2.10	Has a planned PCI been performed?	☒Yes	☐No PPCI2	☐Unknown
2.2.11	Has an unplanned PCI been performed?	☒Yes	☐No UPCI2	☐Unknown
2.2.12	Has a planned coronary artery bypass graft been performed?	☒Yes	☐No PCABG2	☐Unknown
2.2.13	Has an unplanned coronary artery bypass graft been performed?	☒Yes	☐No UCABG2	☐Unknown
Section 2.3: Hospital admission details since index admission (3rd readmission)				
2.3.01	Has the patient been hospitalised because of congestive heart failure (new or worsening)?	☒Yes	☐No CHF3	☐Unknown
2.3.02	Has the patient been hospitalised because of atrial fibrillation?	☒Yes	☐No AF3	☐Unknown
2.3.03	Has the patient been hospitalised because of myocardial infarction/re-infarction?	☒Yes	☐No MIR3	☐Unknown
2.3.04	Has the patient been hospitalised because of stroke, including a transient ischaemic attack (TIA)?	☒Yes	☐No STROKE3	☐Unknown
2.3.05	Has the patient been hospitalised because of recurrent angina?	☒Yes	☐No RA3	☐Unknown
2.3.06	Has the patient been hospitalised because of a bleeding event?	☒Yes	☐No MBE3	☐Unknown
2.3.07	Has the patient been hospitalised because of stent thrombosis?	☒Yes	☐No ST3	☐Unknown
2.3.08	Has a planned cardiac catheterisation been performed?	☒Yes	☐No CC3	☐Unknown
2.3.09	Has an unplanned cardiac catheterisation been performed?	☒Yes	☐No UCC3	☐Unknown

2.3.10	**Has a planned PCI been performed?**	Yes ☐	No ☐	**PPCI3** ☐ Unknown
2.3.11	**Has an unplanned PCI been performed?**	Yes ☐	No ☐	**UPCI3** ☐ Unknown
2.3.12	**Has a planned coronary artery bypass graft been performed?**	Yes ☐	No ☐	☐ Unknown **PCABG3**
2.3.13	**Has an unplanned coronary artery bypass graft been performed?**	Yes ☐	No ☐	☐ Unknown **UCABG3**

Section 3: Current medications (if patient alive)

3.01	**Aspirin** **ASPIRIN6**	Yes	No	Unknown
3.03	**Clopidogrel** **CLOPI6**	☐ Yes	☐ No	☐ Unknown
3.05	**Coplavix** **COPLA6**	☐ Yes	☐ No	☐ Unknown
3.07	**Prasugrel** **PRASUGREL6**	☐ Yes	☐ No	☐ Unknown
3.09	**Ticagrelor** **TICA6**	☐ Yes	☐ No	☐ Unknown
3.11	**Apixaban** **APIXABAN6**	☐ Yes	☐ No	☐ Unknown
3.13	**Rivaroxaban** **RIVAROXABAN6**	☐ Yes	☐ No	☐ Unknown
3.15	**Dabigatran** **DABIGATRAN6**	☐ Yes	☐ No	☐ Unknown
3.17	**Warfarin** **WARFARIN6**	☐ Yes	☐ No	☐ Unknown
3.18	**Beta-blockers** **BETA6**	☐ Yes	☐ No	☐ Unknown
3.20	**ACE-inhibitors** **ACE6**	☐ Yes	☐ No	☐ Unknown
3.22	**Angiotensin receptor blocker (ARB)** **ARB6**	☐ Yes	☐ No	☐ Unknown
3.24 3.26 3.26a	**Statin** **STATIN6**	☐ Yes ☐ If *Yes* ↓ Generic / trade name: **STATIN_GTN6** _____ **STATIN_DOSE6** Dose____ _	☐ No ☐	☐ Unknown ☐
3.27 3.28 3.28a	**Other lipid lowering drug** **OLLD6**	Yes ☐ If *Yes* ↓ Generic / trade name: **OLLD_GTN6** **OLLD_DOSE6** Dose _____	No ☐	Unknown ☐

Section 4: :Lifestyle factors				
4.01	**Serum lipid measured**	Yes ☐ No ☐ Unknown ☐		**SERUM_LIPID_PROFILE6**
4.01a		If *Yes,* Values within normal range? ☐ Yes ☐ No ☐ Unknown		**LIPID_NORMAL_RANGE6**
4.02		Total Cholesterol ☐ Yes ☐ No		**TC6**
4.03/4.04	**TC_VALUE6**	Value _____ ☐ mmol/ L	☐ mg/dL	**TC_UNIT6**
4.05		LDL Cholesterol ☐ Yes ☐ No		**LDLC6**
4.06/4.07	**LDLC_VALUE6**	Value _____ ☐ mmol/ L	☐ mg/dL	**LDLC_UNIT6**
4.08		HDL Cholesterol ☐ Yes ☐ No		**HDLC6**
4.09/4.10	**HDLC_VALUE6**	Value _____ ☐ mmol/ L	☐ mg/dL	**HDLC_UNIT6**
4.11		Triglyceride ☐ Yes ☐ No		**TRI6**
4.12/4.13	**TRI_VALUE6**	Value _____ ☐ mmol/ L	☐ mg/dL	**TRI_UNIT6**
4.14	**Currently Smoking**	Yes ☐ No ☐ Unknown ☐		**SMOKING6**
4.15		If *No,* Never smoked Former smoker (quit before ACS) Former smoker (quit after ACS)		**NO_SMOKING6**
4.16		**If the patient is a current smoker (or has quit following the ACS event) have any of the following been used to assist with smoking cessation?** Nicotine gum **SC_NICOTINE_GUM6** Medication **SC_MEDICATION6** Consultation with a psychologist **SC_CONSULTATION6** Self managed program **SC_SELF_MANAGED6** e cigarettes **SC_E_CIGARETTE6**		

4.18 **4.19**	**Since the index admission has the patient participated in cardiac rehabilitation?**	☐Yes	No ☐	Unknown ☒	**CREHAB6**
	If *Yes*, select from below; ☐1 session of group based cardiac rehabilitation (hospital based) ☐Risk factor counselling by telephone or internet ☐Community based exercise program ☐Self managed program				**CREHAB_SPEC6**
4.20	**How many times has the patient been to visit their GP or primary care physician?**	No of Visits_____			**VISITS_GP6**
4.21	**How many times has the patient been to visit their cardiologist?**	No of Visits_____			**VISITS_CARDIO6**
4.22	**Blood sugar level checked**	Yes☐	**BSL6**	No☒	
4.23	**Dietary advice**	Yes☐	**DIETARY_ADVICE6**	No☒	
4.24	**Current weight** **WEIGHT_FOLLOWUP6**	Value _____	kg☒	☐pounds	**WEIGHT_UNIT6**
4.25	**Current height** **HEIGHT_FOLLOWUP6**	Value _____	cm☒	☐feet	**HEIGHT_UNIT6**

Section 5: Quality of Life Assessment (EQ5D)		
5.00	**Quality of Life (QOL) assessment performed**	Yes ☐ No **QOL_ATTENDED6**
5.01	**Mobility (walking about)**	No problem Slight problem Moderate problem **MOBILITY6** Severe problem Unable to walk about
5.02	**Self Care (washing or dressing)**	No problem Slight problem Moderate problem **SELF_CARE6** Severe problem Unable to wash or dress
5.03	**Usual activities**	No problem Slight problem Moderate problem **USUAL_ACTIVITIES6** Severe problem Unable to perform usual activities
5.04	**Pain and discomfort**	No problem Slight problem Moderate problem **PAIN6** Severe problem Extreme pain
5.05	**Anxiety/Depression**	No problem Slight problem Moderate problem **ANXIETY6** Severe problem Extreme depression /anxiety

Contact: Sydney South West Area Health Service (SSWAHS)
Human Research Ethics Committee – CRGH
Concord Repatriation General Hospital (CRGH)
Concord NSW 2139
Telephone: *(02) 9767 5622* *Fax (02) 9767 6569*
Email: *ethicscrgh@email.cs.nsw.gov.au*

Our Ref: *(08/CRGH/180)*

CONCORD
REPATRIATION GENERAL
HOSPTIAL

25 November, 2008

A/Professor David Brieger
C/- Bernadette Costa
Cardiology Department
CONCORD RGH

Dear Professor Brieger,

Re: 08/CRGH/180 CH62/6/2008-141
Cooperative National Registry of Acute Coronary care, Guideline Adherence And Clinical Events (CONCORDANCE)

Thank you for submitting the above multi-centre project for single ethical and scientific review. This project was first considered by the Sydney South West Area Health Service Human Research Ethics Committee – CRGH Zone at its meeting held on 30 October 2008. This Human Research Ethics Committee (HREC) has been accredited by the NSW Department of Health as a lead HREC under the model for single ethical and scientific review.

This lead HREC is constituted and operates in accordance with the National Health and Medical Research Council's *National Statement on Ethical Conduct in Human Research* and the *CPMP/ICH Note for Guidance on Good Clinical Practice.*

I am pleased to advise that the Committee has granted ethical approval of this research project. The documents reviewed and approved include:

Protocol Identification Number:
Version: 2.0 Date: 11 November 2008

Master Participant Information Sheet & Consent Form
Version: 3.0 Date: 24 November 2008

Master Relative Participant Information Sheet & Consent Form
Version: 3.0 Date: 24 November 2008

Master Patient Letter 6 month follow-up
Version: 2.0 Date: 11 November 2008

Master Patient Letter 2 year follow-up
Version: 2.0 Date: 11 November 2008

Please note the following conditions of approval:

1. You will immediately report anything which might warrant review of ethical approval of the project in the specified format, including:
    - unforeseen events that might affect continued ethical acceptability of the project, (including Serious Adverse Events).

2. Proposed changes to the research protocol, conduct of the research, or length of HREC approval will be provided to the HREC for review in the specified format.

3. The HREC will be notified, giving reasons, if the project is discontinued at a site before the expected date of completion.

4. You will provide an annual report to the HREC, and at completion of the study in the specified format.

5. You will adhere to the study protocol at all times.

HREC approval is valid for four (4) years subject to the supply of an annual progress report. The first report should be sent to the Concord Hospital Research Office by **30/11/2009.**

Should you have any queries about the HREC's consideration of your project please contact the Executive Officer - Ms Virginia Turner on (02) 9767-5622. The HREC Terms of Reference, Standard Operating Procedures, membership and standard forms are available from the website: www.sswahs.nsw.gov.au/concord/ethics .

You are reminded that this letter constitutes ethical approval only. You must not commence this research project at a site until separate authorisation from the Chief Executive or delegate of that site has been obtained.

Please forward a copy of this letter to all site investigators for submission to the relevant Research Governance Officer.

We wish you every success in your research.

Please quote the above file number in all correspondence.

Yours sincerely,

Dr Garry Pearce
Chairman
SSWAHS Human Research Ethics Committee – CRGH

☐ ***Please complete and return a copy of this page to the Concord Hospital Research Office as acknowledgment of your acceptance of the Conditions of Ethical Approval.***

David Bregg — **Printed Name**
Chief Investigator

DB — **Signature**

1/12/08 — **Date**

International Council of Cardiovascular Prevention and Rehabilitation (ICCPR)

International CR Registry (ICRR)

VARIABLES&DEFINITIONS 8.0

Including data entry instructions

March 9, 2021
(post-registry build; pre-usability testing and pilot)

INSTRUCTIONS / INFORMATION BEFORE YOU BEGIN

For any questions, or access to the registry / logins, contact iccpr.icrr@gmail.com. From the main menu, select "enter clinical data" (blue rectangle) to get started. You will see your roster of patients there on your "my patients" screen, or can "add new patient" (top left, green rectangle). (Please note if you wish to delete a patient, we will need to contact Dendrite to do so [this is to prevent accidental deletion of data]).
We have purchased 5 licenses, and therefore 5 users across all sites can be in the registry at any one time. If you can't get on, check back a bit later. We are hoping this is sufficient given this is international, and hence sites will be in different time zones. If you often cannot get in, please email us so we can explore a solution.

Please note that all referred patients should be entered in ICRR if possible, so that we can assess the proportion of referred patients enrolling (CR quality indicator). For those patients who do not enroll, please complete all available information from their referral form. It is hoped that gender, year of birth, referral diagnosis / procedure could be completed.
Only the gender and year of birth variables are mandatory, but of course we encourage as complete data provision as possible to optimize the utility of the ICRR. See the dashboard document for information on how to see data completeness.
All continuous values have minimum and maximum values to prevent data entry errors. Many variables have a blue "i" in a white bubble; hover over it to see the definitions from this document on screen.
Variables are all available in the registry on specific pages, by assessment point. When you are in a record for a patient, you can skip to any page at any time, using the white rectangle drop-down menu in the top middle of any registry page. We have specified below in the table of contents on which registry page you can find the variables, and it is also shown in orange font below.
Timing of assessment (pre-program, post/progress or annual) of the below variables is shown in yellow highlight in the ensuing data dictionary. There is also information regarding when / how assessments stop if patients are unfortunately too ill or die.
Source of information is shown in blue font (program, and potentially patient). Note for patient-reported variables, follow what you have approved with your local ethics board. If patients do not have proficiency in English, you may ask the questions of the patient directly in- person, on the phone or video call if that is approved at your institution, and enter responses directly into the registry. If patients have English-language proficiency but do not have technology skills or access, ICRR can provide you paper versions of the items at each assessment point for their completion, and then someone from your program with an approved ICRR login can enter the data. Just ask!

Table of Contents:

PROGRAM-REPORTED VARIABLES

PRE-PROGRAM/INTAKE ONLY

These variables are all found on page 1 of the registry.

1. Year of Birth

Indicate the patient's year of birth (or best estimate if patient does not know and it is not recorded). This variable is mandatory

Data Entry: 4 digits

2. Gender

Select the patient's sex. This variable is mandatory. *Data Entry*: Choices available are (choose 1):

- ☐ Male
- ☐ Female
- ☐ Other /unknown

3. **Referral Diagnoses**

The referral diagnosis refers to the most recent diagnosis preceding the patient's referral to cardiac rehabilitation. There may be more than one possible referral diagnosis reported if the second occurred within the same hospitalization period. DO NOT report historical diagnoses

Data Entry: Choices available are (select all that apply):

- ☐ Stable coronary artery disease or stable angina
- ☐ Acute coronary syndrome (ACS; e.g., myocardial infarction)
- ☐ Heart failure
- ☐ Other (e.g., arrhythmia, valvular disease)

4. Referral Intervention(s)

Report cardiac interventions or procedures preceding the patient's referral to cardiac rehabilitation (no longer than 1 month). There may be more than one possible referral procedure reported if the second occurred within the same hospitalization period (check all that apply). DO NOT report interventions in the past, as they cannot be reliably captured in all patients.

Data Entry: check all that apply

○ Percutaneous coronary intervention (PCI) ○ Bypass surgery (CABG)
○ Valve surgery or intervention ○ Heart transplant
○ Mechanical circulatory support (e.g., VAD)
○ Rhythm Device insertion (e.g. CRT, ICD, pacemaker) ○ Ablation
○ Other ○ None

5. Initial assessment date

Enter the date the patient had their initial visit with the CR program for assessment of risk, history, etc. This could be in-person or remote.
Note: this date will be used to determine when to trigger follow-up assessments of patients, based on duration of your program as denoted in the program survey. Note 2: If no initial assessment do not enter a date. Even if patients do not enrol, if they are open to completion of patient-reported surveys for comparative purposes and this is approved through your local ethics board, please denote that by providing their contact information in the designated spot.

Data Entry: Enter a date. DD/MMM/YYYY

0. Patient data source

☐ Patient (if this is selected, you will be prompted to provide mobile # and/or email address)

☐ Program is entering patient-reported data (ie., you will ask the questions of the patient)

☐ Neither (i.e., no patient-reported data will be provided)

IF NEITHER IS SELECTED
The patient-related pages of the registry will not be available to complete.

If this was an error and you wish to enter patient data, change your selection. Then you have to click either "Next Page" or "Save & Exit" before the drop-down list at the top of the page is re- populated with the patient-related pages.

IF PATIENT IS SELECTED:
Please note that texts cost the ICRR, so we prefer email, and the registry is set up to contact patients via email first. If there is no response after a week or 2, a text will be sent.

When entering a mobile number, it should be in this format: + CCC NNNNNNN, as follows:
It is necessary to prefix it with a "+" denoting it's an international number.
"CCC" is the international dialling code for the country (as many digits as required).
"NNNNNNN" is the number including any area code. We haven't constrained the number of digits, as the number template differs from country to country. There should be no prefixed "0" or "1".

Once patient contact information is entered, the patient-reported survey for pre-program will be sent by the registry to the patient by the next day. It will come from: icrr@e-dendrite.com

on behalf of DCS Intellect Web <noreply@e-dendrite.com>. The subject line will read “Cardiac Rehab Registry”. Perhaps inform your patient to watch for it.

This will no longer be available 14 days from initial assessment date as it is assumed health behaviour would have changed from baseline. If no initial assessment date is entered, the registry will work from the first date you entered any data on the patient.

Note you can see a log of when correspondence is sent to patients, and if they respond, including dates, by clicking the blue rectangle named “pt report log” from the main menu.

Also note that if the patient is providing data, the post-program survey will not be sent to patients if you specify “death” as cause of premature program termination on page 5 of the registry (program conclusion) for variable 7. The annual surveys will not be sent if you specify “patient died” or “patient to ill to complete further assessments” on any annual follow-up (page 9 or the registry, variable 27). This information is also outlined with the variables below for clarity.

Patients may also request to stop contributing data at any time and/or to withdraw previous data. ICRR has a process in place to enact this, which involves removing any email or text # from this variable. Patients can request this at any time at: https://globalcardiacrehab.com/ICRR-for-Patients. We will be in touch as needed if we receive any such requests, and request you contact us if you receive such requests.

If the patient is alive and has not requested to stop receiving surveys to you or to ICRR between now and the end of when their program would be done (according to the timing provided for your program duration), they will receive the post-program survey at the above contact information. See below for more information.

PROGRAM-REPORTED VARIABLES
POST-PROGRAM ONLY (PROGRESS)

You informed ICRR of the number of weeks duration of your program in the initial program survey. Your site is set up so the post-program assessment will be due the specified number of weeks from the initial assessment date (if no initial assessment date is provided. On the patient search / "my patients" listing page, the "post-program assessment status" column will show as "assessment due" when it is the time to complete this assessment. When data are entered, it will show in green as "up-to-date".

These variables are all found on page 5 of the registry. This section should be completed for ALL patients who enrolled, *regardless of whether they did not complete the program*.

6. Supervised Exercise Sessions Completed

Enter the total number of supervised (on-site, but could be remote if the full session is supervised in real-time remotely) exercise classes completed by the patient during their rehab program (we have the number prescribed from your completed program survey; this can be used to assess program adherence). Do not count days the patient exercises independently at home as that is captured elsewhere. Alternatively, click the box if the patient is in an unsupervised program.
Even if the patient dropped out (which will be captured in the next variable), please report # attended.

Data Entry: click one of the 2 buttons
If you select "supervised exercise", then a box will appear to enter the # of sessions
Or select "patient enrolled in solely home-based program, where exercise classes are not remotely monitored in real-time"… but technology may be used (this is captured also in patient- reported items); this is basically "not applicable"

7. Premature Program Termination / Program Completion

Premature termination refers to the instance where patients do not complete their prescribed exercise sessions or other core components of the program. To complete the CR program a patient must have attended at least some of the CR intervention components AND also have completed a formal re-assessment by the CR team at the conclusion of the CR intervention.

Indicate the reason for premature termination of the patient's cardiac rehab program, if applicable. For example, a cardiac clinical event or procedure could be having bypass surgery or experiencing heart failure decompensation or exacerbation so having to stop coming. A non-cardiac clinical event or procedure could be contracting an infectious condition or cancer for example.

Data Entry: click one of the 2 buttons; more options appear if you click the first:

☐ Premature program termination (i.e., patient did not complete post-program assessment), for the following reason (select 1):

- ☐ Lost to follow-up or unknown / Patient dropout for non-clinical reasons
- ☐ Return to work
- ☐ Clinical issue – Cardiovascular (non-fatal)
- ☐ Clinical issue – Non cardiovascular (non-fatal)
- ☐ Death (*note: once this is selected, this record will be denoted as complete*)
- ☐ other

☐ Program completion (i.e., patient engaged in interventions and had post-program re- assessment)

PROGRAM-REPORTED VARIABLES

PRE/INTAKE AND POST-PROGRAM (OBJECTIVE CLINICAL OUTCOMES)

For each, try to get information from maximum 3 months prior to initial assessment to max two weeks after initial assessment; for post-program, the test should be done +/- 3 weeks from discharge assessment date.

Even if the patient does not complete the program, try to get the values from whatever source you can.

These variables are all found on page 2 (pre-program) and 6 (post-program) of the registry.

8. Lipids: Low-Density Lipoprotein (LDL-C)

Data Source: Lab report

Data Entry: select units (mmol/L or mg/dL). Enter value obtained for LDL to 1 decimal place

☐ Unknown (If there are no values within the time window above, or, the patient did not have any repeat lipid test done at discharge, for example)

9. Body mass index

Enter the patient's BMI.
Data Source: Direct measurement of height (m) and weight (kg) at the intake and discharge assessment. You can use an online calculator to compute if it is easier (e.g., https://www.nhlbi.nih.gov/health/educational/lose_wt/BMI/bmicalc.htm)

Data entry: Enter value obtained from kg/m^2 to 1 decimal place if possible

10. Systolic and
11. diastolic blood pressure (BP; mmHg)

2009 Canadian Hypertension Education Program (CHEP) Recommended Technique for Measuring Blood Pressure

Place the cuff so that the lower edge is 3 cm above the elbow crease and the bladder is centered over the brachial artery. **The patient should be resting comfortably for 5 minutes in the seated position with back support.** The arm should be bare and supported with the antecubital fossa at heart level, as a lower position will result in an erroneously higher SBP and DBP. **There should be no talking, and patients' legs should not be crossed. At least three measurements should be taken in the same arm with the patient in the same position. The first reading should be discarded and the latter two averaged.**

CHEP Recommendations for accurate measurement of blood pressure:
https://guidelines.hypertension.ca/diagnosis-assessment/measuring-blood-pressure/

Enter the patient's systolic blood pressure (mmHg) and the patient's diastolic blood pressure (mmHg). BP assessement should be undertaken manually or with a validated automated device only (e.g., see:

http://www.dableducational.org/sphygmomanometers/recommended_c at.html).
Data Source: Direct measurement at the assessment.

Data entry: Enter value obtained from patient's SBP and DBP.

12. **Peak METs**

Indicate the peak metabolic equivalents of task (METs) achieved during a functional / exercise capacity test or assessment (e.g., GXT, ISWT, 6MWT) in the space provided (we will know the type of test from your program survey responses). The METs can be estimated from standard equations using speed and grade, or can be calculated from the direct measurement of oxygen consumption using gas analysis.

DASI can also be used; DASI is converted to METS by dividing the total score by 3.5.
Conversion table for 6MWT (issues if have to use shorter than 30 m passage) to METs:
https://iacpr.net/resources/Documents/6MWT%20Distance%20Conversion%20Table%20.pdf
Conversion for watts to METs: https://exrx.net/Calculators/CycleMETs
Ideas on conversion of Incremental Shuttle Walk Test to METs (see Table 2 in particular):
https://bjsm.bmj.com/content/42/1/36.long (see also:
https://journals.lww.com/jcrjournal/Fulltext/2019/05000/Validity_of_the_Incremental_Shuttle_Walk_Test_to.13.aspx)

Data Source: Exercise stress test or other functional assessment.
Data Entry: Enter the numeric value of the peak METs as indicated by the exercise test report to the nearest 1/10 of a MET (i.e. 5.4 METs).

PATIENT-REPORTED OUTCOMES (if willing, and sufficient English language capacity, or staff administer)

PRE-PROGRAM/INTAKE only (send after receipt of referral and before first exercise session, after information about registry received by patient):

These variables are all found on page 3 of the registry.

13. Do you have someone in your life who you feel supports you emotionally and with your health?

- ☐ Definitely
- ☐ Most of the time
- ☐ Some of the time
- ☐ Rarely
- ☐ No I do not

14. For how many years did you do formal schooling / education?

_____ years

15. Has a doctor ever told you that you have any of the following health conditions? (check all that apply)

- ☐ Stroke / transient ischemic attack
- ☐ Peripheral vascular disease / claudication
- ☐ Diabetes
- ☐ Liver disease
- ☐ Kidney disease
- ☐ Lung disease (e.g., COPD, Asthma)
- ☐ Osteoporosis
- ☐ Cancer
- ☐ Human immunodeficiency virus / AIDS
- ☐ Movement disorder (e.g., parkinson's, tremor)
- ☐ Musculoskeletal issues (e.g., arthritis, hip or knee replacement)
- ☐ Cognitive issues (e.g., brain injury, cognitive impairment)
- ☐ Mental health problems, including sleep issues (e.g., depression, anxiety)
- ☐ Sexual issues (e.g., erectile dysfunction)
- ☐ Other (please specify: _____)
- ☐ None of the listed options

16. How much do you worry about having enough money to meet your basic needs, including health and health care?

- ☐ Not at all
- ☐ I sometimes worry about this
- ☐ I often worry about this

17. Do you have to pay for heart pills or medicines out of your own pocket?

☐ Yes, I have to pay for any medicine I take out of my own pocket, or some of the cost

☐ No, I have work benefits, or the government or some other source pays for all my heart medicine

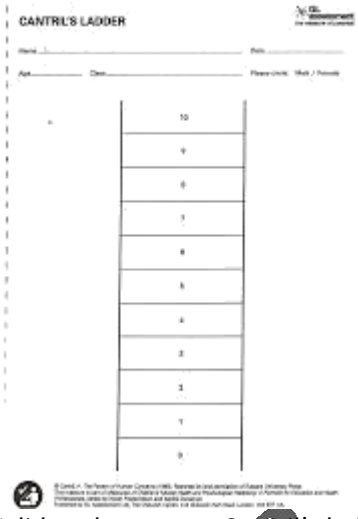
PRE/INTAKE, POST-PROGRAM (administered when program would have been done for all patients [which each program provided in the initial program survey], regardless of whether or not the patient completed the program; if program has no end date, send 4 months from pre-program assessment), and EACH YEAR FROM INITIAL PRE-ASSESSMENT:

These variables are all found on page 4 (pre-program), 7 (post-program/progress), and 10 (first annual) of the registry.

Subsequent annual follow-ups are generated automatically by the registry. They will appear on the main patient search / "my patients" page in the follow-up column as "assessment due" at the applicable number of years from the initial assessment date.

18. My Quality of Life

Assume that this ladder is a way of picturing your life. The top of the ladder represents the best possible life for you. The bottom step of the ladder represents the worst possible life for you. Circle the number that shows where on the ladder you feel you are right now.



Validated measure: Cantril's ladder of life
Data Entry: value between 0 (worst possible life) and 10 (best possible life)

19. Depressive symptoms (validated measure: PHQ-2):

Over the past 2 weeks, how often have you been bothered by any of the following problems?

a) **Little interest or pleasure in doing things**
b) **Feeling down, depressed or hopeless**

Response options are: not at all (0), several days (1), more than half the days (2), nearly every day (3).

20. **In the last month, how many servings of fruit and vegetables did you have in an <u>average</u> day?** (e.g., here are some examples of one serving: 125 mL [½ cup] fresh, frozen or canned vegetables or fruit; 250 mL [1 cup] leafy green vegetables such as lettuce, which is about the size of your fist; 1 small piece of fruit or vegetable such as an apple, guava, nectarine, orange, peach, pear,

large carrot or celery stalk; 60 mL [1/4 cup] of dried fruit such as raisins; or small 125mL glass of pure fruit juice [sugary drinks with fruity taste should not be counted]).

_____ servings /day

21. In the last month, how many minutes per week on average were you physically active to the point of being at least slightly short of breath?

_____ minutes / week

22. Do you use any form of tobacco? (e.g., smoking, vaping etc; select 1)

- ☐ Never = no history of using any form of tobacco
- ☐ Current = use of any form of tobacco within the last month
- ☐ Former = use of any form of tobacco more than one month ago

23. It is hard to remember to take your pills all the time if you take them. Over the last month, how often do you think you have taken your heart pills as directed by your doctor? (select 1)

- ☐ All the time
- ☐ Most of the time
- ☐ Some of the time
- ☐ Rarely
- ☐ Never

Note: this is scored as 1 "never" to 5 "all the time". The mean is shown in the dashboards (see separate file on reviewing reporting dashboards)

24. What is your current work status? (select 1)

- ☐ I work full or part-time for pay (includes self-employment)
- ☐ I am on disability (sick leave) or modified duties at work
- ☐ I am retired
- ☐ I have not been employed, or have been working without formal pay (e.g., household management)
- ☐ Other (e.g., can't work due to health)

POST-PROGRAM ONLY (PROGRESS):

These variables are all found on page 8 of the registry.
Again, these should be administered even if the patient did not complete the program if possible.

25. Please check whether you feel you are fully informed about each of the following ways to control your heart disease (answer yes or no for each):

		Yes	No
a	I know that my primary care or other healthcare provider was informed about what happened for me in cardiac rehab or I informed him/her (leave blank if you do not have a healthcare provider)	☐	☐
b	I understand what heart pills I should be taking	☐	☐
c	I know how to manage my stress	☐	☐
d	I know how much I should be exercising and at what intensity, so I can stay active	☐	☐
e	I know how to follow a heart-healthy diet	☐	☐
f	I know my blood pressure level and how to control it	☐	☐
g	I know my cholesterol level and how to control it	☐	☐
h	I know what to do if I have chest pain	☐	☐
i	I have been supported to get back to the life roles that are important to me (e.g., relationships, domestic duties, driving)	☐	☐

26. Did you do any part of your cardiac rehab **online or via phone**? (does not include scheduling sessions or appointments)

☐ Yes
☐ No

Each Year Post-Initial Assessment Date

Annual follow-ups consist of 1 program-reported variable (vital status; p. 9 or registry) and several patient-reported variables if they are willing (or the program may enter the information directly on behalf of the patient, depending on your arrangement; pages 10 and 11 of registry).

Note: death during the program is denoted through the 'premature program completion" variable #7. This will result in no more annual assessments (program or patient report) being triggered, and the patient record will be complete.

If you have learned your patient has died or is too ill to complete annual assessments, you can denote this in the registry at any time after the post-program assessment. For the first year, go into the record by clicking on the right record the main "my patients" page (you can do a search by year of birth, gender and initial assessment date, or registry ID from your excel file), and go to p. 9 of of 11 from the registry page dropdown in the top middle (white rectangle) called "program report of vital status – annual". Click <save & exit>.
For subsequent years, you can also denote this before the annual follow-up from the main "my patients" page, under the column at the far right "annual follow-ups from 2nd year"; select "patient died" or "patient to ill…." as applicable.

Once the patient is denoted as dead, the record is complete. If the patient is to ill to complete annual assessments, we would appreciate if you could still denote when the patient dies in the registry, by going to "my patients" / patient search page, under the column at the far right "annual follow-ups from 2nd year" and select a new patient follow-up from the dropdown menu, and then select "patient died".

If you simply want to stop annual follow-ups by patients based on patient request, please remove their contact information from page 1 in the registry; we would appreciate if you could still collect vital status annually until the patient has died and record it in the registry; The date of next annual assessment shall appear when due.

Subsequent annual follow-ups are generated automatically by the registry. They will appear on the main patient search / "my patients" page in the follow-up column as "assessment due" at the applicable number of years from the initial assessment date.

Program-Reported

The patient row will show in the colour yellow when this is due.
This program-reported variable for the first year is found on page 9 of the registry. For subsequent years, this will be found on main "my patients" page, under the column at the far right "annual follow-ups from 2nd year".

27. Vital Status

Data Source: call to patient's home / family members to check in about annual ability to complete assessment.

Suggested talking points: "Hello. This is [data steward] calling from [cardiac rehab program name].
Is this [patient's name]?" (if becomes apparent patient has passed, denote and offer condolences;
No further follow-up.)

If patient doing patient report: "I am calling to check in as it has been one year since you started your rehab program with us. Thank you again for taking part in the registry. You will be receiving a survey with 2 questions and I hope you can fill it out" (if patient provides valid reason why they cannot complete further assessment, denote so that survey no longer sent, or confirm patient alive). You should continue however to track vital status annually until patient expiry where possible.

In registry, update patient contact email or mobile if it has changed

Please note that in the registry, on the main page you can see when the next annual follow-up is due for each patient on the right.

☐ patient died (*note: once this is selected, this record will be denoted as complete*)
☐ patient alive
☐ patient too ill to complete any further assessments (e.g., moved to nursing facility, dementia, palliative, disabling stroke; *note selecting this will cease further emails/texts to patients reporting data*)
☐ Could or did not confirm

Patient-Reported

These variables are found on page 11 of the registry (for the first year); subsequent years will appear on the "patient search/ my patients" page when they are due under "annual follow-ups from 2nd year". See above how to cease follow-ups due to patient death, illness or request.

28. How often have you felt short of breath, dizziness or had chest pain on average in the past month?

❑ Never
❑ Rarely
❑ Sometimes
❑ Often
❑ Always

29. Have you been hospitalized or had another heart or other health problem in the past year?

☐ *Yes*
☐ No

29b. If yes, was it (check yes or no for each):

☐ A heart attack

☐ A stroke or mini-stroke (“brain attack”; transient ischemic attack)

☐ I went to the emergency department for a heart problem (e.g., chest pain, heart failure)

☐ I stayed in the hospital overnight for a heart problem

☐ I had a heart procedure (e.g., bypass surgery, stent, rhythm device inserted like a pacemaker)

☐ I went to the hospital for a reason other than my heart

☐ I had another new health diagnosis (e.g., kidney problems, diabetes, cancer, cognitive impairment) by my doctor

☐ I think I am sick, but have not seen a doctor

☐ Other

HUMAN RESEARCH ETHICS APPROVAL

The University of Sydney confirms that this project meets the requirements of the National Statement on Ethical Conduct in Human Research.

Project identifier: 2024/HE000866

Project title: The investigation of cardiac rehabilitation patient and program characteristics associated with patient completion and clinical outcomes in low- and middle-income countries

Version: 0.02

Chief Investigator: Dr Karice Hyun

Authorised project team: Ms Deborah Manandi

Dr Lore Candelaria

Professor Julie Redfern

Date of approval: Friday, 19 July, 2024

Project end date: 18 Jul 2028

Project summary

Cardiac rehabilitation programs improve patients' quality of life, prevent recurrent cardiovascular disease events, rehospitalisations and deaths. However, studies in high-income countries suggest that patients from advantaged socioeconomic status tend to engage with and benefit more from cardiac rehabilitation than their disadvantaged counterparts. In this project, we will investigate whether the relationship between cardiac rehabilitation completion rates in low/middle-income countries and change in patients' exercise capacity, cardiovascular risk factors and quality of life, differs by the characteristics or components offered by the cardiac rehabilitation programs. We will also investigate whether the relationship between cardiac rehabilitation completion rates in low/middle-income countries and change in patients' risk of having a cardiovascular event and dying, differs by self-reported socioeconomic status. This project will help us identify and target interventions towards cardiac rehabilitation programs that are less likely to be completed, and patients who are less likely to complete and benefit from these programs.

Documents approved

Document type	File name	Document version	Application version
Other	2024HE000866_Ethics Application_Revision_VFinal.docx	1	0.02
Application Attachment	ICRR_Ethics Project Description_Revision_VFinal.docx	1	0.02
Project description / Protocol	DM_ICRR Sub-Study Proposal_Revision_VFinal.docx	2	0.02

Conditions of Approval

- Research must be conducted according to the approved proposal.

- An annual progress report must be submitted on or before the anniversary of approval and a final report on completion of the project.
- You must report as soon as practicable anything that might warrant review of ethical approval of the project including:
  - ➢ Serious or unexpected adverse events (which should be reported within 72 hours).
  - ➢ Unforeseen events that might affect continued ethical acceptability of the project.
- Any changes to the proposal must be approved prior to their implementation (except where an amendment is undertaken to eliminate *immediate* risk to participants).
- Researchers working on this project must be sufficiently qualified by education, training, and experience for their role, or adequately supervised. Changes to the project team must be reported and approved.
- Researchers must disclose any actual, potential of perceived conflicts of interest, including any financial or other interest or affiliation, as relevant to this project.
- Research data and primary materials must be retained and stored in accordance with relevant legislation and University guidelines.
- Ethics approval is dependent upon ongoing compliance of the research with the *National Statement on Ethical Conduct in Human Research*, the *Australian Code for the Responsible Conduct of Research*, applicable legal requirements, and with University policies, procedures, and governance requirements.
- If your research project is a clinical trial and is being sponsored by the University or is to be conducted on a University of Sydney site, you must comply with additional University governance requirements prior to commencing your Clinical Trial.
- The University may conduct audits on approved projects.
- The Chief Investigator has ultimate responsibility for the conduct of the research and is responsible for ensuring all others involved will conduct the research in accordance with the above.

Ethics Committee Representative

Chair
On behalf of the University of Sydney

The University of Sydney HRECs are constituted and operate in accordance with the National Statement on Ethical Conduct in Human Research and the Australian Code for the Responsible Conduct of Research (NHMRC). All personnel named on the project should be acquainted with these documents.

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2022/PID01546 - 2022/ETH01373: Application HREA - APPROVED

no_reply@regis.health.nsw.gov.au <no_reply@regis.health.nsw.gov.au>

Wed 2022-10-05 9:20 AM

To:Robert Zecchin (Western Sydney LHD) <Robert.Zecchin@health.nsw.gov.au> Cc:
Matthew Hollings <matthew.hollings@sydney.edu.au>

Date of Decision Notification: 05 Oct 2022 05 Oct 2022

Dear Robert Zecchin,
Thank you for submitting the following Human Research Ethics Application (HREA) for HREC review;

2022/ETH01373: Changes in Health, Functional Capacity and Psychosocial Status in Western Sydney Patients Undergoing Cardiac Rehabilitation

This Application was reviewed as a Low or negligible risk review pathway and was initially considered by the Western Sydney Local Health District Human Research Ethics Committee at its meeting held on INITIAL MEETING DATE.
The project was determined to meet the requirements of the National Statement on Ethical Conduct in Human Research (2007) and was APPROVED. APPROVED.

This email constitutes ethical and scientific approval only.
This project cannot proceed at any site until separate research governance authorisation has been obtained from the Institution at which the research will take place.

This project has been Approved to be conducted at the following sites:

Westmead Hospital

The following documentation was reviewed and is included in this approval:

Study Protocol, 2022 09 28_WSLHD LNR_CR dataset protocol_v3_CLEAN.docx

Application Documents - (link will only be active for 14 days from the decision date. The approved documents are also available to download from forms section of this project in REGIS)

The Human Research Ethics Application reviewed by the HREC was:
Version: 1.02
Date: 28 Sep 2022

The approval is for a period of 5 years from the date of this e-mail (05 Oct 2022) (05 Oct 2022)

The Committee granted a waiver of the usual requirement of consent for the use of re-identifiable information held by NSW agencies, in line with the State Privacy Commissioner's Guidelines for Research and the Health Records and Information Privacy Act 2002 (NSW) and the Guidelines approved under Section 95/95A of the Privacy Act 1988.

The Coordinating Principal Investigator will:

- provide the HREC with an annual report and the final report when the project is completed at all sites. This will be through the submission of a milestone in REGIS.
- immediately report anything that might warrant review of ethical approval of the project.
- submit proposed amendments to the research protocol, including; the general conduct of the research, changes to CPI or site PI, an extension to HREC approval, or the addition of sites to the HREC before those changes can take effect. This will be through a notification of an amendment in REGIS
- will notify the HREC if the project is discontinued at a participating site before the expected completion date, with reasons provided.

Submission of annual progress/final reports (milestone), amendments and safety reports should be done through the forms provided in REGIS.
Guidance on these processes can be found on the REGIS website.

It is noted that the Western Sydney Local Health District Human Research Ethics Committee is constituted in accordance with the National Statement on Human Conduct in Human Research, 2007 (NHMRC).

Please contact us if you would like to discuss any aspects of this process further, as per the contact details below. We look forward to managing this study with you throughout the project lifecycle.

Regards,

Research Office
WSLHD Research & Education Network
Westmead Hospital, Cnr Hawkesbury & Darcy Rds, Westmead NSW 2145
Tel 02 8890 900