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Ph.D. Thesis

Social and Public Health Sciences Unit, School of Health and Wellbeing

College of Medical, Veterinary and Life Sciences (MVLS), University of Glasgow, UK

**Development and evaluation of home-based cardiac
rehabilitation in a low- and middle-income country setting**



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Thesis submitted for the degree of Doctor of Philosophy

The University of Glasgow, 2025

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	Professor Dr. Saidur Rahman Mashreky Honorary Professor & Advisor, Faculty of Public Health, Bangladesh University of Health Science (BUHS) and Department of Public Health, School of Health & Life Sciences, North South University

Thesis Abstract

Background

Cardiovascular disease (CVD) is the leading cause of premature death worldwide, disproportionately affecting low- and middle-income countries (LMICs). Despite this, in many LMIC setting including access to cardiac rehabilitation (CR), is extremely limited due to financial, geographic, and workforce constraints. Conventional centre-based CR models are challenging to scale equitably, leaving significant disease and treatment burden. Evidence from high-income countries shows that home-based CR can achieve similar health outcomes while improving accessibility. However, direct implementation in LMICs risks misalignment with local cultural, linguistic, and structural contexts (chapter 1). This doctoral research aimed to undertake a programme of research leading to the development, culturally adaptation, and evaluation of a culturally adapted home-based CR programme tailored to the Bangladeshi population and to inform implementation and future research.

Methods

Four linked research studies were undertaken. A scoping review to examine global literature on methods for adapting complex health interventions, with specific relevance to LMICs (chapter 2). An adaptation study to culturally and linguistically adapt the UK Heart Manual home-based CR programme for the setting of Bangladesh (chapter 3). A mixed methods study to assess the feasibility and acceptability of the adapted home-based programme and evaluation design (chapter 4). A systematic review and meta-analysis of randomised trials, evaluates the clinical and cost effectiveness, safety, and models of delivery of CR undertaken in LMICs (chapter 5).

Results

The scoping review identified 25 studies with a wide variation in their methodological quality, limited theoretical underpinning, inadequate reporting transparency, and a lack of evidence from LMICs. The review findings emphasise the need for a structured, theory-driven, and stakeholder-engaged process to intervention adaptation. The adaptation study resulted in the development of the 'Bangla Heart Manual', a culturally tailored, home-based cardiac rehabilitation (CR) intervention reflecting Bangladeshi health beliefs, language, and health system contexts. Stakeholders rated the manual highly for clarity, feasibility, and relevance to patient needs. The external feasibility study conducted in 33 patients demonstrated good participant recruitment and retention, and that Bangla Heart Manual that was useful, easy to integrate into daily routines, and safe, with no serious adverse events. The study also indicated improvements in patient health outcomes including exercise tolerance, lifestyle behaviours, psychological well-being, and health-related quality of life. The systematic review and meta-analysis identified 29 randomised trials of CR in LMICs in 6,489 people

with heart disease. In line with evidence from high income settings, the results confirmed that participation in CR improved functional capacity and patient-reported outcomes compared with usual care alone, and that home-based approaches can offer a scalable, cost-effective model in resource-limited health systems.

Discussion and conclusion

The research studies undertaken in this PhD sought to contribute to the evidence-base to improving access to CR in LMICs, with a particular emphasis on Bangladesh. This thesis discusses the strengths and limitations of this research programme and its implications for policy and practice and future research (chapter 6).

Preface

My journey into the world of cardiac rehabilitation began not in a lecture hall, but on the ground at the Ibrahim Cardiac Hospital & Research Institute (ICHRI) in Bangladesh. For over a decade, I have witnessed firsthand the transformative power of cardiac care, yet also the profound gap that exists once patients are discharged. We successfully treated acute cardiac events, but a comprehensive system to support long-term recovery, especially for the many facing the dual burden of heart disease and mental health challenges, remained a distant ideal. It was from this pressing clinical need and a deep-seated desire to bridge this gap that the vision for this PhD was born.

This dissertation, titled “Development and evaluation of home-based cardiac rehabilitation in a low- and middle-income country setting,” is the culmination of that vision. It represents a personal and professional mission to create an affordable, accessible, and sustainable model of care for the people of Bangladesh and similar contexts worldwide.

I have been profoundly fortunate to have the unwavering support and inspiration of two exceptional mentors. Professor Rod Taylor has been a guiding light in this process. His pioneering work in home-based cardiac rehabilitation, exemplified by the REACH-HF trial, provided the essential scientific foundation for my research. His mentorship during my clinical fellowship and his insightful guidance on complex intervention design have been invaluable. Similarly, Professor Ann Dorthe Zwisler has been a monumental influence. Her leadership in cardiac rehabilitation at REHPA, demonstrating the real-world impact of patient-centred rehab, inspired me to believe that such models could be adapted and thrive in a Bangladeshi context. The generosity with which they have shared their expertise and opened their networks to me has been a privilege I will always cherish.

The path of this PhD has been enriched by the collaboration and wisdom of countless individuals. I am deeply grateful for the opportunity to have engaged with renowned cardiologists, dedicated healthcare professionals, and insightful community leaders across Bangladesh. Their perspectives were instrumental in ensuring that the rehabilitation model we developed is not only clinically sound but also culturally resonant and practically feasible. The stakeholder round-table meeting in Dhaka in 2019 was a pivotal moment, reinforcing the collective will to scale up cardiac rehabilitation and highlighting the critical role of home-based programmes.

This work stands on the shoulders of the pioneering efforts at ICHRI, where we took the first steps to introduce and formalise cardiac rehabilitation in Bangladesh. From the initial post-surgery exercise programmes to the development of comprehensive follow-up manuals, that experience was the essential proving ground that made this research possible.

This thesis is more than an academic requirement; it is a testament to the power of global collaboration, local commitment, and the shared belief that every individual, regardless of their country's income, deserves the chance for a full and healthy life after a cardiac event. It

is my sincere hope that the findings within these pages will contribute to making affordable, home-based cardiac rehabilitation a standard of care, bringing hope and healing to countless families in Bangladesh and low and middle income countries.

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Dhaka, Bangladesh, 1st July' 2026

Declaration of used artificial intelligence (AI) tool:

In the preparation of this thesis, generative artificial intelligence (AI) tools (e.g., ChatGPT) were used in a limited and supportive capacity to assist with just rephrasing text for clarity and coherence. All AI-assisted outputs were critically evaluated, verified against original academic sources, and substantially revised to ensure accuracy and alignment with the research objectives. The intellectual content, analysis, interpretation, and conclusions presented in this thesis are entirely my own work. The use of AI did not contribute to the generation of original ideas, arguments, or the structure of the research. In accordance with the University of Glasgow's guidance, the use of generative AI has been transparently acknowledged and applied with appropriate oversight and academic integrity. This approach ensures compliance with institutional expectations that all submitted work reflects the author's own critical evaluation and contribution.

Acknowledgements

This doctoral research, conducted within the School of Health & Wellbeing, College of MVLS at the University of Glasgow, was made possible through the support of many individuals and organisations. I am grateful to MVLS for the financial support that enabled this PhD. I express my deepest gratitude to Allah for continuous mercy, guidance, and strength throughout this journey.

I am profoundly grateful to my supervisory team for their exceptional mentorship. My sincere appreciation goes to my principal supervisor, Professor Rod Taylor, for his sustained guidance and invaluable feedback and commitment to my academic and research growth. I also thank my co-supervisors, Dr Mithila Faruque and Professor Dr Saidur Rahman Mashreky, whose insight, encouragement, and consistent support were vital to completing this thesis. Their collective expertise ensured a supportive and motivating research environment.

I owe a special debt of gratitude to my wife for her wholehearted and emotional support, which was my anchor and enabled me to cross this journey without interruption. Thank you to my two children for their patience and understanding, and to my mother, my mother-in-law, and my entire family for their unwavering encouragement.

I appreciate the professional support of Professor Dr Rezaul Karim, Professor Dr. M A Rashid and Professor Dr Masoom Siraj during the pilot trial, and I am grateful to Dr Md Fakhru Islam Khaled, Professor (Dr) Sajal Krishna Banerjee, Professor (Dr) Chaudhury Meshkat Ahmed, and Mr Masum Khan for their guidance and encouragement.

The development of the Bangla Heart Manual was strengthened by the contributions of all healthcare professionals, patients, and caregivers who participated in expert consultations and focus groups. I extend special thanks to Dr Vicky Joshi for her contributions to the review studies, and to Valerie Wells for her assistance. I am also grateful to NHS Lothian, especially Louise Taylor and Carolyn Deighan, for facilitating translation approvals and Heart Manual facilitator training, with thanks to Professor Dr Hayes Dalal for his constructive guidance.

My sincere appreciation goes to all stakeholders involved in the adaptation activities. I also thank my colleagues in the Physiotherapy and Cardiac Rehabilitation Unit for their support with recruitment and feasibility study activities.

Finally, I thank my friends and colleagues for their encouragement throughout this journey. I share this achievement with all who supported me along the way.

Author declaration

I solemnly declare that the research presented in this thesis is entirely my own work, conducted under the guidance of my supervisory team. Each chapter, including the empirical studies reported in Chapters 2–5, was conceptualised, designed, executed, analysed, and written by me as part of my PhD research.

This thesis comprises four interconnected empirical studies, each developed as standalone manuscripts intended for publication in peer-reviewed journals. At the time of my thesis submission:

- **Chapter 2** (Scoping Review of Adaptation Studies) has been published in Translational Behavioural Medicine (TBM) Journal.
- **Chapter 3** (Adaptation of Home-Based Cardiac Rehabilitation) has been submitted to the BMC Health Services Research journal that has been accepted for publication (In Press)
- **Chapter 4** (Feasibility study of adapted home-based cardiac rehabilitation) has been submitted to the BMJ Open journal, under review process. (submission date: 17th March 2025)
- **Chapter 5** (Systematic review and meta-analysis; effectiveness, safety, costs, and mode of delivery considerations of cardiac rehabilitation in low- and middle-income countries) has been submitted to the European Journal of Preventive Cardiology (EJPC). (Submission date: 24 Dec 2025).

While these manuscripts are co-authored, the intellectual and practical contributions leading to their development were primarily my own, stemming directly from my doctoral research. I am the sole author of each manuscript, with co-authorship reflecting supervisory input, methodological guidance, or institutional collaboration.

Throughout my PhD journey, invaluable mentorship was provided by:

- **Main Supervisor:** Prof. Rod S Taylor (RST)
- **Co-Supervisors:** Dr. Mithila Faruque (MF) and Prof. Dr. Saidur Rahman Mashreky (SRM)

Their expertise and feedback were instrumental in refining the research direction, analytical rigor, and scholarly presentation. However, the core ideas, data collection, analysis, interpretation, and manuscript preparation were my independent contributions.

Detailed below is my substantial contribution to each of the co-authored manuscripts.

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Abbreviations:

CVD – Cardiovascular Disease

CHD – Coronary Heart Disease

LMICs – Low- and Middle-Income Countries

CR – Cardiac Rehabilitation

HICs – High-Income Countries

HBCR – Home-Based Cardiac Rehabilitation

HRQoL – Health-Related Quality of Life

RCT – Randomised Controlled Trial

ESC – European Society of Cardiology

AHA – American Heart Association

ACC – American College of Cardiology

WHO – World Health Organization

MI – Myocardial Infarction

CABG – Coronary Artery Bypass Graft

PCI – Percutaneous Coronary Intervention

ISWT – Incremental Shuttle Walk Test

HADS – Hospital Anxiety and Depression Scale

EQ-5D-5L – EuroQol 5-Dimension 5-Level Instrument

HeartQoL – Heart Disease Health-Related Quality of Life Questionnaire

NCDs – Non-Communicable Diseases

BACPR – British Association for Cardiovascular Prevention and Rehabilitation

REACH-HF – Rehabilitation Enablement in Chronic Heart Failure

ADAPT – A framework for Adapting interventions to new contexts

TIDieR – Template for Intervention Description and Replication

PRISMA – Preferred Reporting Items for Systematic Reviews and Meta-Analyses

CONSORT – Consolidated Standards of Reporting Trials

PROSPERO – International Prospective Register of Systematic Reviews

OSF – Open Science Framework

GRADE – Grading of Recommendations Assessment, Development and Evaluation

SF-12/36 – Short Form Health Survey (12 or 36 items)

6MWT – Six-Minute Walk Test

PeakVO₂ – Peak Oxygen Uptake

PHQ-9 – Patient Health Questionnaire-9

GAD-7 – Generalised Anxiety Disorder Assessment-7

BMI – Body Mass Index

Publications and manuscripts relating to this thesis

Current status of Papers 1-4 of my PhD		Student contribution
Chapter 2 (Paper 1)		
Paper 1 has been published as:	<u>Jamal Uddin</u>^{1,2}, <u>Vicky L Joshi</u>³, <u>Valerie Wells</u>¹, <u>Mithila Faruque</u>⁴, <u>Saidur R Mashreky</u>⁴, <u>Ani Movsisyan</u>^{5,6}, <u>Rhiannon Evans</u>⁷, <u>Graham Moore</u>⁷, <u>Rod S Taylor</u>^{1,8} Adaptation of complex interventions for people with long-term conditions: a scoping review <i>Status: Published in Translational Behavioral Medicine (TBM) Journal. 2024 Sep 3;14(9):514-526. doi: 10.1093/tbm/ibae031</i>	I developed the literature search strategies (with guidance from an experienced information specialist, VW); conducted the screening of titles and abstracts according to the inclusion and exclusion criteria (with an independent second reviewer, VLJ); extracted data from all included studies (verified by VLJ); and carried out the initial data synthesis, including preparation of tables and figures (supported by RST). I drafted the first version of the manuscript (with support from RST), revised it following co-author feedback, submitted it to the journal, responded to peer-review comments, and finalised the paper (with support from RST).
Chapter 3 (Paper 2)		
Paper 2 has been submitted as:	Jamal Uddin^{1,2}, Mithila Faruque³, Saidur Rahman Mashreky^{3,4}, Yousra Siddiquee³, Chaudhury Meshkat Ahmed⁵, Fakhrul Islam Khaled⁵, Rezaul Karim⁶, Carolyn Deighan⁷, Louise Taylor⁷, Hasnain Dalal⁸, Rod S Taylor⁹ Adaptation of an evidence-based home cardiac rehabilitation programme for people with coronary heart disease in Bangladesh.	JU (Jamal Uddin) conceived and designed this adaptation study, with support from the co-authors. RT (R.S. Taylor), MF (M. Faruque), and SRM (S.R. Mashreky) coordinated the study and were actively involved in all key stages, including supervising the forward and backward translation of intervention materials, facilitating stakeholder consultations, and contributing to the analysis and interpretation of the qualitative data. JU prepared the initial and subsequent drafts of the manuscript, incorporating feedback from all co-authors. RT, MF, SRM, CMA, FIK, RK, LT, HD, and YS contributed to manuscript development, while JU, MF, and

	Status: Published in BMC Health Services Research Journal. Published date: 20 March 2026, doi: https://doi.org/10.1186/s12913-026-14056-6	RT contributed to data analysis. All authors critically reviewed and revised the manuscript, provided intellectual input, and approved the final version.
Chapter 4 (Paper 3)		
Paper 3 has been submitted as:	Jamal Uddin ^{1, 2}, Mithila Faruque ³, Saidur Rahman Mashreky ^{3, 4}, Yousra Siddiqueea ³, Chaudhury Meshkat Ahmed ⁵, Md. Rezaul Karim ⁶, Md. Fakhrul Islam Khaled ⁵, Louise Taylor ⁷, Hasnain Dalal ⁸, Rod S Taylor ⁹ Assessment of the Bangla heart manual in patients with coronary heart disease and their caregivers in Bangladesh: A feasibility study. Status: Published in BMJ Open Journal. Published date: 02 March 2026. doi:10.1136/ bmjopen-2025-102350	This feasibility study was conceived and designed by Jamal Uddin (JU), RST and MF. JU secured ethical approval and oversaw all components of data collection. Quantitative and qualitative analyses were undertaken by JU, MF and RST. All authors, including SRM, CMA, LT, HD and FIK, critically reviewed the manuscript and contributed to its revision. JU prepared the final version of the manuscript in line with authors' comments. All authors read and approved the final manuscript submitted for this feasibility study.
Chapter 5 (Paper 4)		
Paper 4 has been submitted as:	Jamal Uddin, Vicky Joshi, Mithila Faruque, Saidur Rahman Mashreky, Valerie Wells, Abraham Babu, Imran Bashir Chaudhry, Gabriela Lima de Melo Ghisi, Taslima Mamataz, Sherry Grace, Rod S Taylor	JU conceptualised the systematic review and meta-analysis and developed the literature search strategies with support from VW. JU screened titles and abstracts for eligibility with an independent second reviewer (VLJ), extracted data from all included studies (verified by VLJ), and conducted the initial data synthesis, including preparation of tables and figures, with support from RST. JU drafted the initial manuscript with input from RST. JU also led the revision of the manuscript in response to co-author feedback, managed the

	Effectiveness, safety, costs, and delivery considerations of exercise-based cardiac rehabilitation in low- and middle-income countries: A systematic review and meta-analysis of randomised controlled trials Status: <i>submitted to European Journal of Preventive Cardiology (EJPC) .</i> <i>Submitted 24 Dec 2025 (Under review process)</i>	submission process, coordinated the responses to peer reviewers, and finalised the manuscript with further support from RST. All other authors contributed to the study design, interpretation of findings, and critical revision of the manuscript for important intellectual content. All authors read and approved the final manuscript.
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Chapter 1

Introduction

Chapter 1: INTRODUCTION

1.1 Cardiovascular disease and its global burden

Cardiovascular disease(CVD) constitutes a broad group of disorders affecting the heart and blood vessels and continue to represent the foremost cause of mortality worldwide. ¹ This category encompasses a spectrum of conditions, including coronary artery disease, cerebrovascular disease, heart failure, congenital heart disease, rheumatic heart disease, and peripheral arterial disease. ^{1,2} Atherosclerosis—characterised by the progressive accumulation of lipid-rich plaque within arterial walls—remains the predominant pathological mechanism underlying most CVD and is responsible for major acute events such as myocardial infarction and ischaemic stroke. ^{3, 4}

Although CVD has long been regarded as a disease of affluence, the global epidemiological pattern has shifted dramatically. Contemporary data indicate that more than three-quarters of CVD-related deaths now occur in low- and middle-income countries (LMICs), and this proportion is projected to exceed 80% by 2030. ^{5, 6} This transition reflects rapid urbanisation, population ageing, and a rising prevalence of modifiable cardiovascular risk factors, including hypertension, dyslipidaemia, diabetes, tobacco use, physical inactivity, unhealthy dietary behaviours, and increasing exposure to ambient air pollution. ^{6,7}

The socioeconomic implications of this shift are particularly pronounced in LMICs. In these settings, CVD often affects individuals during economically productive stages of life, resulting in substantial household-level financial hardship and reduced national productivity. ^{8,9} Health systems in many LMICs—already constrained by limited financing, inadequate workforce distribution, and insufficient infrastructure—struggle to deliver comprehensive acute and long-term cardiovascular care. Consequently, preventable morbidity and mortality remain disproportionately high. ¹⁰

Bangladesh provides a particularly salient example of these challenges. The burden of CVD has risen sharply over the past two decades, driven largely by demographic changes, urban lifestyle transitions, and persistent inequities in access to preventive and rehabilitative services. ^{11, 12} A national survey examining secondary prevention for CVD in Bangladesh revealed substantial gaps in guideline-based management, particularly in the provision of risk factor control, pharmacotherapy adherence, and structured follow-up care. ¹³ These deficits highlight the limited capacity of current service models to respond to the escalating burden of disease.

When integrated with the broader global picture, it is evident that coronary heart disease (CHD) remains the single largest contributor to both mortality and disability within the CVD spectrum. ^{14,15} The increasing concentration of CHD deaths in LMICs not only reflects underlying epidemiological risk transitions but also exposes systemic vulnerabilities in health-care delivery, particularly concerning long-term management, secondary prevention, and

cardiac rehabilitation. The convergence of high disease prevalence, delayed diagnosis, suboptimal post-acute care, and resource limitations underscores the urgent need for cost-effective, scalable, and context-appropriate interventions. In Bangladesh and similar LMIC contexts, strengthening secondary prevention—including accessible models of cardiac rehabilitation—represents a critical strategy for reducing premature mortality and improving quality of life among individuals living with CVD.^{16, 17}

1.2 Family oriented care: A foundational context for healthcare in Bangladesh

In Bangladesh, the management and rehabilitation of chronic conditions including CHD are deeply embedded within a family-oriented care model, reflecting the socio-cultural fabric of the society. Family members, including spouses, children, and extended relatives, traditionally assume significant roles in caregiving, providing not only physical but also emotional, financial, and social support to patients.¹⁸ This collective involvement is often crucial in navigating healthcare challenges, particularly in low-resource settings where formal support systems may be limited.¹⁹ The importance of family-centered care is increasingly recognized in global health discourse, especially in LMICs such as Bangladesh, where familial networks serve as a primary safety net.¹⁹ Studies highlight that involving families in rehabilitation processes can improve adherence to treatment, enhance psychological well-being, and foster better health outcomes.²⁰ In the context of CR, family engagement is not merely supportive but integral to the sustainability and effectiveness of interventions, particularly in home-based settings.²¹ Given the high burden of CHD in Bangladesh and the critical shortage of specialized healthcare services, leveraging the familial care structure offers a culturally congruent and pragmatic approach to expanding access to rehabilitation.^{22,23} This thesis, therefore, emphasizes the adaptation and implementation of the Bangla Heart Manual—a home-based CR intervention—within this family-oriented framework, aiming to align evidence-based practice with local care traditions to optimize patient recovery and system feasibility.

1.3 Heart Manual background and underlying evidence

The Heart Manual (HM) is a structured, home-based and self-directed cardiac rehabilitation (CR) programme originally developed in the United Kingdom for individuals recovering from acute myocardial infarction (AMI) and coronary revascularisation procedures. Introduced in the early 1990s, the programme was designed to complement conventional post-discharge care by promoting patient empowerment, behaviour change, and long-term self-management. Over the past three decades, the HM has been supported by a substantial body of evidence, including randomised controlled trials (RCTs), economic analyses, and real-world implementation studies, establishing it as one of the most rigorously evaluated home-based CR interventions to date.

One of the earliest and most influential evaluations of the HM was the multicentre parallel-group RCT conducted by Lewin et al., published in *The Lancet* in 1992.²⁴ This trial enrolled 1,421 patients following AMI across several UK hospitals and compared outcomes between individuals receiving the HM and those receiving usual post-discharge care. The primary outcomes focused on psychological adjustment, particularly symptoms of anxiety and depression, alongside healthcare utilisation. At 12 months' follow-up, participants in the HM group demonstrated significantly lower anxiety scores and fewer depressive symptoms, measured using the Hospital Anxiety and Depression Scale, compared with controls. In addition, the HM group reported reduced general practitioner consultations and hospital readmissions, indicating both clinical and economic benefits and providing early robust evidence for the effectiveness of home-based CR.²⁴

Subsequent trials further strengthened the evidence base for the HM. The Birmingham Rehabilitation Uptake Maximisation (BRUM) trial, led by Jolly et al., was a pragmatic multicentre RCT involving 525 patients eligible for CR following AMI or coronary revascularisation.²⁵ Participants were randomised to receive home-based CR using the HM, conventional centre-based CR, or usual care. Health-related quality of life, assessed using the Short Form-36 (SF-36) physical component score at 12 months, was the primary outcome. The study demonstrated no significant differences between the HM and centre-based CR groups in SF-36 scores, exercise capacity, cardiovascular risk factors, or smoking cessation rates. Importantly, uptake of CR was significantly higher among patients allocated to the HM compared with those offered centre-based programmes, highlighting the potential of home-based models to improve access and participation without compromising clinical effectiveness.²⁵

Additional evidence was provided by the Cardiac Home-Based Rehabilitation Management Study (CHARMS), which evaluated the HM in a broader population of patients with coronary heart disease. This RCT randomised 453 participants to either home-based CR using the HM or standard centre-based CR. Outcomes included changes in cardiovascular risk factors and functional capacity at 6 and 12 months.²⁶ The findings demonstrated comparable improvements in exercise tolerance, blood pressure, and lipid profiles between the two groups, with no significant differences in adverse events. These results reinforced both the safety, clinical equivalence and cost effectiveness of the HM relative to centre-based CR programmes.^{26, 27}

Collectively, findings from these RCTs have contributed substantially to the international consensus that home-based CR is as safe, effective and cost effective as centre-based delivery models. This conclusion has been consistently supported by systematic reviews and meta-analyses, including multiple Cochrane reviews in which the HM is frequently cited as a leading example of evidence-based home-based CR.^{27,28} As a result, the HM has informed

major international policy and practice guidelines, including the 2019 Scientific Statement on Home-Based Cardiac Rehabilitation jointly issued by the American Heart Association, the American College of Cardiology, and the American Association of Cardiovascular and Pulmonary Rehabilitation.²⁹ More recent audits, digital adaptations, and studies incorporating patient-reported outcomes continue to demonstrate the HM's effectiveness in supporting sustained lifestyle change, psychosocial wellbeing, and long-term cardiovascular self-management, consolidating its role as a benchmark intervention for accessible and scalable CR delivery.

1.4 Cardiac Rehabilitation

CR is recognised as a cornerstone of secondary prevention for cardiovascular disease and represents a comprehensive, evidence-based model of care delivered by a multidisciplinary team. The World Health Organization (WHO) defines CR as “the sum of activities required to influence favourably the underlying cause of the disease, as well as to provide the best possible physical, mental and social conditions, so that patients may, by their own efforts, preserve or resume as normal a place as possible in the community”.³⁰ Within this framework, CR encompasses a structured combination of core components, including initial patient assessment, exercise training, health education, medical risk factor management, lifestyle modification, and psychosocial support.³¹⁻³³ CR is commonly delivered across a continuum of care, beginning during the inpatient phase following an acute cardiac event (Phase I), followed by structured, supervised early outpatient rehabilitation (Phase II), and, where available, ongoing community-based or home-based maintenance programmes (Phases III and IV) aimed at supporting long-term risk reduction and behavioural change.³⁴ The CR team incorporates a multidisciplinary health professional team, including physicians, nurses, physiotherapists, psychologists and dietitians. The team must be also interdisciplinary, integrating their expertise to jointly assess and treat patients, creating a unified, synthesized approach to care.³⁵

Reflecting this robust evidence base, leading international societies—including the European Society of Cardiology (ESC), the American Heart Association (AHA), and the American College of Cardiology (ACC)—provide a Class I, Level A recommendation for CR for eligible cardiac patients.^{36, 37} The WHO has further emphasised CR as a global priority within its Global Action Plan for the Prevention and Control of Noncommunicable Diseases, identifying it as an essential, yet underutilised, component of cardiovascular care.³⁸

A recent systematic review of 26 RCTs conducted across eight LMICs reported significant improvements in exercise capacity—measured by peak oxygen uptake—comparable to outcomes observed in trials from HICs.³⁹ In LMICs, there is low to moderate-certainty evidence establishing that CR improves functional capacity.⁴⁰ Evidence on cost-effectiveness in LMICs remains limited; however, emerging evaluations, particularly from

middle-income regions such as Latin America, suggest that CR is likely to be cost-effective and may even lead to downstream reductions in healthcare expenditure.⁴¹ Collectively, these findings underscore the global relevance of CR and highlight the urgent need to expand access, particularly in resource-constrained settings.

1.4.1 Evidence base for cardiac rehabilitation

A substantial body of RCT evidence from high-income countries (HICs), consistently demonstrates that participation in CR leads to significant reductions in cardiovascular mortality and hospital readmissions.^{31, 42} CR has also been shown to improve functional capacity, symptoms, health-related quality of life (HRQoL), and psychological well-being in populations with acute coronary syndrome, post-revascularisation, and heart failure with reduced ejection fraction.⁴³ Importantly, these clinical benefits are complemented by economic advantages, as numerous studies confirm CR to be relatively low cost and cost-effective intervention within contemporary health systems.⁴⁴

Although the majority of foundational evidence originates from HICs, research from low- and middle-income countries (LMICs) is rapidly expanding. A contemporary Cochrane meta-analysis published of 85 RCTs involving over 23,000 participants showed that exercise-based CR significantly reduces cardiovascular mortality, hospital admissions, and myocardial infarction.⁴⁵ Moreover, participation in CR programmes was associated with improvements in HRQoL and demonstrated good cost-effectiveness.^{45, 46}

A recent systematic review and meta-analysis of 26 RCTs (6,380 participants) conducted across eight LMICs found that CR leads to clinically meaningful improvements in functional capacity, reductions in systolic blood pressure, and modest improvements in lipid profile and body mass index.⁴⁰ Health economic evidence in LMICs is limited but supportive, with some studies reporting CR as cost-saving or cost-effective.³⁹ However, CR remains under-resourced, and accessible, affordable models (such as home-based or hybrid CR) are urgently needed.^{39, 47}

A key barrier in LMICs is program availability. A global survey found that only 55 of 138 LMICs (40%) have any CR programmes, and in many of those, patients bear a substantial portion of the cost out of pocket.⁴⁸ Financial constraints, lack of reimbursement, limited staff, and low patient awareness are major obstacles to CR uptake.^{48, 49}

1.4.2 Historical evolution and modern context of CR

CR has undergone a profound transformation over the course of the twentieth and twenty-first centuries. In the early 1900s, following a myocardial infarction (MI), the standard clinical prescription was prolonged bed rest, often resulting in severe deconditioning, muscle atrophy, and adverse outcomes.⁵⁰⁻⁵²

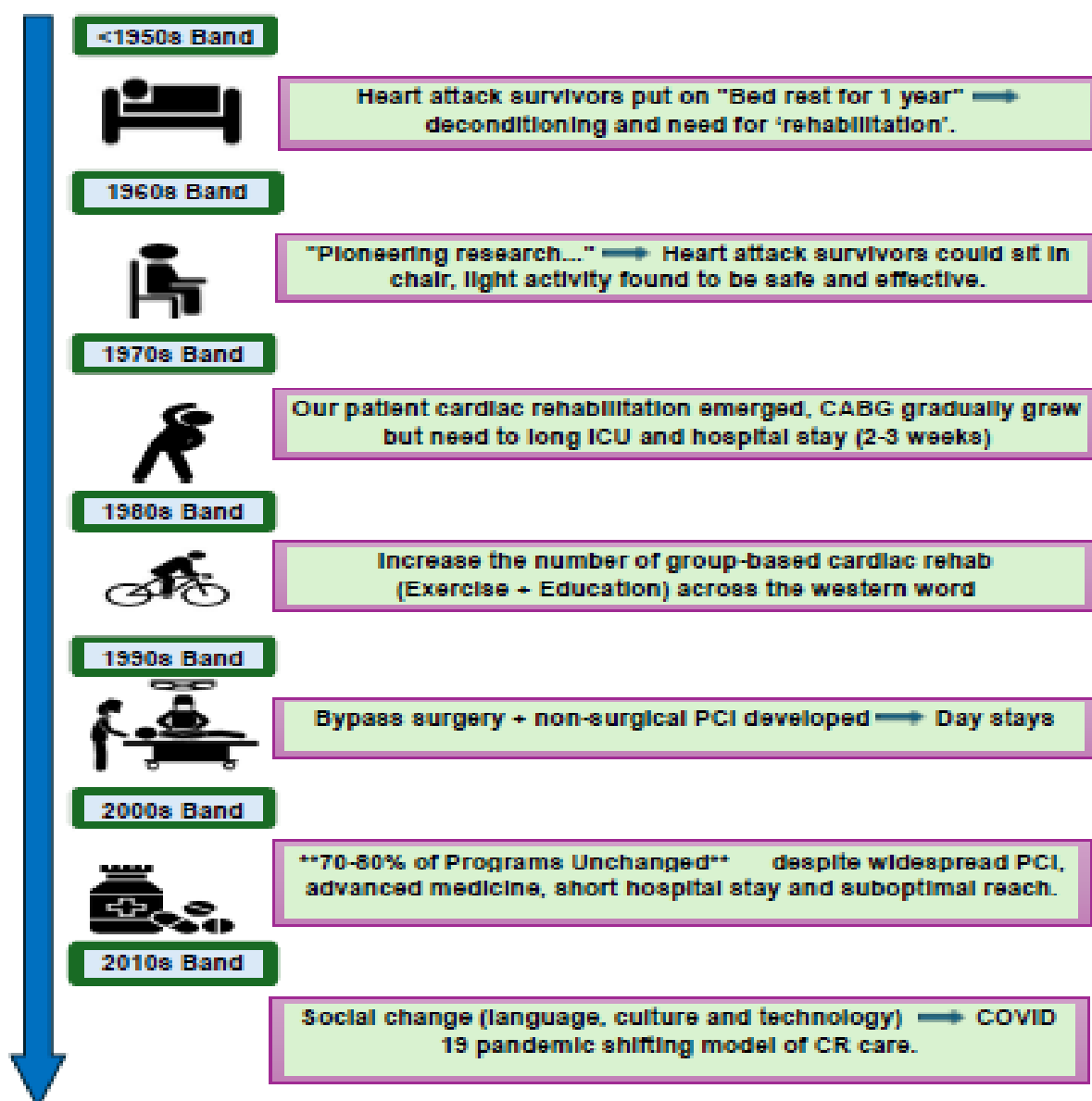


Figure 1: Historical evolution of CR: Aligning acute care with societal needs.

This paradigm began to shift in the 1950s and 1960s when clinicians promoted “armchair therapy,” permitting patients to sit for short periods daily.⁵⁰ [Figure 1]. The landmark “Dallas Bed Rest and Exercise Study” (1968) demonstrated that supervised exercise improved physical and physiological parameters without increasing risk.^{51, 52}

By the 1970s, structured outpatient CR programmes, under medical supervision, had emerged in many countries.⁵⁰ These programmes initially emphasized exercise, later incorporating psychosocial support, education, and risk-factor modification.^{50, 51} Modern CR now aims for sustained risk reduction, integrating nutritional counselling, psychological care, and self-management strategies.^{53, 54} Innovations in delivery, such as home-based models, telehealth, mobile applications, and remote monitoring, are particularly relevant for LMICs, where traditional centre-based CR may be less feasible.^{54, 55}

1.4.3 Cardiac rehabilitation delivery models

Traditional centre-based models of CR have been the dominant approach internationally and are valued for offering structured, supervised, and multidisciplinary care.⁵⁶ These programmes typically provide continuity of follow-up, direct monitoring by clinicians, and opportunities for patient education and peer support. However, centre-based CR also presents several limitations that restrict participation, particularly in LMICs. Key barriers include the need for repeated travel to specialist facilities, transportation costs, and time away from family or employment—all of which can disproportionately disadvantage rural populations and individuals with limited socioeconomic resources.^{32, 57-59} Operationally, centre-based CR is also resource-intensive, requiring dedicated infrastructure, trained personnel, and sustained funding, which may be challenging for overstretched health systems in LMIC settings.

To address these longstanding barriers, alternative models of CR delivery have been implemented globally. Home-based CR, increasingly supported by digital tools such as telemonitoring, mobile health applications, and remote coaching, has emerged as a clinically effective and scalable approach. Robust evidence demonstrates that home-based CR achieves outcomes comparable to centre-based programmes for key indicators such as cardiovascular mortality, functional capacity, and health-related quality of life.^{32, 60, 61} Moreover, home-based models may improve patient adherence and accessibility by allowing individuals to undertake rehabilitation activities within their own environment, reducing logistical burdens and promoting greater equity in service provision.

Despite this promising evidence, the global availability of CR remains critically inadequate. A 2020 international audit reported only 5,848 CR programmes across 111 countries, revealing an overwhelming shortfall between service capacity and clinical need.^{62, 63} On average, only one CR place exists for every 12 eligible patients worldwide, illustrating the substantial unmet need for secondary prevention services. Regional disparities are particularly striking: while the Americas offer approximately one CR spot for every four patients requiring care, South-East Asia—home to a large proportion of the global cardiovascular disease burden—provides only one spot for every 283 patients.^{64, 65} These inequities underscore the urgency of adopting flexible, scalable, and context-sensitive CR delivery models, particularly in resource-constrained health systems.

1.4.4 Barriers to CR access in LMICs

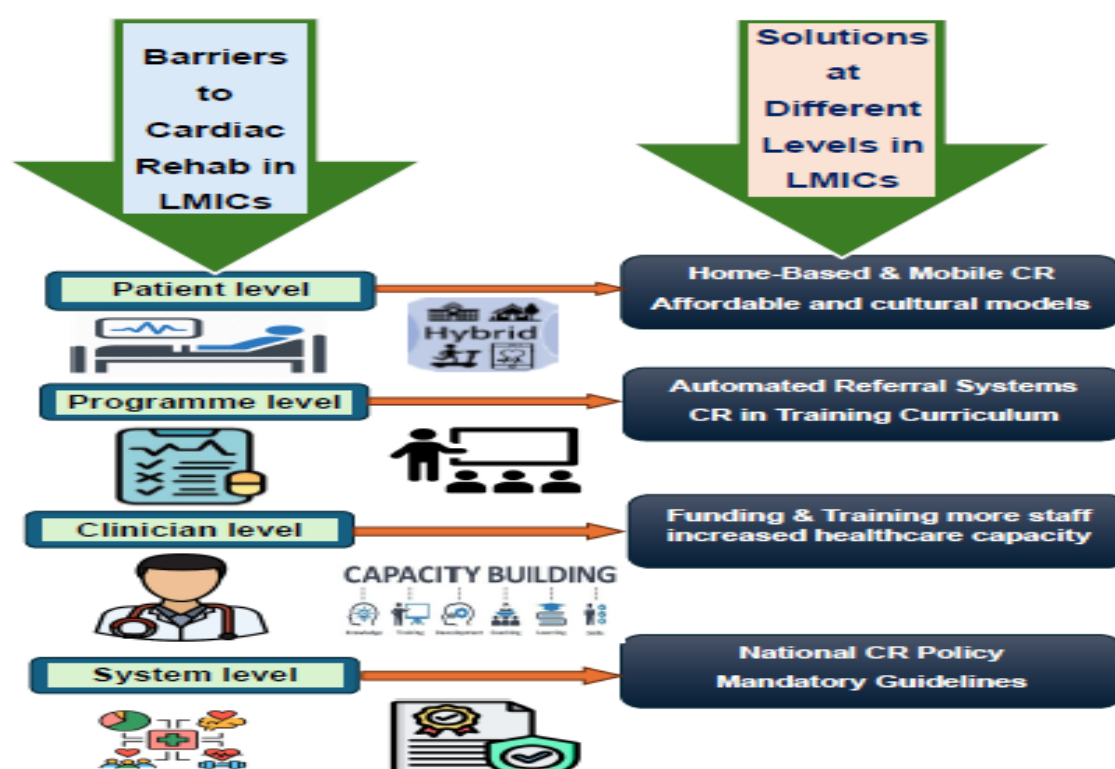


Figure 2: Potential barriers to CR access and actionable solutions in LMICs. ⁶³ [figure 2]

Despite a strong evidence base demonstrating the effectiveness of CR and strong guideline recommendations – a practice gap remains worldwide. CR access remains stubbornly suboptimal, with especially in LMICs. Barriers to CR access in LMICs are multifaceted and interrelated, operating at multiple levels of the healthcare system. ^{66, 67}

- **System-level barriers:** Limited programme availability and capacity: Only about 40% of LMICs have any CR programmes, and where they do exist, capacity is severely constrained; for example, there is roughly one CR “spot” per 66 incident CHD patient in LMICs, compared with around one per 3–4 in high-income countries. ⁶² Financial barriers and payment models: In LMICs, a large proportion of CR costs are borne out-of-pocket by patients. ⁶⁶ Low political commitment / health policy support: Governments in many LMICs have not prioritised CR at a policy level. ⁶⁸
- **Clinician-level barriers:** Lack of awareness and referral: Many healthcare providers lack sufficient knowledge about CR benefits or fail to systematically refer eligible patients. ⁶⁹ Low endorsement: Without strong physician encouragement, patients are less likely to enrol, particularly in LMICs. ⁷⁰
- **Programme-level barriers:** Resource constraints: CR programmes often suffer from a lack of trained staff, inadequate infrastructure, and insufficient equipment. ⁷¹ Rigid scheduling and delivery models: Many programmes operate only in fixed locations and limited times.

- Patient-level barriers: Financial cost: High out-of-pocket costs prevent attendance.⁷² Transportation and distance: Travel costs and long distances to centres are major obstacles. Time conflicts: Work and family obligations interfere with participation.⁷² Low awareness / health literacy: Limited understanding of CR benefits reduces uptake.⁷³
- Actionable solutions include advocating for political commitment and funding implementing systematic referral pathways investing in workforce capacity promoting alternative delivery models such as home-based CR and raising patient awareness.^{56, 67, 74}

1.5 Context of Bangladesh

1.5.1 Country Setting

Bangladesh, a low-lying riverine country in South Asia, is one of the world's most densely populated nations, with over 165 million people living in an area of approximately 148,460 km².⁷⁵ Despite significant socio-economic progress, including a notable reduction in poverty from 44.2% in 1991 to 18.7% in 2022, the country faces immense challenges related to climate change, rapid urbanisation, a persistent burden of communicable diseases, and a rapidly growing burden of non-communicable diseases.⁷⁵⁻⁷⁸ The healthcare system, while achieving successes in immunisation and maternal health continues to struggle to meet the population's needs due to resource constraints, infrastructural limitations, and significant regional disparities in access to care.^{77, 78}

The historical context of Bangladesh shapes the current environment for healthcare service delivery. Following the liberation war in 1971, during which the country suffered massive destruction of infrastructure and displacement of civilians, the health and social systems required reconstruction and redevelopment. This legacy intersects with contemporary challenges—demographic transition, epidemiological shift and health system reforms—that are relevant when considering implementation of complex interventions, including CR.

1.5.2 Demographic configuration and its impact on chronic Disease

Demographic features—including age and sex distribution, economic resources, referral pathways, transportation services, the trend of morbidity and mortality in the general population, and cultural and social aspects—are important context for planning the implementation of a CR service in a community or country.⁷⁹ Bangladesh is undergoing a significant demographic transition, moving from Stage 2 (high fertility, falling mortality) to Stage 3 (low fertility, falling mortality) of the demographic transition model.⁷⁹ This transition has resulted in a growing proportion of older adults, increasing the prevalence of non-communicable diseases including heart disease. Although the population remains relatively young (median age around 28 years), the segment aged 60 years and above is rapidly expanding, posing new challenges for chronic disease management.⁸⁰

Thus, the demographic shift in Bangladesh implies that conditions formerly more associated with older age groups are becoming more common, and health systems must adapt accordingly. Dependency ratios, life expectancy, and other demographic indices are changing, affecting not only demand for services but also resource allocation and workforce planning.

1.5.3 Epidemiological transition and heart disease

Concurrent with its demographic shift, Bangladesh is experiencing a rapid epidemiological transition characterised by a 'double burden' of communicable diseases and a sharp rise in non-communicable diseases.⁸¹ In Bangladesh, non-communicable diseases account for approximately 67% of all deaths, and cardiovascular diseases are responsible for an estimated 30% of total mortality.⁷ The most recent data suggest that heart disease now contributes approximately 34% of all deaths in Bangladesh.⁸² This pattern mirrors the broader trend in LMICs, where non-communicable diseases are disproportionately affecting younger and economically productive populations.⁸³ The rise of CVD as a leading cause of death in Bangladesh presents a major public health challenge and underscores the urgent need for effective secondary prevention interventions, such as CR, which hitherto have been largely developed and implemented in high-income settings.

1.5.4 Risk Factors of CVD in Bangladesh

The spectrum of CVD Bangladesh includes ischaemic heart disease, hypertensive heart disease, heart failure, rheumatic heart disease, and stroke. Among these, ischaemic heart disease is the principal contributor to cardiovascular mortality.^{84, 85} The prevalence of overall CVD in people aged 35 years and above in Bangladesh has been reported to be approximately 4.5%, with 1.8% experiencing had stroke and 3.2% heart disease.⁸⁶

The risk factors for CVD can be broadly divided into non-modifiable (e.g. age, sex, genetics) and modifiable (e.g. hypertension, dyslipidaemia, diabetes, smoking, unhealthy diet, physical inactivity, and ambient air pollution).⁸⁷ In Bangladesh, hypertension and diabetes are major risk factors on the causal pathway to CVD; the aforementioned study found a significant association between hypertension, diabetes and CVD prevalence.⁸⁸ Socio-economic factors, such as educational status, wealth, and rural vs. urban residence, also influence both exposure to risk factors and access to care.^{89, 90}

In Bangladesh, the rise of heart disease is fuelled by changes in lifestyle—sedentary behaviour, increased consumption of processed and fatty foods, smoking, obesity alongside environmental factors such as high levels of air pollution.⁹⁰ Regionally, some divisions record higher heart attack death rates; for example, in Chattogram, approximately 20.85% of deaths were attributed to heart attacks in a recent survey.⁹¹

1.5.5 Health seeking beliefs

Bangladesh's health system is deeply shaped by lay epidemiology, wherein cultural, religious, and traditional explanatory models of illness coexist with, and often compete against, biomedical understandings.⁹²⁻⁹⁵ Within this pluralistic context, cardiovascular diseases are frequently interpreted through non-biomedical lenses, such as emotional distress, fate, or spiritual imbalance, rather than pathophysiological mechanisms.^{94, 96} Despite epidemiological transition, non-communicable diseases, particularly cardiovascular conditions, now account for a substantial proportion of morbidity and mortality in Bangladesh, intensifying the importance of timely biomedical care.^{96, 97} However, initial health-seeking pathways often involve traditional or faith-based providers, contributing to delays in diagnosis, suboptimal adherence to treatment, and poorer clinical outcomes.^{94, 96, 97} Health-seeking behaviour for heart disease thus reflects a complex interaction of sociocultural perceptions, informal care systems, and structural limitations within the broader health system.^{98, 97} Early symptoms such as chest discomfort, fatigue, or breathlessness are frequently normalised or attributed to non-medical causes, prompting consultation with traditional healers (kabiraj) or religious practitioners whose treatments are primarily spiritual or herbal and do not address underlying cardiovascular pathology.^{96, 98} In addition, informal drug vendors and community pharmacy sellers remain a major source of first-contact care, particularly in rural and underserved areas, often dispensing cardiovascular medications without proper diagnosis or prescription, thereby increasing risks of inappropriate treatment and delayed referral.^{99, 97} Furthermore, gendered household decision-making structures shape access to care, with women often experiencing delayed treatment due to financial dependence and sociocultural constraints.^{96, 99} Overall, these interacting factors demonstrate how cultural beliefs, informal healthcare provision, and systemic health system constraints continue to delay timely cardiovascular care in Bangladesh, posing persistent challenges for equitable chronic disease management and universal health coverage.^{94, 97}

1.5.6 Healthcare delivery system and chronic disease management

The healthcare system in Bangladesh is pluralistic, fragmented, and modestly regulated. It is characterised by a mix of government, private sector, non-governmental organisation and donor-funded services.^{94, 95} The Ministry of Health and Family Welfare oversees a hierarchical structure intended to deliver primary care through community clinics, union sub-centres, and upazila health complexes, which refer complex cases to secondary or tertiary facilities.⁹⁶ However, this referral system is challenged by high rates of self-referral and limitations in lower-level facilities.⁹⁷ The system remains predominantly focused on episodic and acute care, with limited integration of chronic disease management (such as heart disease) into primary health care services.⁹⁸⁻¹⁰⁰ This results in a large treatment gap for non-communicable diseases patients, particularly in rural areas. Further, the system is

characterised by high out-of-pocket payments (approximately 66% of total health expenditure), creating severe financial burden and pushing many households into impoverishment.^{101, 102} Government health expenditure remains very low (approximately 0.8% of GDP), severely constraining public system capacity.¹⁰³

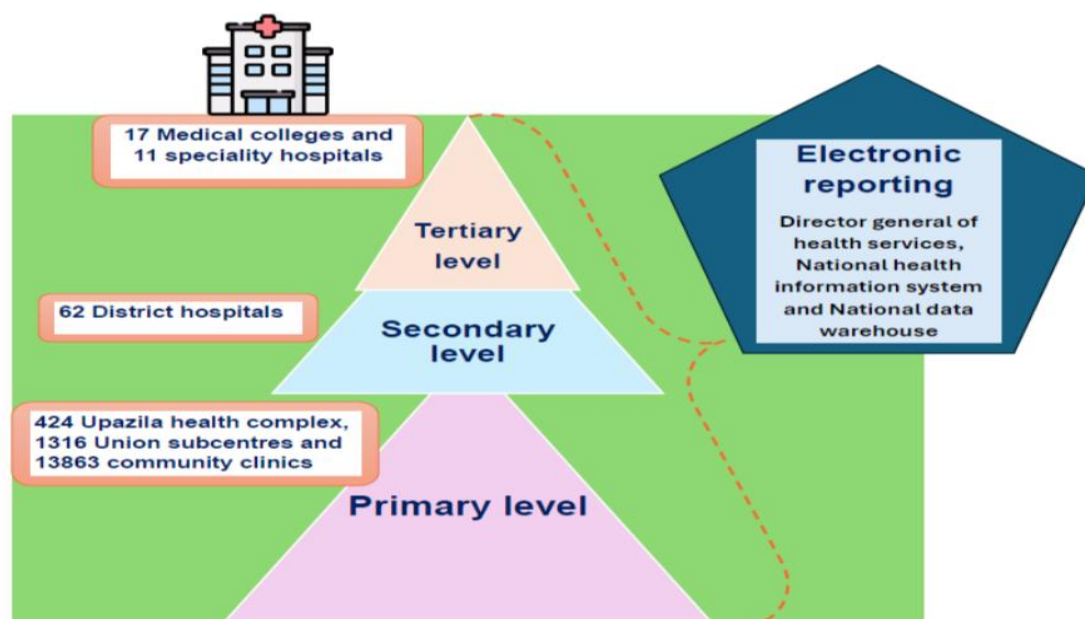


Figure 3: Health care delivery system in Bangladesh. ⁹⁶

For CVD care and secondary prevention in Bangladesh, the infrastructure, workforce, and referral pathways remain limited, especially outside major urban centres. These system constraints profoundly influence the feasibility, implementation, and sustainability of interventions such as CR.

1.5.7 Heart disease management and secondary prevention status in Bangladesh

The management of heart disease in Bangladesh illustrates a health-care system struggling to meet a profound national burden. Data suggest that heart attacks alone claimed 17% of Bangladeshi lives in 2022 and that only one-third of the necessary 30,000 heart surgeries per year are being performed in the country. ^{104, 105}

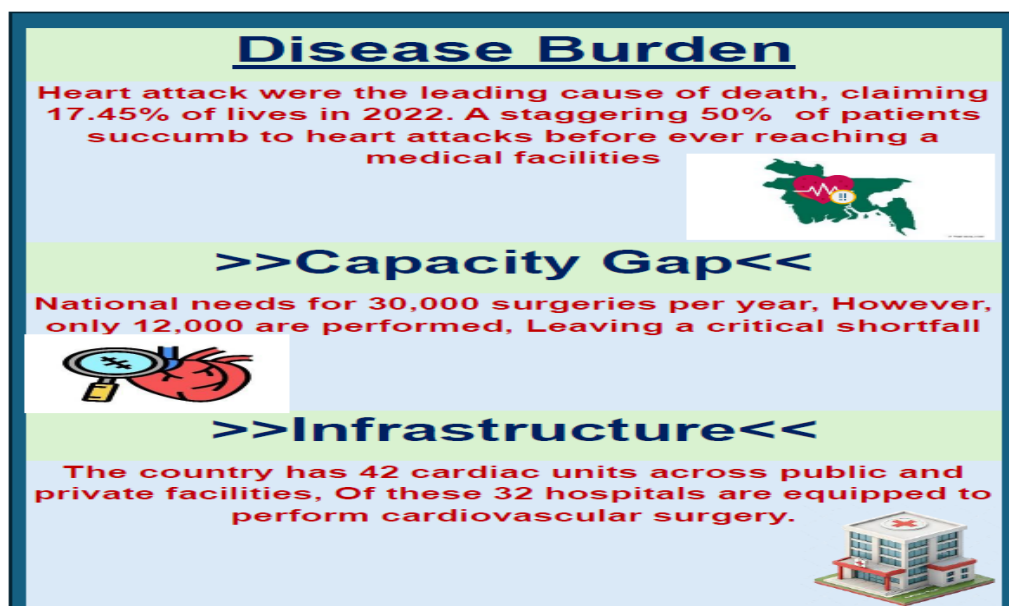


Figure 4: The State of Cardiac Care: Mortality, Surgical Gaps & Facilities.^{104, 105}

Specialised cardiac care facilities are predominantly concentrated in capital city of Dhaka, creating significant access barriers for rural populations.^{106, 107} Consequently, secondary prevention services for heart disease—including structured patient education, risk factor modification, and long-term follow-up—are virtually non-existent at the primary care level.^{108, 109} This gap in secondary prevention is critical because timely and optimal post-event care (including lifestyle modification, medication adherence, counselling, and rehabilitation) is known to improve outcomes and reduce recurrence. In the absence of structured programmes, patients with heart disease in Bangladesh face higher risk of morbidity, recurrent events, and mortality.¹¹⁰ As previously noted, the availability of advanced acute cardiac care stands in stark contrast to the near absence of structured CR services.¹¹¹ A national survey confirmed this stark disparity, revealing a high unmet need for secondary preventive care.¹¹² This gap is driven by a complex interplay of factors, including a lack of integrated national policies, standardised referral pathways, and limited awareness among both healthcare providers and patients.¹¹³

1.6 The Imperative for adapted, home-based CR models in LMICs

In LMICs, including Bangladesh, the implementation of conventional centre-based CR is constrained by structural, economic, and sociocultural barriers. CR services are predominantly urban based, limiting coverage for rural populations.¹¹⁴⁻¹¹⁶ Shortages of trained personnel and inadequate financial and infrastructural resources reduce the feasibility of scaling traditional models.¹¹⁷ High out-of-pocket expenditure and poorly developed referral pathways further constrain access.¹¹⁸

Sociocultural and gender-related obstacles exacerbate these challenges. Women, older adults, and individuals from lower socioeconomic backgrounds report household responsibilities, stigma, and lack of transportation as barriers. Differences in health system

capacity, funding, workforce distribution, and cultural norms necessitate contextualisation of CR interventions.^{118, 119}

Intervention adaptation allows for systematic modification of evidence-informed interventions to improve fit with new populations or settings while retaining core components.^{120, 121} Home-based CR has demonstrated comparable clinical outcomes to centre-based models, with greater accessibility, patient satisfaction, and cost efficiency.^{31, 122} The COVID-19 pandemic accelerated the adoption of remote, hybrid, and home-based models, proving their feasibility and acceptability.¹²³ For Bangladesh, culturally appropriate, scalable home-based CR is strategically essential to expand coverage, reduce inequities, and strengthen secondary prevention.

1.6.1 The Science of intervention adaptation and the current evidence

The systematic adaptation of evidence-based health interventions is a critical step in ensuring their effectiveness, acceptability, and sustainability when implemented in new cultural, economic, or healthcare contexts. Adaptation is defined as the intentional modification of an intervention to improve its fit within a new setting while preserving its core functional components.^{30, 31, 124, 125} Without thoughtful adaptation, even interventions with strong evidence from high-income countries may fail due to contextual mismatches in language, culture, healthcare infrastructure, patient literacy, or social norms.

Why Adaptation is Important

In low- and middle-income countries (LMICs) like Bangladesh, the burden of coronary heart disease (CHD) is high, yet resources for developing new interventions from scratch are limited. Adaptation offers a cost-effective and efficient strategy to leverage existing evidence-based programmes, reducing duplication of effort and accelerating implementation.

Moreover, adaptation enhances:

- **Cultural relevance:** Ensuring content resonates with local beliefs, dietary habits, family structures, and communication styles.
- **Feasibility:** Aligning intervention delivery with available human resources, training capacity, and technological access.
- **Acceptability:** Engaging local stakeholders—patients, caregivers, clinicians—in the adaptation process fosters ownership and improves uptake.
- **Sustainability:** Contextually adapted interventions are more likely to be integrated into existing health systems and maintained long-term.

Methodological Frameworks for Adaptation

Several structured frameworks guide the adaptation process, emphasising a balance between fidelity to the original intervention and flexibility to contextual needs. Key frameworks include:

- The ADAPT Guidance ³² : A four-step process focusing on assessment, adaptation, piloting, and implementation.
- FRAME (Framework for Reporting Adaptations and Modifications) ¹²⁶: Documents modifications made during implementation.
- MRC (Medical Research Council) Guidance for Complex Interventions ¹²⁵ : Highlights iterative development, feasibility testing, and evaluation.

These frameworks typically involve:

1. Needs and context assessment
2. Stakeholder engagement (patients, providers, policymakers)
3. Content and delivery modification
4. Piloting and refinement
5. Evaluation of feasibility and effectiveness

Examples from Other Adaptation Studies

Recent studies demonstrate the application of adaptation methodologies in cardiovascular care and beyond:

- REACH-HF in Denmark: Eghøj et al. (2024) adapted the UK-based *Rehabilitation Enablement in Chronic Heart Failure* programme for Danish patients with heart failure, employing a participatory process involving clinicians and patients to modify content, language, and delivery modes.⁴³
- Hypertension Control in Guatemala: Fort et al. (2019) engaged stakeholders to adapt a hypertension management programme for Guatemala's primary care system, addressing barriers related to medication supply, health worker training, and patient education.³⁶
- Stroke Prevention in Ghana: Ojo et al. (2020) culturally adapted a stroke prevention intervention by incorporating local beliefs, language, and community health worker roles, demonstrating improved acceptability and preliminary effectiveness.³⁷

1.6.2 Gaps in the current evidence base

Despite growing interest, the reporting quality of adaptation studies remains inconsistent. Many publications focus on the early phases of adaptation (e.g., content modification) but fewer detail feasibility testing, implementation strategies, or long-term outcomes.^{127, 128} There is also a scarcity of adaptation studies from LMICs, particularly in the field of cardiac rehabilitation. Transparent reporting and rigorous evaluation are essential to build a robust evidence base and guide future adaptation efforts.

Integration with the Current Study

This study applied the ADAPT framework.³² to modify the UK *Heart Manual* for use in Bangladesh. Through structured stakeholder consultation, we identified key areas for adaptation: reducing text density, creating pictorial and audiovisual materials, integrating

family-centred care, and tailoring examples to local dietary and cultural practices. This process not only preserved the core components of the original intervention but also enhanced its relevance and usability in a resource-limited setting.

1.6.3 Cardiac rehabilitation provision in Bangladesh

Despite the availability of advanced cardiac-care technologies in Bangladesh—including revascularisation procedures—secondary prevention and CR remain severely under-utilised. For example, a national audit reported that only a single centre-based CR programme was functioning across the entire country.¹³ This profound scarcity is compounded by multiple systemic and logistical barriers: the absence of integrated national policies, lack of standardised referral pathways, and limited awareness among both healthcare providers and patients of the multifaceted benefits of CR.¹²⁹

In response, research efforts have begun to explore alternative models aimed at bridging this critical care gap. A controlled trial of a home-based CR programme in Bangladesh demonstrated its potential, showing significant improvements in patient-reported outcomes and exercise capacity—that is, providing proof-of-concept for a decentralised approach in a lower-middle-income setting.¹³⁰ However, such initiatives remain isolated and have not yet been translated into routine clinical practice. For sustainable implementation and equitable access, what is required now is a systematic approach to intervention development, robust feasibility testing, and strategic integration into national health policy.

In Bangladesh, these barriers are acutely felt. The International Council of Cardiovascular Prevention and Rehabilitation (ICCPR) survey confirmed that only a single centre-based CR programme exists in the country. LMICs faces significant resource constraints for implementing CR and shortage of trained professionals, lack of dedicated space, and limited equipment and infrastructure.⁶⁵ Consequently, the status of formal CR is dire, and there remains a large unmet need for secondary prevention nationwide.¹³¹

1.7 Aims and objectives of this PhD

1.7.1 Overarching aim

The overarching aim of this doctoral research programme is to assess potential role of home-based CR as a model of delivery in LMICs.

1.7.2 Specific objectives

The PhD programme comprises four interlinked research studies with the following study specific objectives.

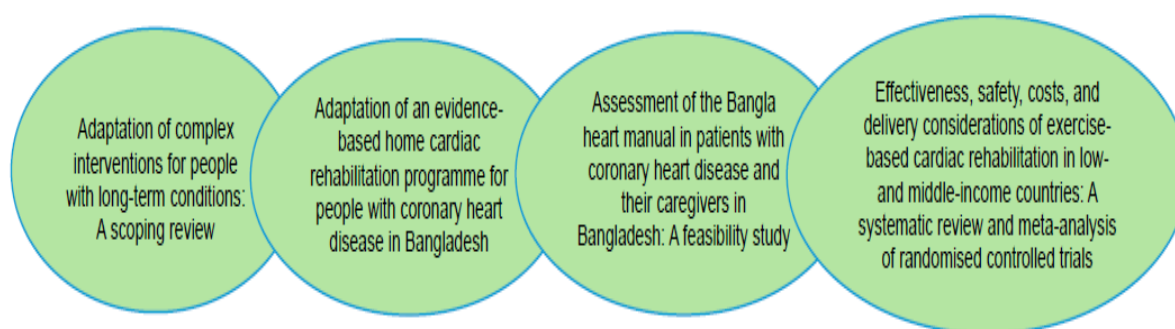
- (i) to undertake a scoping review of adaptation studies undertaken in LMICs.
- (ii) to cultural adapt the UK-developed Heart Manual home based intervention to Bangladesh.
- (iii) (to evaluate the acceptability and feasibility of adapted Bangla Heart Manual

- (iv) to undertake an updated systematic review and meta-analysis evaluating the effectiveness, safety, cost-effectiveness, and delivery models of CR across LMICs.

Collectively, this programme seeks to contribute to the evidence base for scalable, context-sensitive cardiac rehabilitation interventions suitable for implementation in LMICs.

1.7.3 Organisation of the dissertation

The four research studies are presented as subsequent dissertation chapters, as illustrated below.



Scoping Review: "Adaptation of complex interventions for people with long-term conditions: a scoping review" This study provided a methodological foundation by examining global practices in adaptation, informing the approach taken in the subsequent empirical work – chapter 2

Intervention adaptation: "Adaptation of an evidence-based home cardiac rehabilitation programme for people with coronary heart disease in Bangladesh". This study involved the systematic co-design and cultural adaptation of the UK Heart Manual to develop the Bangla Heart Manual– chapter 3.

Feasibility trial: "Assessment of the Bangla Heart Manual in patients with coronary heart disease and their caregivers in Bangladesh: A feasibility study". This study assessed the acceptability, feasibility, and preliminary outcomes of the Bangla Heart Manual,) – chapter 4.

Systematic review and meta-analysis: "Effectiveness, safety, costs, and delivery considerations of exercise-based cardiac rehabilitation in low- and middle-income countries: A systematic review and meta-analysis of randomised controlled trials". This study aims to provide a contemporary synthesis of the evidence for CR in LMICs) – chapter 5.

The final overall discussion section (chapter 6) synthesises the findings across of four research studies. This chapter critically reflects on how these studies collectively advance understanding of adapting and implementing home-based CR in low-resource settings, highlighting theoretical, methodological, and practical contributions. The chapter also outlines the implications for policy and future research, proposing directions for scaling and sustaining CR in LMICs, including Bangladesh.

1.8 Theory of Change model

This research is underpinned by a Theory of Change model (Table 1), which visually outlines the causal pathway from inputs and activities to the desired long-term impact. The model illustrates how this thesis contributes directly to the early and intermediate stages of this pathway.

- **Inputs:** Existing evidence-based CR interventions (the UK Heart Manual), cross cultural stakeholder expertise involvement.
- **Activities (This Thesis):** The four interlinked studies described in section, which include understanding adaptation methods, co-designing the intervention, testing its feasibility, and synthesising the broader evidence base.
- **Outputs:** A culturally adapted Bangla Heart Manual, evidence of its feasibility and acceptability, and an updated meta-analysis of CR in LMICs.
- **Short-Term Outcomes:** The immediate results of the outputs, including proven feasibility, trained healthcare facilitators, informed patients and caregivers, and a refined protocol for a future definitive trial.
- **Long-Term Impact:** The ultimate goal, to be realised through future definitive trials and scale-up, is the successful implementation of an effective, affordable, and sustainable home-based CR model in Bangladesh. This will contribute to improved cardiovascular health outcomes for patients, a reduced burden on the healthcare system, and enhanced overall health system capacity.

Table 1: Theory of Chang, Development and Evaluation of the Bangla Heart Manual

Inputs	Activities (PhD Research)	Outputs	Short-Term Outcomes	Long-Term Impact
UK Heart Manual and Stakeholder networks	Scoping Review	Adapted Bangla Heart Manual	Proven feasibility and acceptability	Improved heart health in Bangladesh via ▪ Scalable, effective CR ▪ Improved patient outcomes ▪ Strengthened health systems
	Cultural Adaptation		Trained facilitators	
	Feasibility pilot trial	Heart Manual		
	Systematic Review	Updated meta-analysis of CR in LMICs	-Get current trained of CR intervention and delivery model and its safety and cost and cost effectiveness	

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Chapter 2 (Paper 1)

Adaptation of complex interventions for people with long-term conditions: a scoping review

Chapter 2 (Paper 1) : Adaptation of complex interventions for people with long-term conditions: a scoping review

2.1 ABSTRACT

Background

Adaptation seeks to transfer and implement healthcare interventions developed and evaluated in one context to another. The aim of this scoping review was to understand current approaches to the adaptation of complex interventions for people with long-term conditions (LTCs) and to identify issues for studies performed in low-and-middle-income countries (LMICs).

Methods

Bibliographic databases were searched from 2000 to October 2022. This review involved five stages: (i) definition of the research question(s); (ii) identifying relevant studies; (iii) study selection; (iv) data charting; and (v) data synthesis. Extraction included assessment of the: rationale for adaptation; stages and levels of adaptation; use of adaptation frameworks, and quality of reporting using a checklist based on the 2021 ADAPT guidance.

Results

Twenty-five studies were included from across 21 LTCs and a range of complex interventions. The majority (16 studies) focused on macro (national or international) level interventions. Rationale for adaptation included intervention transfer across geographical settings (high-income country (HIC) to LMIC: 6 studies, one HIC to another: 8 studies, one LMIC to another: 2 studies), or transfer across socio-economic/racial groups (5 studies), or transfer between different health settings within a single country (1 study). Overall, studies were judged to be of moderate reporting quality (median score 23, maximum 46), and typically focused on early stages of adaptation (identification and development) with limited outcome evaluation or implementation assessment.

Conclusions

Improved reporting of the adaptation for complex interventions targeted at LTCs is needed. Development of future adaptation methods guidance needs to consider the needs and priorities of LMIC context.

Keywords: adaptation, complex intervention, long-term conditions, methodological frameworks, low-and-middle-income countries.

2.2 INTRODUCTION

The provision of effective evidence-based healthcare services for people with long-term conditions (LTCs) is one of the key priorities facing healthcare systems across the world [1, 2]. LTCs, such as diabetes, heart failure, and chronic pain, often require sustained engagement with the healthcare delivery system and support to enable people to manage their condition(s) [3]. It is estimated that LTCs contribute to 60% of deaths and 46% of the global health burden with much of this impact occurring in low-and-middle-income countries (LMICs) [4, 5]. Alongside the growing burden of LTCs, is the challenge of constrained finance and human capacity in the development and evaluation of de novo interventions and the provision of healthcare services more broadly.

One potential solution to these challenges is intervention adaptation, which seeks to transfer and implement healthcare interventions developed and evaluated in one context to another [6, 7]. Use of interventions with a previous evidence base in new contexts might be more efficient than developing new interventions in LMICs and increase the chances of maintaining effectiveness and ensuring success in implementation. Intervention adaptation has been described as a process that involves “*intentional modification(s) of an evidence-informed intervention, to achieve a better fit between an intervention and a new context. Modification can include planned adaptations (changes made before introducing a new intervention) and responsive adaptations (changes made intentionally but in response to emerging contextual issues occurring during implementation)*” [7, 8].

The science of adaptation of healthcare interventions is a rapidly growing field with an evolving methodology [8-11]. The ADAPT guidance was published in 2021 to provide a framework and guidance for the conduct and reporting adapted interventions [12]. Whilst a small number of previous reviews have assessed the reporting and methodology of studies describing the adaptation of healthcare interventions, none to date have focused on LTCs or considered the implications for the conduct of adaptation studies in LMICs [6,7].

The aim of this scoping review was to understand current approaches to the adaptation of complex healthcare interventions for people with LTCs. Key research questions were: (1) What is the rationale for adaptation of complex interventions for LTCs? (2) What research methods are used by adaptation studies? (3) Do adaptation studies use methodological guidance/frameworks? (4) How well do the conduct and reporting of adaptation studies conform to 2021 ADAPT guidance? In addressing these research questions, we sought to identify the specific issues and challenges to conducting adaptation of complex healthcare interventions in the context of LMIC setting.

2.3 METHODS

2.3.1 Study design

To address our study aim and research questions, a scoping review was undertaken [13]. We used a methodological framework as initially proposed by Arksey and O'Malley [13] and adapted by Levac et al [14] and Colquhoun et al [15]. The review comprised five stages: (i) definition of the research question(s); (ii) identification of relevant studies; (iii) study selection; (iv) data charting; and (v). data synthesis. The study is reported in accordance with the Preferred Reporting Items for Systematic Reviews for Scoping Reviews (PRISMA-ScR) extension [16].

2.3.2 Identifying relevant studies

The study inclusion and exclusion criteria were adapted from Movsisyan et al [17] and are summarised in eTable 1. A list of eligible LTCs was compiled by combining conditions listed by the Cambridge Multimorbidity Score and Barnett et al (see eTable 2) [18, 19]. The following electronic databases were searched: Medline, CINAHL, PsycINFO, and Cochrane Library. The research strategy was designed with an experienced information specialist. The search strategy development followed an iterative piloting process and was modified to ensure that we identified appropriate literature based on a small number of adaptation studies already known to the research team. Details of searches are provided in eTables 3a-c. To reflect the recent development of the field of intervention adaptation in healthcare, databases were searched from 1st January 2000 to 3rd October 2022. We limited inclusion to studies published in English.

2.3.3 Study selection

Search results were exported into Covidence (Veritas Health Innovation Ltd, Melbourne, Australia) [20], where duplicates were removed. Two reviewers independently undertook study screening based on the inclusion and exclusion criteria; a third reviewer resolved any conflicts.

2.3.4 Data charting

Data were extracted by a single reviewer and checked by a second. Key domains data were extracted in accord with the study research questions. General study characteristics included details of the population and intervention (original and adapted). The level of intervention was assessed as - 'micro', i.e., intervening with individuals and their immediate social network and relationships; 'meso', i.e., intervening with medium-level population groups and institutional or cultural change; or 'macro' i.e., operating at the national or global level, such as through regulations, taxation, other government policies, or mass media [21]. In addition, details of rationale for adaptation, methods of adaptation (use of qualitative/quantitative

research; stages of adaptation process addressed; level of evidence for the original intervention), use of methodological/theoretical frameworks/guidance, and reporting of the adaptation process. Studies were assessed as to whether they undertook the following five stages of the adaptation process: (i) identification (identifying the factors that would need to be addressed to adapt an intervention); (ii) development (the process of developing an adapted version of the intervention); (iii) feasibility (assessment of the acceptability or feasibility of the adapted intervention); (iv) evaluation (assessment of the efficacy/safety of the adapted intervention); and (v) implementation (a scaled roll out of the adaptation into 'real world' practice) [22].

Reporting of the adaptation process and methodology was assessed using a checklist developed by a group of the authors based on the 2021 ADAPT guidance [12]. This checklist includes details of forming an adaptation team (4 items); rationale for the intervention adaptation-context fit (6 items); methods of intervention adaptation (5 items); methods of intervention evaluation (6 items) and plans for implementation and maintenance of the adapted intervention (2 items). Each checklist item was judged as 'fully met' (score: 2), 'partially met' (score: 1), or 'not reported' (score: 0). Item scores were totalled with a possible total checklist score ranging from 0 to 46. The reporting checklist template is shown in e-Table 4. For each item, where available, details from each individual publication were extracted as evidence to support the scoring decision. The checklist was piloted across three studies.

Data extraction was undertaken by a single reviewer using a standardised pre-piloted Excel proforma and checked by a second reviewer. Where there were disagreements between the two reviewers, discussion took place until a consensus was reached.

2.3.5 Data synthesis

Given this is scoping review, the focus of data presentation and synthesis was a descriptive narrative analysis supported by the presentation of tabular and graphical summaries of included studies that directly address the study research questions. Findings are presented using descriptive statistics, including frequency counts (and percentages) and medians.

2.4 RESULTS

2.4.1 Study selection

The results of the search and study selection process are presented in a PRISMA flow diagram (see Figure 1). Of the 1,020 titles and abstracts identified, a total of 25 adaptation studies (30 publications) were included. The two main reasons for exclusion were that studies did not focus on a LTC population or the purpose of the study was not about intervention adaptation.

2.4.2 General characteristics of included studies

The study characteristics of the included studies are detailed in Table 1 [23-52]. Six studies were published up to 2015 and 19 studies between 2016 and 2022. The two main study countries of publication were USA (16, 64%) and UK (2, 8%), with one study from Belgium, Brazil, Nigeria, Pakistan, Portugal, Thailand, or Vietnam. Studies included a wide range of LTCs, including cancer (3, 12%), dementia (3, 12%), chronic pain (2, 8%), hypertension (2, 8%), and HIV/AIDs (2, 8%). A wide range of complex interventions were employed across studies that included promotion of mental health, disease self-management, and medication adherence.

2.4.3 Rationale for adaptation

The rationale for intervention adaptation fell into four broad categories (see Table 1). Most studies (16, 64%) took an intervention developed in one country and adapted the intervention for the same LTC population in another country (or group of countries) - high country income country (HIC) to LMIC (6 studies), one HIC to another HIC (8 studies), or one LMIC to another LMIC (2 studies). The remaining studies aimed to transfer an intervention within a single country across either different across socio-economic/racial groups (5 studies), different LTCs (3 studies), or different health settings (1 study).

2.4.4 Adaptation study methods

Nature of original intervention evidence.

For the majority of studies (23 studies), the evidence base for the original version of the intervention was a randomised controlled trial (see Table 1).

Level of adaptation:

For 17 studies, the level of intervention was at the macro level (e.g., Carver et al. (2021) [34], transfer from Iceland to Scotland), five studies were at meso level (e.g., Cassel et al. (2014) [25], different racial groups - African American to Samoans population - in the same country – USA), and three studies were at a micro level (e.g., Gorman et al. (2021) [42], different disease groups (different cancers) in the same country – USA) (see Table 1).

Stages of adaptation process and research methods:

Whilst the majority of included studies undertook the early stages of adaptation, i.e., identification (24, 96%) and development (18, 72%), few studies undertook the later stages of either assessment of feasibility (8, 32%) or evaluation (4, 16%), and only 6 (24%) reported proceeding to implement the adapted intervention (see Table 2). None of the studies that stated they had implemented the adapted intervention or reported testing either the feasibility or effectiveness of the adapted version.

Research methods employed:

All studies used a qualitative research approach (e.g., individual interviews and or focus group discussions with study participants) and eight studies also using quantitative methods (e.g. randomised and non-randomised pilot trial) (see Table 2).

2.4.5 Use of adaptation frameworks/guidance

Although twenty (80%) studies reported using a theoretical framework or guidance there was very little consistency in the specific framework/guidance that was cited across studies (see Table 3).

2.4.6 Quality of reporting and conformance with ADAPT guidance checklist

Figure 2 shows how adaptation studies conformed with the ADAPT 2021 guidance [22]. The median total ADAPT reporting checklist score across studies was 23 (range 11 to 32) out of a maximum of 46. The three initial domains of the checklist (i.e., 'forming an intervention team'; 'assessment of the rationale for intervention and context fit'; and 'planning and undertaking the adaptation') were generally well reported whilst the latter two domain items ('planning/undertaking an evaluation' or 'implementing/maintaining the intervention at scale') more poorly reported. However, some of the specific checklist within the first three domains were consistently poor or not reported across most studies i.e., item 1C - working with (original intervention) developers and handling conflicts of interest; item 2F - intellectual property issues around the adapted intervention; item 3C – unintended contexts. For each of the checklist domain items, examples of good ('fully met') reporting were extracted verbatim from the included studies and are provided in e-Table 5.

2.5 DISCUSSION

This scoping review provides a contemporary synthesis of 25 international studies published since 2000 and reports on the adaptation of complex interventions for people with LTCs. Our review included adaptation studies across a wide range of interventions and diseases, typically focusing on a macro (or national) level. The most common rationale for adaptation was transferring an intervention from one geographical setting (e.g., from a HIC to a LMIC) or across ethnic or LTC groups. Although the majority of studies referred to an underpinning theoretical framework or guidance, there was no consistency in reporting. Whilst studies addressed all five stages of the adaptation process (i.e., identification, development, feasibility, evaluation, and implementation) [21] we found the focus was often only on the first three stages. Using a checklist developed from the ADAPT 2021 guidance, the overall quality of study reporting was judged to be moderate, and a number of reporting items were consistently omitted. A key strength of the studies identified by our review was the large proportion where the adaptation was based on an original intervention with evidence of efficacy/effectiveness assessed based on a randomised trial design.

Comparison to current knowledge

Our findings have some similarities and differences with the limited number of previous scoping reviews of adaptation studies published to date [7, 8, 17]. Movsisyan reported that 12 of their 28 (43%) included studies described the transfer of a public health intervention from one country to another, the remainder examining adaptations across different population groups within the same country. In contrast to this study, both the ADAPT 2021 guidance publication [8] and Movsisyan [17] found macro (or national)-level interventions to be relatively rare. Similarly, the ADAPT 2021 guidance group noted of the reporting of several adaptation frameworks but there was no consensus. Our finding that the majority of included studies focused on the early stages of adaptation of identification and development (24, 96%) is consistent with Movsisyan [17], and the review of adaptation frameworks by Escoffery [7]. Given that the ADAPT 2021 guidance is probably one of the first attempts to provide consensus-informed guidance for adapting and transferring healthcare interventions to new contexts, we were surprised to find that it was not referenced in any of the included studies. However, this may simply reflect the fact that the guidance was only published in the last 2-3 years and its uptake will be seen in future adaptation studies.

2.6 Strengths and limitations

This scoping review has several strengths. It provides a comprehensive and contemporary overview of the international literature on complex intervention adaptation studies for people with LTCs. Second, this study addresses some gaps in the use of theoretical and methodological guidance for intervention adaptation for which there is no current consensus on best practice. Third, we have developed and applied a checklist for describing the quality of reporting based on the ADAPT 2021 guidance [22]. Given the likely growing importance and utilisation of intervention adaptation approaches [22, 53, 54], there is a need for the adoption of rigorous methodology approaches across the research community. Our checklist developed based on the ADAPT 2021 guidance provides a potential tool to help assess and quantify the quality of reporting of future intervention adaptation studies. Finally, we provide a listing of examples of good reporting to assist the authors of future adaptation studies. However, our review has some limitations. The assessment of the quality of reporting of adaptation studies is challenging as it involves subjective judgement; The scoring of our ADAPT reporting checklist often required discussion between the review team as to whether the reporting item was adequately met or not. Adaptation studies may be poorly indexed in databases, so there is a risk that potentially includable studies may have been overlooked by literature searches. This was evidenced by the fact that we identified 10 potentially relevant studies from reviewing the references of included studies; two of which were included in our final list of 25 studies [51, 52]. Non-English publication was pre-defined as an exclusion criterion of this review. However, we did not exclude any studies based on language. We acknowledge there was no formal patient or other stakeholder consultation as part of this scoping review.

2.7 Implications

Our findings have important implications. We confirm the importance of a systematic methodological approach to intervention adaptation and the need for high-quality reporting to enable healthcare professionals and programme planners to inform their implementation of adapted interventions. This can be particularly relevant in the transfer of healthcare interventions between LMICs and HICs where there are often fundamental differences in context and culture [55]. Without rigorous customisation and adaptation, an intervention is likely not fit the context of the adapted intervention and its implementation is likely to be suboptimal. However, such a rigorous methodological approach requires adequate research resources, human capacity and expertise and funding, both of which are often scarce in a low-income country. As we have seen in our review, several studies have been based on global partnerships across academic institutions and research funding [55]. However, a sustained approach to intervention adaptation requires continued research investment and capacity building in lower income context. It is also important to recognise the opportunities

for bilateral knowledge transfer. With the challenge of exploding global healthcare costs, translating affordable and efficient approaches to interventional delivery from LMICs to HICs is likely to be increasingly important. It is key that future development of adaptation methods guidance considers the needs and priorities of the LMIC to inform high quality but also feasible research, and ultimately improve healthcare, in these regions [56, 57].

2.8 CONCLUSIONS

This scoping review presents a comprehensive and contemporary identification and synthesis of the international literature of complex intervention adaptation studies for people with LTCs. It provides a resource for researchers, policymakers and practitioners working to adapt interventions to new contexts. Our review highlights two key developmental issues going forward: (i) the need for better conduct and reporting of all the stages of adaptation process, including both the evaluation and implementation of an adapted intervention; and (ii) that the future development of adaptation methods guidance considers the needs and priorities of LMICs.

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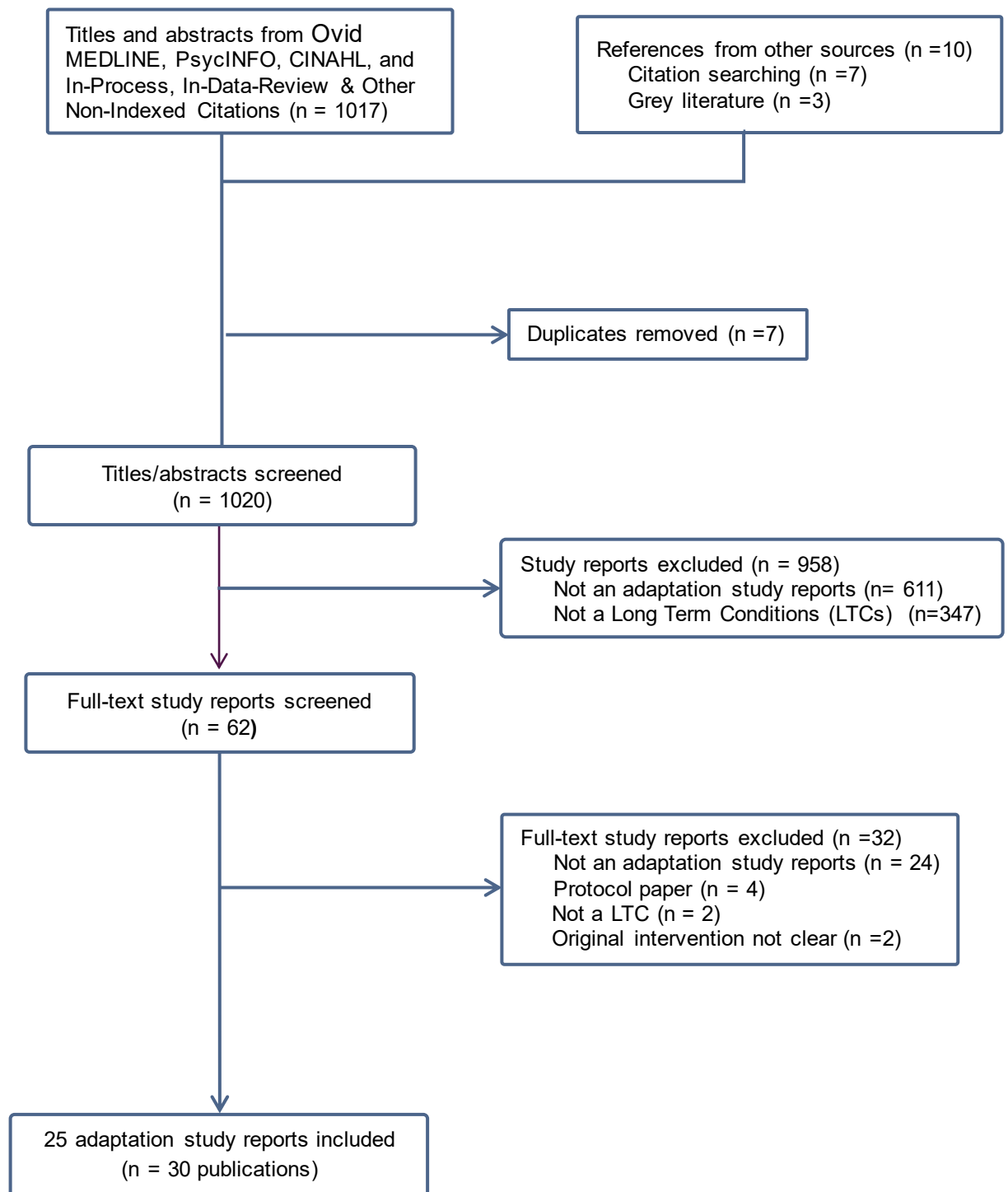


Figure 1: PRISMA flow diagram reporting study selection

2.10: Tables and figures

Table 1: Characteristics of included studies and adaptation methods

Author (year), country of publication	Population	Intervention			Rationale for adaptation	Level of evidence for the original interventio n	Interven- tion level *
		Description	Original version Name	Adapted version name			
O'Donnell (2022), UK	Heavy alcohol use & depression	Intervention and training programme for the treatment and prevention of comorbid heavy drinking and depression	Scale-up of Prevention and Management of Alcohol Use Disorders and Comorbid Depression in Latin America (SCALA)	Not stated	Different geographic setting (UK to Latin America)	Quasi experiment al study	Macro
Atif (2020), Pakistan	Anxiety during pregnancy	Psychosocial intervention based on principles of cognitive behaviour therapy	Thinking Healthy Programme (THP)	Happy Mother, Healthy Baby	Different geographic setting (HICs to Pakistan)	Systematic review	Macro

Bertrand (2019) / Marinho (2021), Brazil	Dementia	Intervention to improve cognition and quality of life	Cognitive stimulation therapy (CST)	Not stated	Different geographical setting (UK to Brazil)	Randomise d controlled trial	Macro
Bornheimer (2022), USA	Schizophreni a spectrum & other Psychosis disorders	Intervention based on cognitive behavioural methods to prevent suicide in community mental health settings	Cognitive Behavioral Suicide Prevention for psychosis	Not stated	Different geographical setting (UK to USA)	Randomise d controlled trial (pilot)	Macro
Carver (2021), UK	Substance use	Intervention for preventing substance use among young people	The Icelandic Model (IM)	The Icelandic Model in Scotland	Different geographical setting (Iceland to Scotland)	Randomise d controlled trial	Macro
Cassel (2014), USA	Obesity and cancer	Intervention for reducing obesity among cancer patients	Body and Soul	Not stated	Different racial group (African Americans to Samoans population in same country - USA)	Randomise d controlled trial	Meso
Chen (2012) / Parker (2012), USA	Arthritis	Arthritis self- management	Evidence-based interventions of arthritis	Arthritis Self- Help Program for	Different racial group (African American,	Randomise d controlled trial	Meso

		programme for older adults		older African American, Hispanic and non-Hispanic white adults	Hispanic and non-Hispanic white adults) in same country - USA)		
Cho (2020), USA	Prostate cancer and partners	Intervention for cancer survivors' and their partners' potential unmet needs including anxiety/uncertainty about cancer progression, communication between partners, cultural sensitivity, and of motivation and behaviours between partners.	Active Living After Cancer (ALAC)	Watchful Living	Different disease population (different cancers) in same population country (USA)	Randomised controlled trial	Micro
Fort (2019), USA / Paniagua-Avila (2020), Guatemala	Hypertension	Programme to control blood pressure	Hypertension Control Program in Argentina by Community Health Worker (CHW)-Led	Not stated	Different geographical setting (Argentina to Guatemala)	Randomised controlled trial	Macro

Gorman (2021), USA	Cancer	Intervention to improve aspects of sexual health, including sexual arousal, desire, satisfaction, and overall sexual functioning	Mindfulness-based interventions (MBIs) of different cancer men and women in USA	Not stated	Different disease group (different cancers) in same country - USA	Randomised controlled trial	Micro
Greenberg (2019), USA	Heterogeneous Chronic Pain	Intervention programme to integrate physical activity with mind-body skills to increase comprehensive physical and emotional functioning of chronic pain	Mind-body interventions	Get Active and Get Active With Fitbit Programs	Different disease group (generic disease to pain) in same country (USA)	Randomised controlled trial	Micro
Alvares Pereira (2022), Portugal	Dementia	Intervention to improve cognitive function and quality of life.	Cognitive Stimulation Therapy	Making a Difference	Different geographical setting (UK to Portugal)	Randomised controlled trial	Macro
Hopkins (2022), USA	People at risk of obesity, CVD, and diabetes	Intervention to promote a healthy diet and lifestyle	Celebremos La Salud	Not stated	Different population in a same county (Latino to Alaskan Yup'ik population in USA)	Randomised controlled trial	Meso

Jans (2020), Belgium	Chronic conditions	Intervention to promote self-management in community-setting	Chronic Disease Self-Management Program of Stanford University (CDSMP)	Not stated	Different geographical setting (USA to Belgium)	Randomised controlled trial	Macro
Kangovi (2016), USA	Chronic illness	Intervention to help patients track progress toward their chronic disease management goals to motivate health behaviour change	Community health worker (CHW) programs	IMPACT program	Different settings in same country (hospital to community setting -USA)	Randomised controlled trial	Meso
Magidson (2014), USA	HIV/AIDS with depression	Intervention to address improvements in depressive symptoms and adherence	Behavioral activation (BA) & Life-Steps	Act Healthy Group integrated BA and Life-Steps treatment	Different setting (mental health setting to general medical setting) in the same country - USA).	Randomised controlled trial	Meso
Muroff (2017), USA	Alcohol & other drug/mental disorders	Programme to assist recovery, continuing their access to resources, case management, and quality information after	A smartphone application, Addiction–Comprehensive Health Enhancement	CASA-CHESS	Different racial population (English speaking Hispanics to Spanish speaking	Randomised controlled trial	Meso

		leaving residential treatment	Support System (A-CHESS)		Latinos) in same country (USA)		
Ojo (2020), USA	Stroke prevention	Programme for optimal hypertension management	Discharge Education Strategies for Reduction of Vascular Events (DESERVE)	Not stated	Different geographical settings (USA to Ghana)	Randomised controlled trial	Macro
Okoli (2021), Nigeria	Hypertension	Programme to improve hypertension diagnosis, treatment, and control and reduce deaths from cardiovascular diseases	US Kaiser Permanente Northern California (KPNC) model and (WHO) HEARTS	Not stated	Different geographical settings (USA to Nigeria)	Randomised controlled trial	Macro
Olson (2022), USA	Type 2 Diabetes	Web-Based Self-management education programme to support the management of Type 2 diabetes	Diabetes Education and Self-Management for Ongoing and Newly Diagnosed (My DESMOND)	Not stated	Different geographical settings (UK to Australia)	Randomised controlled trial	Macro
Risendal. (2014 & 2015), USA	Cancer	Intervention for chronic disease self-management	Cancer Thriving and Surviving Program (CTS)	Chronic Disease Self-Management Program	Different geographical setting (UK to USA)	Randomised controlled trial	Macro & micro

		programme for cancer survivors		(CDSMP) for cancer survivors' adaptation			
Tongsiri (2022) / Chen (2022), Thailand	Dementia	Intervention for dementia to reduce behavioural and psychological symptoms of dementia	Reducing Disability in Alzheimer's Disease (RDAD)	Thai Reducing Disability in Alzheimer's Disease (Thai-RDAD)	Different geographical settings (USA to Thailand)	Randomised controlled trial	Macro
Tran (2022), Vietnam	HIV and AIDS with depression, anxiety, and/or stress disorder	Programme to improve common mental disorders (CMDs)	Friendship Bench (FB), a problem-solving therapy	Not stated	Different geographical settings (Zimbabwe to Vietnam)	Randomised controlled trial	Macro
Wechsberg (2015), USA	High risk of HIV/AIDS	Behavioural intervention for couples and the men as partners programme to address the interrelated issues of substance use, sex risk behaviors, gender role	Western Cape Women's Health, program	Not stated	Different geographical settings (USA to South Africa)	Randomised controlled trial	Macro

		expectations, and gender-based violence					
Williams (2013), USA	HIV/AIDS self-reporting poor adherence to antiretroviral drugs	Nursing intervention to improve medication adherence	Adherence Through Home Education and Nursing Assessment (ATHENA)	Not stated	Different geographical settings (USA to China)	Randomise d controlled trial	Macro

Level of intervention - Macro: operating at the national or global level, such as through regulations; Meso: intervening with medium-level population groups, institutional or cultural change; Micro: intervening with individuals and their immediate social network and relationships.

Table 2. Stage of adaptation and research methods employed of included studies

Author (year)	Stage of adaptation					Research methods
	Identification	Development	Feasibility	Evaluation	Implementation	
O'Donnell (2022)	✓	✓	x	x	x	Qualitative
Atif (2020)	x	✓	x	✓	x	Qualitative
Bertrand (2019) / Marinho (2021)	✓	x	x	x	x	Qualitative
Bornheimer (2022)	✓	x	✓	x	✓	Mixed
Carver (2021)	✓	x	x	x	x	Qualitative
Cassel (2014)	✓	x	✓	x	x	Qualitative
Chen (2012) / Parker (2012)	✓	✓	x	x	x	Mixed
Cho (2020)	✓	✓	x	x	x	Qualitative
Fort (2019) / Paniagua-Avila (2020)	✓	x	x	x	x	Qualitative
Gorman (2021)	✓	✓	✓	x	x	Mixed
Greenberg (2019)	x	✓	✓	x	x	Qualitative
Alvares Pereira (2022)	✓	✓	x	x	x	Qualitative
Hopkins (2022)	✓	✓	x	x	x	Qualitative
Jans (2020)	✓	✓	x	x	x	Qualitative
Kangovi (2016)	✓	X	✓	x	✓	Mixed
Magidson (2014)	✓	✓	✓	x	x	Mixed
Muroff (2017)	✓	✓	x	x	✓	Mixed
Ojo (2020)	✓	X	✓	x	✓	Qualitative

Okoli (2021)	✓	X	x	x	✓	Qualitative
Olson (2022)	✓	✓		✓	x	Qualitative
Risendal (2014 & 2015) / Tongsiri (2022) & Chen (2022)	✓	✓	✓	✓	x	Mixed
Tran (2022)	✓	✓	x	x	✓	Qualitative
Wechsberg (2015)	✓	✓	x	x	x	Qualitative
Williams (2013)	✓	✓	x	x	x	Qualitative

✓: adaptation stage reported; x: adaptation stage not reported

Table 3: Reference to adaptation guidance/framework of included studies.

Author (year)	Use of guidance /theoretical framework	Guidance/frameworks used
O'Donnell (2022)	✓	Community based developmental approach to adapt CST to different cultures and the Formative Method for Adapting Psychotherapy (FMAP)
Atif (2020)	✓	Medical research Council MRC (UK) framework for development and evaluation of complex interventions
Bertrand (2019) / Marinho (2021)	x	
Bornheimer (2022)	✓	Community-based participatory research (CBPR) methods
Carver (2021)	✓	Consolidated Framework for Implementation Research (CFIR)
Cassel (2014)	✓	Community-based participatory research (CBPR)
Chen (2012) / Parker (2012)	✓	The Method for Program Adaptation through Community Engagement (M-PACE)
Cho (2020)	✓	Intervention Mapping Adapt (IM Adapt) and Typology of Adaptation
Fort (2019) / Paniagua-Avila et al. (2020)	✓	RE-AIM (reach, effectiveness, adoption, implementation, maintenance) framework
Gorman (2021)	✓	ADAPT-ITT model and Modifications were tracked and coded according to the Framework for Reporting Adaptations and Modifications expanded (FRAME)
Greenberg (2019)	✓	National Institute of Health (NIH) stage model for behavioral intervention development, National Institute of Complementary and Integrative Health (NCCIH) model for developing and testing mind-body intervention
Alvares Pereira (2022)	✓	Barrera and Castro framework

Hopkins (2022)	✓	Modified versions of Adapted Intervention Mapping (IM) approach
Jans (2020)	✓	Goldstein Framework
Kangovi (2016)	x	
Magidson (2014)	x	
Muroff (2017)	✓	The cultural adaptation stage model
Ojo (2020)	✓	FRAME framework for reporting adaptations to evidence-based interventions.
Okoli (2021)	✓	Primary Health Care Performance Initiative (PHCPI) conceptual framework and mapped onto Consolidated Framework for Implementation Research (CFIR) main domains
Olson (2022)	x	
Risendal (2014 & 2015)	x	
Tongsiri (2022) / Chen (2022)	✓	Different theoretical frameworks
Tran (2022)	✓	Assessment-Decision-Adaptation-Production-Topical (ADAPT-ITT) framework
Wechsberg (2015)	✓	ADAPT Framework
Williams (2013)	✓	Castro & Barerrera framework

✓: framework/guidance reported; x: framework/guidance not reported

First author (year)	Forming an adaptation team				Assessment of the rationale for the intervention, and consideration of the intervention context fit						Planning and undertaking the adaptation					Planning and undertaking the evaluation						Implementing and maintaining the intervention		Total checklist score
	1 A	1 B	1 C	1D	2 A	2 B	2 C	2 D	2 E	2F	3 A	3 B	3 C	3 D	3E	4 A	4 B	4 C	4 D	4 E	4 F	5A	5B	
Chen (2012)/ Parker (2012)	2	2	2	2	2	0	2	2	1	0	2	2	0	2	1	0	0	0	0	0	0	0	0	22
Williams (2013)	2	2	2	0	2	2	2	2	2	0	2	0	0	1	1	2	1	0	0	0	1	0	0	24
Magidson (2014)	2	1	0	0	2	1	1	2	2	0	1	2	0	0	0	0	1	1	0	0	0	0	0	16
Cassel (2014)	2	2	0	1	2	0	1	2	2	0	1	0	0	1	2	2	1	0	0	0	1	0	0	20
Risendal (2014, 2015)	2	1	1	1	2	1	1	2	2	0	0	2	0	1	2	1	2	0	0	0	0	0	0	21
Wechsberg (2015)	2	2	2	2	2	2	2	2	1	0	2	2	0	0	2	0	1	0	2	0	0	1	0	27
Kangovi (2016)	1	0	0	0	2	0	2	2	2	0	0	1	1	0	1	0	0	0	0	0	0	0	0	11
Muroff (2017)	2	2	0	2	2	2	0	0	2	0	2	2	0	1	2	1	0	0	1	1	0	0	0	22
Greenberg (2019)	1	1	0	0	2	1	1	1	0	0	1	2	0	0	1	2	1	0	0	0	1	0	0	15
Fort (2019) / Paniagua (2020)	2	2	2	2	2	0	1	2	2	0	2	2	0	0	0	2	2	2	0	0	0	1	2	28
Bertrand (2019)/Marinho (2021)	1	2	0	1	2	1	2	2	2	0	2	2	0	0	1	2	2	0	1	0	1	0	0	24
Atif (2020)	2	2	0	0	2	2	1	1	2	0	1	1	0	1	1	2	1	1	1	0	2	0	0	23
Cho (2020)	2	1	2	2	2	2	1	2	2	0	2	2	0	1	2	2	0	0	0	0	0	1	0	26
Jans (2020)	2	1	0	1	1	1	1	2	2	0	2	2	0	1	2	2	1	0	2	0	0	1	0	24
Ojo (2020)	2	0	0	0	2	1	2	2	2	0	2	1	0	2	2	0	1	0	0	0	0	0	0	19
Carver (2021)	1	0	0	0	2	1	2	2	2	0	2	2	0	0	1	2	2	0	0	0	0	2	2	23
Gorman (2021)	2	0	0	1	2	1	1	1	2	0	2	2	0	0	0	1	1	0	0	0	0	0	0	16
Okoli (2021)	2	1	0	0	2	1	2	2	1	0	1	1	0	1	2	2	2	0	0	0	2	0	0	22
Olson (2022)	2	2	2	1	2	1	2	1	2	0	2	2	2	1	1	2	2	0	2	0	0	2	0	31
O'Donnell (2022)	2	2	0	1	2	2	2	2	2	0	2	2	0	1	1	0	1	1	0	0	1	0	0	24
Bornheimer (2022)	2	2	2	2	2	2	2	2	2	0	1	1	0	1	1	0	0	1	2	0	1	0	0	26
Alvares Pereira (2022)	2	2	0	0	2	2	1	1	2	0	2	2	0	1	1	1	1	0	2	0	0	1	0	23
Hopkins (2022)	2	0	0	1	1	2	1	0	0	0	1	2	0	0	1	0	0	0	0	0	0	0	0	11
Tongsiri (2022)/Chen H (2022)	2	2	2	1	2	2	1	2	2	0	1	2	0	1	2	2	2	0	1	0	2	1	0	30
Tran (2022)	2	2	2	1	2	2	2	2	2	0	2	2	0	1	2	2	2	0	2	0	2	0	0	32
Number of studies that achieve the highest score 2 (fully reported) of each of the domain items of the ADAPT checklists	2	1	9	6	2	1	1	1	1	0	1	1	1	2	10	1	9	1	6	0	4	2	2	Median: 23
	1	4			3	1	2	7	9		5	8				3								Range of all 25 studies: 11-32

*Score 2: Fully reported, score 1 - Partially reported, and score 0 - Not reported

Figure 2 A summary of ADAPT checklist assessment of the quality of reporting of included studies. *Score 2: fully reported, score 1—partially reported, and score 0—not reported

Chapter 3 (Paper 2)

Adaptation of an Evidence-Based Home Cardiac Rehabilitation Programme for People with Coronary Heart Disease in Bangladesh

Chapter 3 (Paper 2) : Adaptation of an Evidence-Based Home Cardiac Rehabilitation Programme for People with Coronary Heart Disease in Bangladesh

3.1 Abstract

Background Cardiac rehabilitation (CR) is a clinically proven cost-effective intervention and reduces the risk of hospital readmissions and recurrent cardiac events and improves exercise capacity and health-related quality of life in people. However, access to CR in low and middle-income countries remains scarce and a high unmet need. The purpose of this study was to adapt a home-based CR programme ('the Heart Manual') originally developed and evaluated in the United Kingdom (UK) for the people with coronary heart disease (CHD) in Bangladesh.

Methods Guided by the 2021 ADAPT methodological framework, a multiphase approach to intervention adaptation was undertaken that included mapping of the Bangladeshi healthcare context and in-depth consultation meetings and workshops with key stakeholders (patients and their families, healthcare professionals, and health service providers).

Results In addition to language translation (English to Bangla) and cultural adaptation, the UK Heart Manual content and structure were modified whilst retaining its core interventional components and principles. The resulting Bangla Heart Manual comprises of three main adaptations: (1) combination of the UK Heart Manual post-myocardial infarction and revascularisation manuals into a single document; (2) development of a short version for easy reference for patients; and (3) creation of audiovisual and animated versions of materials to promote patient accessibility.

Conclusion Using an evidence-based approach, the UK Heart Manual programme was contextually and culturally adapted for people with CHD in the Bangladesh healthcare setting. The Bangla Heart Manual provides the opportunity for access to home-based CR in a low resource setting. Research is needed to confirm the feasibility and acceptability of the delivery of the adapted Bangla Heart Manual for healthcare practitioners, patients, and their families.

Keywords: Home-based cardiac rehabilitation, Adaptation, Heart Manual, Post-myocardial infarction, Revascularisation

3.2 Introduction

Coronary heart disease (CHD) is the single major cause of global disability and death [1,2]. By 2030, more than 80 percent of the impact of heart disease will occur in low- and middle-income countries (LMICs) [3]. In the South Asian region, heart disease often affects people of working age resulting in major socio-economic burden [4].

Cardiac rehabilitation (CR) is a clinically proven cost-effective intervention. CR has been shown to reduce the risk of hospital readmissions and recurrent cardiac events and improve exercise capacity and health-related quality of life in people with CHD and heart failure [5-8]. CR is a multifaceted secondary prevention intervention, that typically involves structured exercise based on an exercise prescription, health education, lifestyle modification and psychological support [8]. Despite CR being a level I and grade A recommendation by both American Heart Association/American College of Cardiology, the European Society of Cardiology, and other international guidelines [9-11], participation rates of CR remain stubbornly low. The World Health Organisation has identified CR as a priority in its Global Action Plan for the Prevention and Control of Noncommunicable Diseases [9]. Access to CR is particularly poor in LMICs where the burden of CHD is high and increasing [10,11].

CR has traditionally been delivered in a centre or hospital-based setting supervised by healthcare professionals [5]. However, centre-based CR poses potential barriers to patient attendance including the time, inconvenience and cost of travelling, absence from employment, and challenges in involving caregivers [5,12]. Home-based programmes provide an alternative affordable and scalable model of CR for LMICs that can overcome many of these barriers. The COVID-19 pandemic has provided a unique opportunity for healthcare systems across the globe to fast track the development and delivery of home and digitally supported remote models of care [13-15]. Randomised trials have shown that home and digitally supported models of CR can be as effective and safe as centre-based programmes [16]. Nevertheless, many of these trials have been conducted in high income countries which may lack generalisability and applicability to the LMIC setting [8].

Adaptation is defined as an 'intentional modification(s) of an evidence-informed intervention, to achieve a better fit between an intervention and a new context [17-19]. Adapting existing evidence-based interventions can be a more efficient effective strategy than creating new interventions.

This study aimed to undertake adaptation of the Heart Manual home-based CR programme originally developed and evaluated in the United Kingdom (UK) to develop the 'Bangla Heart Manual' for use by people with CHD and their families in Bangladesh.

3.3 Methods

3.3.1 Study design

This study was designed in accordance with the 2021 ADAPT guidance [20] that proposes four steps to the adaptation of an intervention: (1) assessment of rationale for intervention and intervention and context fit, (2) plan and undertake adaptations, (3) piloting and evaluation of adapted intervention, and (4) implementation of the adapted intervention. This paper reports the first two of these four steps (i.e., adaptation of the UK Heart Manual for people with CHD in Bangladesh) and will inform future planned piloting and implementation of this adapted intervention. In addition to language (English to Bangla) translation, we anticipated that adaptation of the UK Heart Manual would need to address potential contextual differences between countries, including the needs of Bangladeshi people living with CHD and their caregivers and the Bangladeshi health and social care systems (see e-Table 1).

The study was undertaken between 1st May 2023 and 29th February 2024. The protocol for the study was pre-registered on the Open Science Framework (<https://osf.io/tuakh/>).

3.3.2 Procedure

The process for adapting public health evidence-based interventions [21,22] and 2021 ADAPT guidance [20] were combined into a seven-phase procedure for purposes of this study (see Figure 1). This procedure is summarised below (see e-Appendix 1 for further details).

We purposively identified study participants/stakeholders who were relevant to the adaptation process. We first held an international expert group consultation meeting that include from the (Lothian Health Board) of the original UK Heart Manual developer, UK users of the Heart Manual, and Bangladeshi healthcare professionals. Following this meeting, two national meetings were held: (1) an expert group consultation meeting was held on 10th October 2023 including consultant cardiologist, cardiac surgeon, public health expert, senior physiotherapist, psychiatrist, senior staff nurse, and nutritionist, followed by (2) a consultative workshop was held on 10th January 2024 with stakeholders likely to involved in the delivery and receipt of the Heart Manual in Bangladesh. This included a medical officer of cardiology, medical officer of cardiac surgery, physiotherapist, cardiac staff nurse, medical technologist, patient counsellor, dietitian, patients with CHD (post myocardial infraction and revascularisation), and their caregivers. We collated all feedback from consultative workshops attendees based on their completed semi-structured questionnaires, see (see e-Appendix 2). Following an expert group consultation meeting and a consultative workshop

with different healthcare professional experts, service providers, patients and their caregivers to check the Bangla Heart Manual understandability and deliverability. We discussed in these two national consultation meetings for the adaptation and appropriateness of the content of the UK Heart Manual, the sequence of material content, use of language/pictures, and understandability of materials (see e-Appendix 3. A final consensus meeting was held to finalise all the training materials for the patients and facilitator training materials and to confirm the intervention delivery approach and a summary of the participants in the process stakeholders is shown in Table 1

3,3,3 Data analysis

Consultation meetings and workshops were audio recorded which was the analysed to produce draft meeting minutes that were approved by participants. The Bangla Heart Manual and materials were modified based on participant feedback suggestions. This data analysis process was coordinated by two researchers and supported by a third researcher.

3,4 Results

3.4.1 Initial review of UK Heart Manual intervention

The initial review of the UK Heart Manual material identified four key areas for adaptation: (1) reduce volume of Heart Manual text to be reduced for the Bangla patient audience, (2) develop a shorter 'easy to use' version for the Bangla Heart Manual; (3) develop an animated version of exercise programme; (4) develop an audio-visual version for relaxation and doctor-patient conversations, and (5) combine the two UK original Heart Manuals (for post myocardial infraction and revascularisation patients) into a single Bangla Heart manual. These identified areas informed the interview guides for the consultation meetings and workshops.

3,4,2 Expert group consultation meeting and consultative workshop

A total of 28 participants attended the expert group meeting and consultative workshop (see Table 1). Two key themes were identified: (1) the sociocultural, physical and mental health context (2) current CR practice in Bangladesh (see Table 2). The implications of these themes on the adaptation of the Heart Manual materials are detailed in (see Table 3). It was agreed that the holistic CR approach (i.e. combination of exercise promotion, psychological support, and risk factor education) of the original UK Heart Manual intervention was an appropriate model for Bangladesh CR practice. How the specific elements of the UK Heart Manual were adapted are detailed in the sections below.

3.4.3 Bangla Heart Manual

Patient manual

Whilst the UK Heart Manual was designed as a reference resource for patients, a consistent element of stakeholder feedback was the 'overwhelming' nature of the UK Heart Manual in terms of the volume of text and page length of manuals. As a result, it was unanimously agreed that the Bangla adapted version should comprise two versions - a full manual version that could be used by patients and caregivers as a detailed reference resource and a shorter pictorial version for easy day to day patient access/use. For clearer understanding, the adapted Bangla Heart Manual was split in 4 parts and reduce the text volume but in the context of content it was suggested to retain the core components of UK Heart Manual.

The original UK Heart Manual consisted of 3 parts (see e-Appendix 4)

Part-1: Your heart condition: the facts,

Part-2: The weekly programme (6 weeks tailored walking and exercise programme, stress management programme

Part-3: Facts and advice to help your recovery.

The Bangla Heart Manual was adapted to consist of 4 parts comparison with original UK heart manual

(see e-Appendix 5):

Part 1: How to use the Bangla Heart Manual.

Part 2: Weekly programme (6 weeks exercise programme and stress and mental health self-management).

Part 3: Information and advice to help you.

Part 4: Risk factors of heart disease.

The adapted Bangla Heart Manual set a 6-week home exercise programme after revascularisation where the original HM had exercise including stretching, strengthening exercise. Patients, caregivers, and health care professionals suggested the need to demonstrate all the animated version of the 6 weeks home-exercise programme to the patients and their caregivers before discharge from hospitals. For delivery of CR in Bangladesh it is proposed that: (1) physicians (cardiologists) should consistently refer their patients for CR, (2) physiotherapists, nurses, medical technologists, dietitians, and patient counsellor would work on their specific roles as team members and (3) the (physiotherapists

and cardiac nurses having the primary responsibility to take forward CR and the Bangla Heart Manual with patients and their families.

Recognise the needs of families and caregivers in Bangla Heart Manual

The involvement of families and caregivers is already integrated in the original UK Heart Manual. The adapted Bangla Heart Manual gives particular emphasis to the integration of the involvement of families and caregivers. The nature of the Bangladeshi population's caregiving primarily involves their family members (e.g. spouses, children and other close relatives). Healthcare professionals considered the involvement of caregivers as a key potential aspect of CR. Family members highlighted some topics as particularly relevant to their needs, i.e. handling 'cardiac emergencies', managing patient's 'smoking cessations', and 'stress management'. The Bangla Heart Manual Family Resource therefore seeks to emphasise self-care activities to support the mental and social well-being and risk factors of caregivers.

Progress tracking by keeping of weekly exercise, walking and activities records:

The progress tracker is a resource to enable patients to keep a record of their participation in the Heart Manual programme. The tracker was widely accepted by the stakeholder group in its original format and, it was considered readily adaptable by simply translating its content.

Facilitator training course material

The two-day web-based Heart Manual facilitator training course delivered in English by the UK team at Lothian Health Board was considered appropriate to the Bangladeshi setting. However, it was also agreed that this UK training needed to be supplemented with a face-to-face Bangladeshi training session lead by a certified Heart Manual facilitator and experienced CR practitioner. This additional session would particularly highlight the differences between UK and the adapted Bangla Heart Manual materials. The original UK and Adapted Bangla Heart Manual materials (see e-Appendix 6)

Finalisation of the Bangla Heart Manual

The amended Bangla Heart Manual materials underwent a final stage of professional proof reading and printing (Front covers shown in e-Appendix 7).

3.5 Discussion

Despite the advancement and accessibility of cardiac care technology, including cardiac revascularisation and medical treatment, there has been less focus on the provision of CHD secondary prevention and rehabilitation services in Bangladesh [19,23]. Home-based programmes offer the opportunity to improve access to CR. In this paper we describe the process for adapting the Heart Manual home-based CR programme (originally developed and evaluated in the UK) for patients with CHD and their caregivers based in Bangladesh - the 'Bangla Heart Manual'.

Our evidence-based process of adaptation and stakeholder (patients, caregivers, clinicians, and service providers) involvement identified several key areas for the adaptation the original UK Heart Manual into the Bangladeshi healthcare system. First, we identified the lack of current health care professionals' knowledge and skills in CR, emphasising the need for training and capacity building. Second, the UK manual content was considered too dense, text-based, and long. The adapted Bangla Heart Manual therefore focused on less text and more pictorial format but keeps the core components of CR of the original intervention. The Bangla Heart Manual incorporates two main adaptations: (1) the addition of a short manual 'easy to use' version for patients using and (2) development of an animated video version of the exercise programme available for smart mobile or computer/ laptop. The Bangla Heart Manual caregiver resource was adapted to reflect the strong tradition and culture of family involvement and responsibility in healthcare provision in Bangladesh [24]. This included maximising the opportunity to improve the health outcomes of family members and friends who may face the burden of supportive care for those with CHD,

We believe this to be the first study to describe the process of formally adapting a CR intervention in a LMIC. Eghøj and colleagues recently published their adaptation of home-based CR programme (REACH-HF) originally developed in UK for patients with heart failure and their caregivers in the Danish healthcare setting [25]. Our recent systematic scoping review reported healthcare intervention adaptation studies focusing on LMICs [26]. This scoping review showed, In the context of underdeveloped nations, a limited number of studies have detailed the modifications made to various cardiovascular disease therapies [26-28]. Implementing existing evidence-based interventions in new contexts offers a more efficient approach than developing new interventions for every geographical context. The clinical and cost effectiveness of the UK Heart Manual home-based intervention is supported by randomised trials in patients following myocardial infarction and revascularisation [29, 30]. A recently published a single centre quasi-randomised trial comparing home-based CR plus usual care versus usual care alone in Bangladesh, showed patients outcome benefits with

CR participants. This study provides proof of concept of the feasibility and acceptability of a home-based CR approach in this setting [31].

A key strength of this study was the application of a formal methodological process for intervention adaptation [20,22]. However, we acknowledge there are limitations. First, while we sought to involve a diverse population of stakeholders, we cannot claim this to be a representative sample. We purposively sampled stakeholders from different specialised cardiac hospitals and academic institutions in Bangladesh. Second, this study focuses on the adaptation process. A pilot trial is planned to evaluate the feasibility and acceptability of the adapted Bangla Heart Manual for Bangladeshi healthcare professionals, patients, and their caregivers to inform future national implementation potentially wider deployment in the future.

Using an evidence-based approach, the UK Heart Manual programme was contextually and culturally adapted for people with CHD in the Bangladesh healthcare setting. The Bangla Heart Manual provides the opportunity for access to home-based CR in a low resource setting. Further research is needed to confirm the feasibility and acceptability of the delivery of the adapted Bangla Heart Manual for healthcare practitioners, patients, and their families.

3.6 Conclusion

Adapting interventions with an existing evidence base, offers healthcare systems a more efficient approach to implementation than the development of a new intervention. Following an evidence-based approach, we adapted the UK Heart Manual home-based CR intervention to the Bangladesh healthcare context. Although this adaptation maintained the core components of the original intervention, the adapted Bangla Heart Manual included the development of a shorter 'easy to use' version of the manual and an animated version of the 6-week exercise programme. The feasibility and acceptability of the adapted Bangla Heart Manual programme for patients, caregivers, healthcare providers, and service providers will be tested in future pilot trial study in Bangladesh.

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Figure 1. Seven phase adaptation procedure

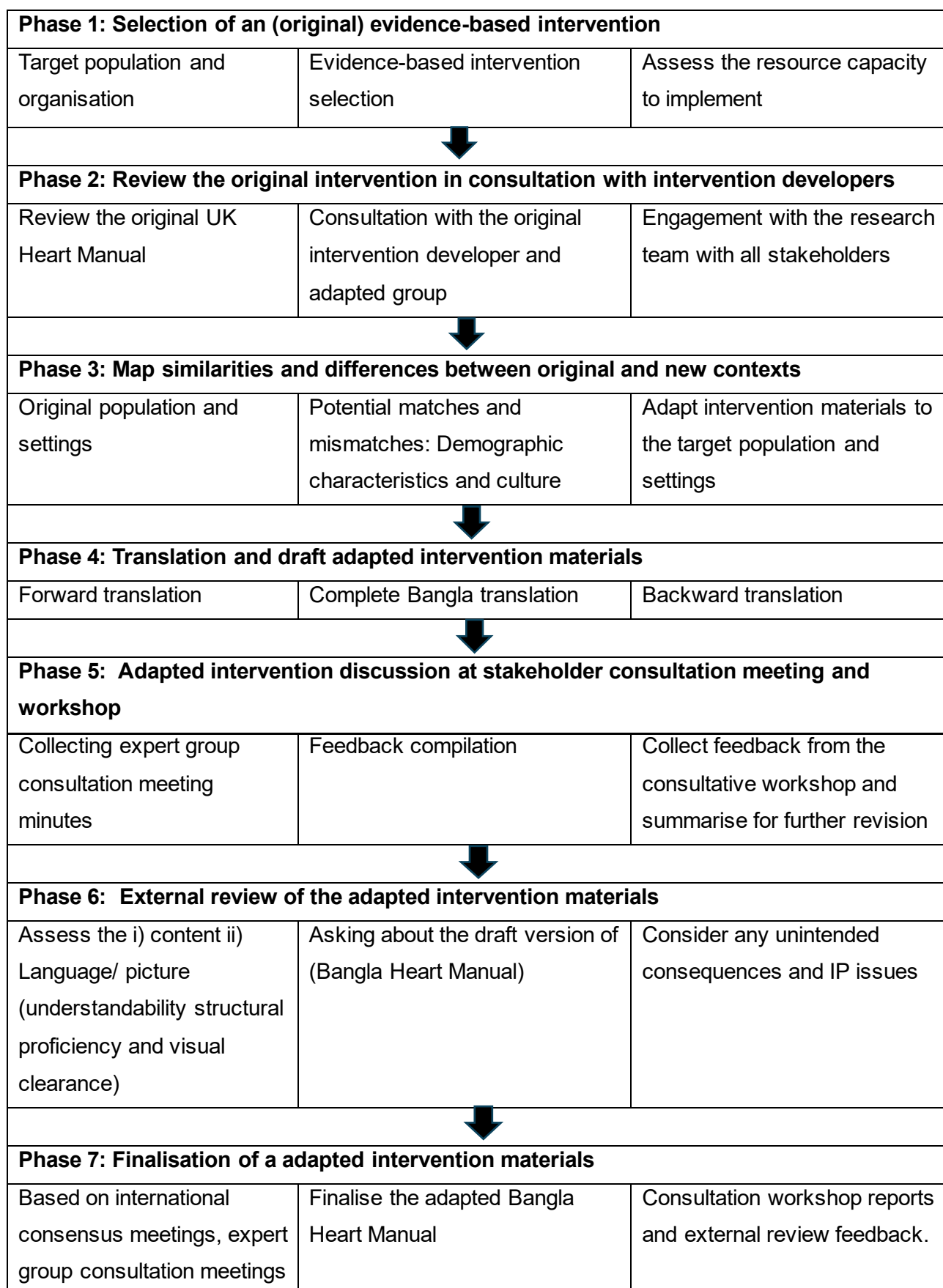


Table 1: Summary of expert meeting and consultative workshop participants

Participant characteristics	Number (N= 28)
Gender	
Men	15
Role	
Cardiologist (consultant)	5
Cardiac surgeon (consultant)	1
Psychiatrist (consultant)	1
Public health expert	1
Medical officer (Cardiology and cardiac surgery)	4
Physiotherapist	5
Nutritionist	2
Nurse	3
Patient counsellor	1
Medical Technologist	1
Patient	2
Caregiver	2
Total	28

Table 2: Key themes and their implications for adaptation of Heart Manual delivery.

Theme	Analytical observation	Implication for adaptation	Adaptation of intervention delivery
Sociocultural, physical, and mental health context	Communication and conversational language about rehabilitation	Healthcare professionals across healthcare settings need to have a day to day communication language to discuss rehabilitation interventions.	Adaptation should better use of conversational language.
	Initiation of CR (timing)	Timing of referral and uptake of CR need to be considered.	The adaptation of CR needs to be introduced from the beginning of the patient hospital admission and delivered before discharge from the hospital.
	Involvement of patients and caregivers	Family members and caregivers in Bangladesh are mostly responsible for psychological, financial, and social support.	Families and caregivers should be involved during the delivery of the adapted intervention., .
Current practice	Lack of existing CR infrastructure	Need to develop staffing and infrastructure to support and develop CR services in Bangladesh.	Importance of adapting existing Heart Manual training to meet the needs of Bangladeshi healthcare professions who will deliver Bangla Heart Manual.
	Barriers for CR referral	Address the barriers to referral and need to encourage cardiologists and cardiac surgeons to refer patients to CR.	Involvement and cooperation with physicians in the adaptation process and establishment hospital CR referral systems.
	Regional and institutional variation of services	Majority of cardiac hospitals /services currently based in Dhaka.	Home-based programme well suited to a 'de-centralised' model of CR provision.

Table 3: Summary of the format, content, and materials for adaptation of the Bangla Heart Manual intervention.

Topic	Intervention component	Adaptation of the intervention
Heart Manual approach	Cross-sectional approach	Facilitator training will have to encompass difficulties of cross-sectorial set-up.
	Role of healthcare professionals	Use same model as UK Heart Manual of health care professionals -as intervention facilitators – physiotherapists, nurses and other suitable professional groups.
	Target patient group	Need to meet the needs of patients with CHD (both post-MI and revascularisation) in Bangladesh.
Heart Manual content		Ensure that Bangla Heart Manual reflects the comprehensive nature of UK Heart Manual.
	Exercise training	Supplement manual with animated version and visual images to aid patients to follow the 6 weeks home-exercise programme
	Psychosocial management	Mental health content has been customised to meet the needs of the Bangladeshi people and adopted into Bangla
	Risk factor management	Adapt risk factor content to reflect Bangladeshi cultural setting e.g. change specific dietary examples.
Heart Manual materials & training	Heart Manuals for patients with CHD (post-MI and revascularisation)	Combine original post-MI and revascularisation UK Heart Manuals into one Bangla Heart Manual. Develop two versions of Bangla Heart manual: (1) longer version - provide ‘encyclopaedia’ for both facilitators and patients, (2) short version –more pictorial to assist patients to use.
	Weekly exercise, walking and activities records	Inbuilt progress tracking chart into the adapted Bangla heart manual.
	Facilitator documents and training	The facilitator training was conducted a hybrid format with an in-person session led by a Bangladeshi specialist adapted from a 2-day UK web-based course. This approach ensured local adaptation while maintaining the original training structure.

* Cross sectional approach-A type of research study in which a group of people is observed, or certain information is collected, at a single point in time or over a short period of time.

Chapter 4 (Paper 3)

Assessment of the Bangla heart manual in patients with coronary heart disease and their caregivers in Bangladesh: A feasibility study

Chapter 4 (Paper 3) : Assessment of the Bangla heart manual in patients with coronary heart disease and their caregivers in Bangladesh: A feasibility study

4.1 Abstract

Objectives: To assess the feasibility and acceptability of the home-based Bangla Heart Manual of CR programme for people with CHD following revascularization living in Bangladesh.

Methods: Tertiary level cardiac hospital in Dhaka city; a single centre feasibility pilot study, with a mixed-methods single arm pre-post design. The study involved 33 CHD patients admitted for revascularization (CABG or PCI) between June and July 2024, selected from 72 screened. Two physiotherapists and one nurse conducted the research, focusing on patients deemed suitable for cardiac rehabilitation. Selected patients received the Bangla Heart Manual intervention that consisted of a six-week programme of home based CR including exercise training, self-care, relaxation, risk factor management, and psychological support facilitated supported by a healthcare professional. The primary outcomes focused on feasibility, assessing patient recruitment, retention, and adherence to the intervention using quantitative and qualitative methods, including interviews with patients, caregivers, and healthcare professionals. Secondary outcomes measured patient-reported metrics like health-related quality of life (HeartQoL, EQ-5D-5L), psychological well-being, exercise capacity (Hospital Anxiety and Depression Scale), and serious adverse events (hospitalization and mortality) before and after the Bangla Heart Manual intervention.

Results: The 33 patients recruited included 29 (88%) males with a mean age of 55 years. The following feasibility outcomes were achieved: 46% (33 patients from 72 screened) recruited, (33 patients from 72 screened), 91% (30/33) retention (complete outcome data at follow up), and 75% intervention adherence (≥ 6 sessions attended of 8 sessions). Improvements following CR participation were seen in patient reported outcomes and exercise capacity. Two deaths and one rehospitalisation occurred during the study.

Conclusions: This study showed that the Bangla Heart Manual home-based CR programme was acceptable and feasible for people with CHD in Bangladesh and healthcare professional staff to deliver. Our results also support the feasibility of recruitment and data collection processes for a future a multicentre randomised trial to formally test the clinical and cost effectiveness of the adapted Bangla Heart Manual.

Key words: home-based cardiac rehabilitation, patient reported outcomes, feasibility study

4.2 Introduction

Coronary heart disease (CHD) is a single major cause of global disability and death.^{1, 2} By 2030, more than 80 percent of the deaths and disability due to heart diseases across the world will occur in low- and middle-income countries (LMICs).³ CHD is a major socioeconomic burden to LMICs where it directly impacts the people of working age.⁴ Cardiac rehabilitation (CR) is a clinical and cost-effective intervention for people with heart diseases reducing their risk of recurrent cardiac events and hospital readmissions and improving exercise capacity and health-related quality of life (HRQoL).^{5, 6} CR is a multifaceted secondary prevention intervention, that involves structured exercise, health education, lifestyle modification, and counseling.⁷ and is typically delivered by a multidisciplinary team.^{5,7, 8} The World Health Organisation recommends CR as a priority intervention for secondary prevention and management of heart disease,⁹ However, despite its potential benefits and consistent recommendation in clinical guidelines, CR is globally under-utilised, particularly in LMICs where levels of CHD continue to rise.^{10, 11} The traditional model of CR provision of a supervised center-based programme typically located in a hospital setting poses a number of practical potential access barriers for patients (i.e. traveling, time and cost, dislike of group sessions).¹² The COVID-19 pandemic underlined the need for alternatives to centre-based models of healthcare provision.^{13, 14} There is strong evidence that home and center-based CR programmes yield similar health benefits and have comparable per patient cost.¹⁵⁻¹⁷ The vast majority of the evidence-base for CR to date derives from high income countries. A systematic review and meta-analysis on CR were found that 26 trials out of 135 countries (LMICs).¹⁸ So, Caution is needed in directly extrapolating the observed benefits and costs of CR from the high-income settings to LMICs where nature of healthcare systems in terms of funding sources, access to facilities, staffing capacity, and patient income levels are likely to be very different. Despite the availability of advanced cardiac care technology, secondary prevention and CR for heart disease is insufficiently available both in government and private hospitals in Bangladesh. A global survey conducted in 2016-17, reported only one CR centre-based programme across the whole of Bangladesh.^{19, 20} Developing alternative approaches to CR delivery including home and/or digitally supported models, offers the opportunity to increase access. Using extensive stakeholder participation, our research group have recently developed a cultural adapted version of the 'Heart Manual', home-based programme originally developed in the United Kingdom (UK), for CHD patients and their caregivers living in Bangladesh on– the 'Bangla Heart Manual' . Before the Bangla Heart Manual can be used and implemented in routine practice, research is needed to test its feasibility and acceptability.

The objectives of this study were to: (1) assess the feasibility and acceptability of delivering the Bangla Heart Manual home-based CR programme for CHD patients and their caregivers in Bangladesh; (2) explore the change in exercise capacity and patient-reported outcomes following participation in the home-based Bangla Heart Manual programme.

Our hypothesis was that the adapted Bangla Heart Manual was a feasible and acceptable home-based cardiac rehabilitation programme for people with CHD and their caregivers in Bangladesh.

4.3 Methods and analysis

This feasibility study protocol was registered on the Open Science Framework (<https://osf.io/pjz3c/>). The study received approval by the ethical review committee of Ibrahim Cardiac Hospital & Research Institute (Ref-ICHRI/Research/ERC/2024/05) 16th May 2024. Written information consent including details of the study procedures were provided to all potential participants. The study is reported in accordance with the Consolidated Standards of Reporting Trials (CONSORT) extension for randomised pilot and feasibility trials.²¹

4.3.1 Study design

The study employed a mixed-methods single arm design with pre-post assessment of patient outcomes and qualitative interviews with healthcare staff involved in the intervention delivery, patients and caregivers. Patients were recruited from the Ibrahim Cardiac Hospital & Research Institute based in Dhaka, Bangladesh.

4.3.2 Participant identification and recruitment

Consecutive patients aged ≥ 18 years were recruited with a CHD diagnosis defined as either a previous myocardial infarction (MI) or angina pectoris (AP) who were admitted in a hospital for an intended revascularisation intervention (angioplasty and or coronary artery bypass graft (CABG) procedures) between June and July 2024 and deemed suitable for CR participation by the clinical team. Patients were excluded if they: (1) underwent an emergency revascularization, (2) had undertaken CR within the last 12 months, (3) had contraindications to exercise testing or exercise training as part of their documented medical history, or (4) were unwilling or unable to travel to the clinical site for their research assessments.

4.3.3 Bangla Heart Manual intervention

The Bangla Heart Manual is a home-based, health professional-facilitated, 6-week CR programme supporting self-care in patients with CHD. Details of the intervention development process are published elsewhere.²² The programme described in detail according to the template for intervention description and replication (TIDieR) checklist (see e-table 1). The Bangla Heart Manual intervention includes specific exercise programmes that meet the needs of patients following myocardial infarction, coronary artery bypass grafting (CABG) and percutaneous coronary intervention (PCI). Healthcare professionals including physicians, physiotherapists, nurses, and dietitians were trained to deliver these tailored components appropriately. In brief the Bangla Heart Manual includes the key elements of a comprehensive CR programme i.e. exercise training, psychological support, and education around self-management including medial therapy and healthy lifestyle. Patients were introduced and educated to the patients and caregivers to the intervention materials by a physiotherapist during hospital stay. On discharge, patients then received a weekly phone call to discuss their progress over 6 weeks with the final contact again taking place in the hospital setting.

The seven health professionals (3 physiotherapists, 2 nurse, 2 medical technologist) with CR experience attended the 2 day of online training delivered by the staff of the Heart Manual Office in UK. Training

focused on the seven steps of successful facilitation of the Bangla Heart Manual: (1) building rapport; (2) assessing the needs and building an understanding of CHD patients; (3) support self-management and progress monitoring; (4) discussing 6 weeks exercise and well-being; trained how to measure ISWT. (5) summarise and plan next steps; (6) reviewing progress; and (7) supporting long-term maintenance.

All study participants, continued to receive their usual medical management and care according to local hospital and national CHD guidelines.

4.3.4 Data collection procedure

Baseline and follow-up data collection were conducted by a trained researcher at two timepoints – baseline: when the patient was in hospital for percutaneous event (before CR intervention) and follow up: follow up visit following the 6-weeks of CR intervention. Baseline data included baseline medical and demographic characteristics and at both baseline and 3-months follow up: exercise capacity a range of participant reported questionnaires (see below) and patient and caregiver satisfaction. Data were obtained via face-to-face interview and from medical records. Semi-structured interviews with patients and clinicians were completed by phone by a trained research interviewer. A standardized interview guide was used for all semi structured interview qualitative interviews.²³ Patient interview guides included open ended questions about patients' transition into home care, their experience with Bangla Heart Manual via phone call. and their current lifestyle and follow-up plan. Clinician interview guides included open-ended questions about clinicians' perception of the program, experience working with patients, and barriers to implementation. All interviews were audio recorded and professionally transcribed.

4.3.5 Outcomes measures

Primary outcomes:

The primary outcomes were the feasibility and the acceptability of the adapted Bangla Heart Manual CR intervention. There were three pre-specified primary outcome criteria: study recruitment (number of consented participants relative to the total number of eligible patients screened), study retention (proportion of study participants who completed outcomes at 3-months follow up), adherence to the intervention (proportion of completion of the Bangla Heart Manual intervention components according to training logs where ≥ 6 of 8 sessions attended seemed adequate) (see Table 2). These criteria informed potential progression to a potential future full multicentre randomised controlled trial to assess the clinical and cost effectiveness of Bangla Heart Manual.

Patients and their caregiver's satisfaction with receiving the Bangla Heart Manual was assessed using a level by five grade Likert scale at 3-months follow up^{24,25} (see e-Appendix C, **e-Figure 2**)

Secondary outcomes:

Secondary outcomes included participant exercise capacity (Incremental Shuttle Walk Test (ISWT)²⁶) and patient-reported outcomes (disease-specific HRQoL - Bangla HeartQoL²⁷, generic HRQoL –

EuroQoL/EQ-5D-5L²⁸, and psychological well-being - Hospital Anxiety and Depression Scale (HADS).²⁹ assessed at baseline and 3-months follow up.

4.3.6 Data Analysis

To achieve the objectives of this study and based on the recommendation of Treweek et al³⁰ for pilot and feasibility trials of minimum of 10 to 15 participants, the study planned to recruit a total of 30 patients over a 2-months period allowing for loss to follow-up of up to 20% at 3 months follow up. Pre- and post-intervention participant outcome data are presented descriptively as frequencies (and percentages) for binary outcomes, and as mean (SD) for continuous outcomes. Pre-post differences in outcomes are presented as means and 95% confidential intervals (CIs). Given the exploratory nature of the study, the focus of outcome interpretation was around 95% CIs rather than P-values. Quantitative data were analysed using SPSS V.23.0 with the significance level set at $p < 0.05$. Baseline data were presented for continuous variables as means and standard deviations, while for categorical variables, frequencies and percentages were used to represent the data. Pre-post differences in outcomes are presented as means and 95% confidence intervals (CIs)) and calculated using paired-sample t-tests. P-values reported for descriptive purposes only. Qualitative interview data were analysed using thematic analysis, as described by Braun and Clarke (2006),³¹ by two qualitative researchers (JU, YS) who developed codes and identified themes.

4.4 Results

A total of 33 CHD patients were recruited, that included 29 males (88%) with a mean age of 55 (SD: 7.7) years, and underwent either CABG (70%) and PCI (30%) (see table 1).

4.4.1 Primary Feasibility outcomes

33 (46%) patients were recruited out of 72 patients screened over a 2-months period (i.e., 16.5 patients recruited per month) (see table 2). Some patients did not consent to participate due to lack of confidence in completing the study, their caregivers were not interested, or they felt under too much stress with the process of revascularization. Intervention adherence were 75% (Completion of the Bangla Heart Manual intervention components according to training logs). (see table 2). 30 of 33 (91%) participants provided full outcome data at 3-months follow-up. Two patients died (one due to septic shock and one with cardiac arrest after CABG) and one patient dropped out. Neither of these two serious adverse events were deemed related to the CR intervention. Patients and caregivers reported high level of satisfaction with study participation and the CR intervention. (see table 3)

4.4.2 Secondary outcomes

Improvements at 3-months follow up compared to baseline were seen in exercise capacity assessed by ISWT (see table 4) and patient-reported outcomes of the HeartQoL, HADS, and EQ-5D-5L (see table 5).

Patient interviews

We developed a set of 9 codes that were applied to the transcripts to identify two overarching themes emerged (see Table 6) : Theme 1: Knowledge and practice of home CR: Patients get some knowledge regarding heart disease and its management. One patient said that “learn about the coronary heart disease and its treatment option”. Other patients explain that “We did some exercise and not in bed diet but good to know the importance of self-management diet and relaxation”. Patients reported they had a very positive experience of effective communication from physiotherapist at the hospital, home (via phone call) and across all of the parts of the Bangla Heart Manual programme.

Theme 2: self-motivation to change lifestyle and follow-up plan: Patients were motivated to make lifestyle changes. Patients expressed that they followed the healthy diet (following the diet chart book provided) and followed the instruction to avoid fatty and junk food. Most of the patients commented that they motivated to regain prior functioning by doing proper weekly exercise and walking programme. One patient state that “ they workout properly the weekly home exercise and relaxation practice that has given in to the book and practically treated by the physiotherapist the animated and audiovisual version of exercise and relaxation section”. One patient stated that “the clinicians were instrumental in helping them to achieve these

goals". Another patient stated that "the physiotherapist were motivating with having weekly phone call that's really encouraging."

Clinician interviews

We developed seven codes applied to the transcripts to identify themes. Two themes emerged (see table 6).

Theme 1: Systematic and comprehensive approach of home CR delivery: Clinicians described the home-based CR programme as a systematic approach complete rehabilitation of patients at their home and emphasizing the importance of patients having access to the programme materials. One facilitator stated: , " I liked the way intervention delivered sequentially by giving first visit, second visit etc and their contents". Another facilitator explain that " by the time I discharged the patient they really get clear demonstration of exercise, educated to diet management, for stress and mental health management practiced relaxation, educate on risk factor management which really ties into managing their disease".

Theme 2: Motivation and involved clinical practice: Clinicians spoke about their experiences of the challenges with working with patients who were not motivated to change or struggled with the components of the educational part of the programme and the importance of engaging patients caregivers. Facilitators were expressed that " they were highly motivated to keep continue this experience into their clinical practice".

4.5 Discussion

This study aimed to determine the feasibility and acceptability of the Bangla Heart Manual, an adapted six-week home based CR intervention, for people with CHD in Bangladesh in order to inform both the potential future clinical access to the intervention and also feasibility of undertaking a future definitive randomised controlled trial to assess its clinical and cost-effectiveness. Our mixed methods analysis provides supportive evidence of feasibility and acceptability of the intervention with patients and healthcare staff delivering the intervention. Good levels of intervention adherence (75% attended a minimum of 80% of intervention sessions) were seen and patients and caregivers reported high levels of satisfaction following their participation in the 6-week facilitated period of intervention delivery.

Recruitment rate was 46% (success rate of recruitment is $\geq 30\%$) which shown to be acceptable and outcome retention 91% participants (30/33) completing outcomes at 3-month follow up. Although not formally powered for efficacy, this study also showed improvements in exercise capacity and patient reported outcomes of HRQoL and psychological wellbeing following participation in the CR intervention. Finally, the Bangla Heart Manual appeared be a safe intervention for CHD patients following revascularisation. Although the evidence base for CR in the LMIC setting is relatively limited continues to evolve, our results appear to be consistent with the benefits of CR reported in other studies in low resource settings. A single centre randomised trial comparing home-based CR plus usual care versus usual care alone in Dhaka, Bangladesh, showed benefits in patient reported outcomes of mental well-being and exercise capacity with CR. This study provides proof of concept of the feasibility and acceptability of a home-based CR approach in this setting.³²

The Yoga-CaRe multicentre randomised trial in India reported improved self-rated health and return to pre-infarct activities after acute myocardial infarction with a yoga based rehabilitation programme.³³ Recent studies in Bangladesh and India show improved HRQoL of post-PCI and CABG, with greater physical than emotional gains.³⁴ CABG patients had higher HRQoL than PCI patients at 6-24 months.³⁵ Both CABG and PTCA enhance HRQoL,³⁶⁻⁴⁰ but CABG improves both physical and psychological domains, while PTCA mainly benefits physical health.⁴¹ Indian studies found significant physical but limited psychological HRQoL improvements post-revascularization.^{42,43} These findings highlight the varying impacts of revascularisation on HRQoL.

To our knowledge, this is the first study to assess the feasibility and acceptability of delivering a home-based CR program in Bangladesh. A home-based model of delivery offer offers an affordable and scalable approach to improve CR in the wider LMIC setting. However, this study has some limitations. First, recruitment from a single urban tertiary hospital and the predominantly male sample limit the generalizability of the findings.. Second, the lack of a control group precludes attribution of observed improvements solely to the CR intervention,

as these may partly reflect natural recovery following revascularisation. In addition, the small sample size and short follow-up period preclude definitive conclusions regarding efficacy. Third, patient-reported outcomes are susceptible to reporting bias.

4.6 Strengths & limitations of this study:

- Employed a mixed-method design to gather both quantitative and qualitative data, ensuring a thorough and comprehensive understanding of the study's outcomes.
- Incorporated diverse perspectives from patients, caregivers, and facilitators, enhancing the robustness of evidence for feasibility and acceptability findings.
- Baseline assessments were conducted before revascularization, making it unclear whether improvements in exercise capacity and patient-reported outcomes were due to the CR intervention, revascularization, or both.
- Lack of a control group, small sample size, and short follow-up period restrict the study's generalizability and depth of findings.
- The study did not formally assess the efficacy of the Bangla Heart Manual CR intervention, focusing instead on feasibility and acceptability.

4.7 Implications for practice and future research:

Worldwide, CR programme uptake attendance rate has been suboptimal. In 2019, in UK and United States only 50% of all patients who were eligible attended CR programme.^{43, 44} A noticeable change in the healthcare services provided have been seen in response to the COVID-19 pandemic. Between 2018 and 2021, in UK the proportion of home-based CR programs rose from 16% to 70%.⁴³ According to ICCPR survey, COVID-19 has impacted cardiac rehabilitation (CR) delivery around the globe resulted in at least temporary cessation of ~75% of CR programs.^{45, 46} The availability of alternative modes of delivery to traditional centre-based CR programs, including home and digitally supported models are key to improving global CR access. Our study supports the potential to increase access to CR in Bangladesh using the Bangla Heart Manual a – a model of home-based CR is supported by healthcare professionals using a mobile phones. Our results also support the importance and feasibility of a larger and more focused study to formally assess the clinical and cost-effectiveness of Bangla Heart Manual for patients with CHD and their caregivers in Bangladesh.

4.8 Conclusions

The culturally adapted Bangla Heart Manual was found to be a feasible and acceptable home-based CR intervention for Bangladeshi CHD patients and their caregivers and for healthcare professionals to deliver. Whilst not formally powered for efficacy, the observed improvements in patient exercise capacity, HRQoL and psychological wellbeing following CR participation are supportive of the value of this intervention. A fully-powered multicentre randomised trial is needed to confirm the clinical and cost effectiveness of Bangla Heart Manual for patients with CHD following revascularization in Bangladesh.

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4.10: Tables and figures

Table 1: Demographic, comorbidities, clinical and biomedical characteristics.

Gender , Male	29 (88%)
Age, years	55 (7.7) years
BMI, kg/m ²	25.4 (2.6)
Education: Primary school completed	3 (12%)
High school completed	12 (36%)
Higher secondary school and graduation completed	12 (36%)
Post graduation completed	6 (18%)
Marital status	33 (100%)
Intervention procedure	
CABG	23 (70%)
PCI	10 (30%)
Co-morbidities:	
Diabetes	28 (85%)
Dyslipidaemia	27 (82%)
CKD	3 (9%)
Stroke	2 (6%)
COPD	1 (3%)
Risk Factors:	
Smoker	19 (58%)
Physically inactive	17 (52%)
Fatty food	20 (61%)
Family history	15 (45%)
Alcoholic	0 (0%)
Biomedical parameters:	
Total Cholesterol	138.8 (42.3) mg/dl
Triglyceride	163.3 (81.7) mg/dl
LDL	66.5 (30.5) mg/dl
HDL	39.6 (8.1) mg/dl
Clinical parameters, LVEF (%)	52 (0.09)

BMI= Body Mass Index, CABG= Coronary Artery Bypass Grafting, PCI= Percutaneous Coronary Intervention, CKD= Chronic Kidney Disease, COPD= Chronic Obstructive Pulmonary Disease, LDL= Low Density Lipoproteins, HDL= High- Density Lipoproteins, LVEF = Left Ventricular Ejection Fraction

Table 2: Summary of feasibility outcomes.

Outcomes	Definition	Prespecified success criteria	Study outcome
Recruitment	Number of consented participants relative to the total number of eligible patients approached for consent	Recruitment rate of $\geq 30\%$	33 patients were recruited/ 72 were screened over a 2 month period ($33/72 \geq 16$ patients per months, 46%)
Retention	Number of participants who complete the final study assessment relative to the total number of participants enrolled for pilot trial.	Retention rate of $\geq 80\%$	2 deaths and dropout 1 (30/33), 91%
Adherence	Percentage of completion of the Bangla Heart Manual intervention components according to training logs.	Intervention adherence of $\geq 75\%$	(6 session out of 8 session delivered in 6 weeks programme), 75%

Table 3: Level of satisfaction of patients and caregivers assessed at 3-months follow up

	Mean (SD) and 95% CI
Patients	4.3 (0.6)
Caregivers	4.4 (0.6)

Table 4: Secondary outcomes: Exercise capacity (ISWT) at baseline and 3-months follow up

	ISWT (metres) mean (SD)	Pre-post ISWT (metres) mean difference (95% CI)	P-Value
Baseline (n=17)	91.2 (33.3)	62.2 (36.27 to 88.18)	<0.0001
Follow-up (n=19)	155.3 (33.1)		

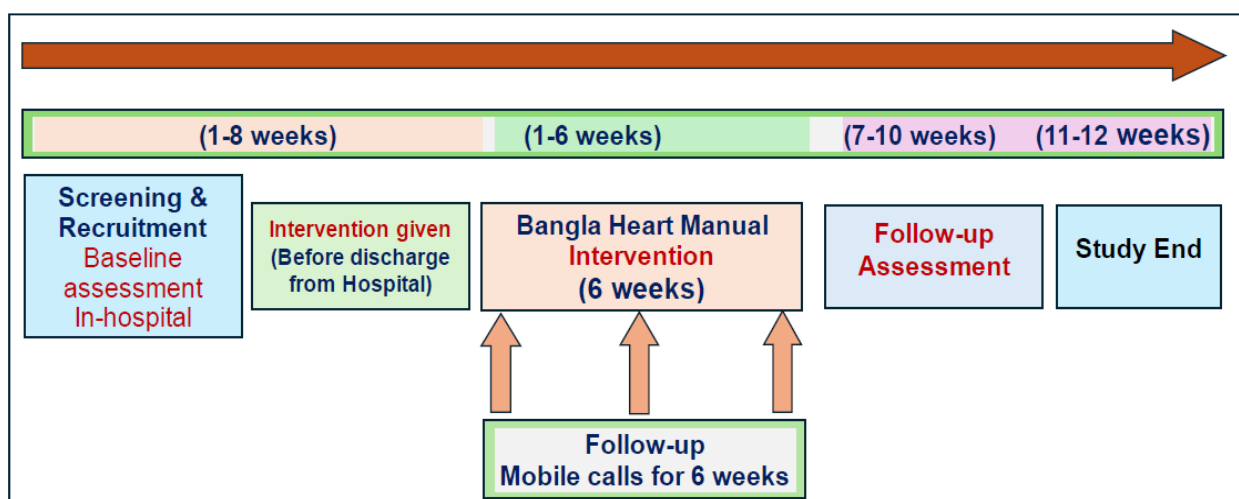
Table 5: Secondary outcomes: HeartQoL physical and emotional subscale, HADS and EQ-5D-5L at baseline and 3-months follow up

HeartQoL physical and emotional subscale				
Subscale	Baseline (n=33) mean (SD)	Follow-up (n=30) Mean (SD)	Mean difference and 95% CI	P Value
Physical	1.69 (0.64)	2.62 (0.41)	0.94 (0.66 to 1.21)	<0.0001
Emotional	1.78 (.79)	2.67 (.55)	0.87 (0.47 to 1.27)	
HADS				
	Baseline (n=33) mean (SD)	Follow-up (n=30) Mean (SD)	Mean difference and 95% CI	P Value
Anxiety	6.79 (4.08)	1.55 (1.56)	5.24 (3.94 to 6.55)	<0.0001
Depression	5.27 (3.39)	2.12 (2.30)	1.93 (1.14 to 2.72)	
EQ-5D-5L dimensions				
Domain	Baseline (n=30), Mean (SD)	Follow-up (n= 29) Mean (SD)	Mean difference and 95% CI	P-Value
Mobility	2.23 (1.15)	1.13 (0.35)	1.10 (0.64 to 1.56)	<0.0001
Self-care	1.74 (1.06)	1.2 (0.41)	0.52 (0.15 to 0.92)	0.01
Usual activities	1.84 (1.07)	1.1 (0.31)	0.76 (0.34 to 1.17)	0.0008
Pain or discomfort	2.19 (0.91)	1.5 (0.51)	0.66 (0.23 to 1.07)	0.004
Anxiety or Depression	2.29 (0.86)	1.3 (0.47)	1.03 (0.69 to 1.38)	<0.0001
EQ-5D-5L VAS				
EQ-VAS	Baseline (n=30), Mean (SD)	Follow-up (n= 29) Mean (SD)	Mean difference and 95% CI	P-Value
VAS score, Mean (SD)	68 (18)	86 (09)	17 (11.16 to 22.91)	<0.0001
EQ-5D-5L utility scores using Indian population health value norms				
EQ-5D-5L pre and post (value norms)	Baseline (n=30), Mean (SD)	Follow-up (n=29) Mean (SD)	Mean difference and 95% CI	P-value
EQ-5D-5L index score	0.69 (0.37)	0.94 (0.06)	0.25 (0.11 to 0.39)	0.00094

Table-6: Examples of quotes to illustrate patient and clinician (facilitators) themes:

Theme	%, participants	Quotes
<i>Patients:</i> - Knowledge and practice of home CR - Self-motivation and follow-up plan	N=6 86% 75%	“ Learned about the coronary heart disease and its treatment option”. “We did some exercise and not in bed diet but good to know the importance of self-management diet and relaxation”.
<i>Clinicians:</i> - Systematic and comprehensive approach of home CR - Motivation and involved clinical practice	N= 3 91% 82%	“ I liked the way intervention delivered sequentially by giving first visit, second visit etc and their contents”. “Generally, patients are excited about the programme. Involvement of caregivers is a great idea” “ they were highly motivated to keep continue this experience into their clinical practice”.

Figure 1 Summary of study participant pathway



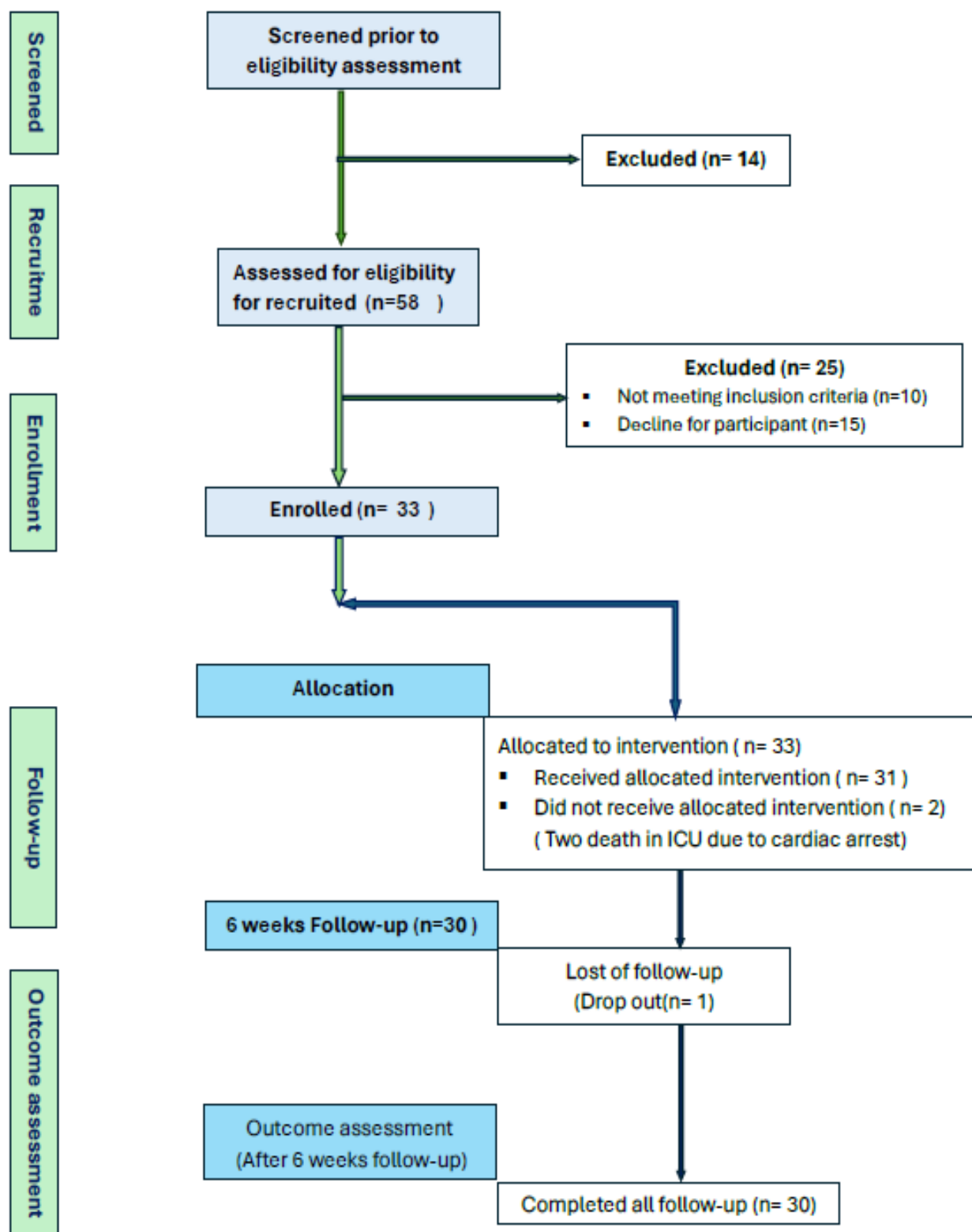


Figure-2: Consort diagram for recruitment and enrollment

Chapter 5 (Paper 4)

**Effectiveness, safety, costs, and delivery considerations of
exercise-based cardiac rehabilitation in low- and middle-
income countries: A systematic review and meta-analysis
of randomised controlled trials**

Chapter 5 (Paper 4) : Effectiveness, safety, costs, and delivery considerations of exercise-based cardiac rehabilitation in low- and middle-income countries: A systematic review and meta-analysis of randomised controlled trials

5.1 Abstract

Introduction: Cardiovascular disease (CVD) disproportionately burdens low- and middle-income countries (LMICs). Although cardiac rehabilitation (CR) is a cornerstone of CVD management, its availability in LMICs remains limited. This study aimed to undertake a systematic review and meta-analysis of randomised controlled trials (RCTs) evaluating exercise-based CR in LMICs.

Methods: We identified RCTs of exercise-based CR programmes in LMICs from a previous systematic review and by searching bibliographic databases up to June 2025. Study quality was assessed using the Cochrane risk of bias tool. Mortality, hospitalisation, exercise capacity, health-related quality of life (HRQoL), and mental health outcomes were pooled using random-effects meta-analyses. Safety, cost, and cost-effectiveness data were narratively synthesised. Meta-regression was used to explore potential effect modification and the certainty of evidence assessed using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) framework.

Results: Twenty-nine RCTs (6,682 participants) from Central Asia, South Asia, Africa, and South America were included, with an overall moderate-high risk of bias. The included studies varied widely in patient populations, CR interventions, and delivery modes. Pooled analysis showed that exercise-based CR may lead to a moderate improvement in overall exercise capacity (standardised mean difference: 0.71, 95% CI 0.47 to 0.96) compared to control. Despite high statistical heterogeneity ($I^2 = 72\%$), there was no evidence of a difference in the effect of CR on exercise capacity across study-level factors such as delivery model, exercise dose, follow-up, or risk of bias. CR participation was also associated with improvements in HRQoL and mental health. However, few trials reported data on mortality, hospitalisation, safety, costs, or provided details on CR programme delivery.

Conclusions: This contemporary review indicates that exercise-based CR in LMICs improves exercise capacity and HRQoL consistent with evidence from high-income settings. However, due to statistical heterogeneity, risk of bias, and inconsistent data collection, the certainty of these outcome impacts is low to very low. High-quality RCTs collecting patient-relevant outcomes from CR programmes appropriately designed for the low-resource and cultural contexts of LMICs remain a strategic priority.

Keywords: cardiac rehabilitation, low- and middle-income countries, systematic review, meta-analysis, exercise capacity, health-related quality of life, randomised controlled trial

5.2 Introduction

Cardiovascular disease (CVD) is a leading cause of global mortality and disability, with low- and middle-income countries (LMICs) bearing a disproportionate burden. By 2030, LMICs are projected to account for up to 80% of all global CVD-related deaths and disability.^{1,2} Over the past century, Significant progress has reshaped the management of individuals with CVD), including advances in diagnostics, arterial revascularisation, cardioprotective pharmacotherapy, and multidisciplinary care.^{3,4} These developments have contributed to improved rates survival following initial cardiac events and reduced lengths of hospital stay. Nonetheless, due to population aging and the continued prevalence of unhealthy lifestyle behaviours, global healthcare systems now face the growing challenge of managing an increasing number of individuals living longer with CVD and its associated sequelae.⁵

Cardiac rehabilitation (CR) is a model of CVD care that involves provision of core components (including secondary prevention) by a multidisciplinary team.⁶ These include initial assessment, medical risk factor management, structured exercise, patient education, lifestyle counselling (e.g. tobacco cessation and diet), and psychosocial management (e.g., stress and depression screening, and support in returning to life roles).⁷ Meta-analyses of randomised controlled trials (RCTs) have consistently demonstrated that participation in CR reduces the risk of rehospitalisation and improves functional capacity and health-related quality of life (HRQoL).^{8,9} Despite high disease prevalence and mortality, LMICs currently have the lowest global levels of CR access, due to variety of factors including a lack of public health funding and limited healthcare professional capacity.¹⁰⁻¹² Furthermore, our global approach to CR, has traditionally been driven from clinical guidelines and evidence emanating from high-income countries (HICs).

LMICs require affordable, scalable, and contextually relevant CR models. Adaptations to traditional centre based HIC models of CR delivery are essential to address the needs of LMIC populations and healthcare systems.¹³⁻¹⁵ Strategies to improve CR access in LMICs include universal health coverage, expanding home- and community-based programmes supported by accessible digital technologies (e.g., internet and mobile phones), and capacity building and training of healthcare staff to ensure the quality of CR delivery.¹⁶⁻¹⁸

To address these issues, this study undertook a contemporary systematic review and meta-analysis of RCTs of CR in a LMIC setting. Specific objectives were: (1) to assess the impact of CR on patient outcomes (exercise capacity, HRQoL, hospitalisation, mortality, and adverse events); (2) to assess the costs and cost-effectiveness of CR; and (3) to examine models of CR delivery in terms of their core components and staffing.

5.3 Methods

This study was conducted in accordance with the Cochrane Handbook for Systematic Reviews of Interventions and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA-P) statement.^{19,20} The study protocol was pre-registered on PROSPERO (CRD420251009678).

5.3.1 Search strategy

A two-phase approach to study identification was undertaken. First, the studies included in a previous systematic review of CR in LMICs published by Mamataz et al in 2022,²¹ were assessed for their potential eligibility. Second, as Mamataz et al searched to May 2020, this study undertook a search of bibliographic databases were searched from 1 May 2020 to June 2025 that included the Cochrane Controlled Register of Trials (CENTRAL), EMBASE, MEDLINE, Cumulative Index to Nursing & Allied Health Literature (CINAHL), PsycINFO, and Global Index Medicus. In addition, reference lists of retrieved articles and other recent systematic reviews were hand-searched. Titles and abstracts were imported into Rayyan software.²²

5.3.2 Eligibility criteria and study selection

Study inclusion was based on the following criteria: (1) study design: any RCT designs, . Non-randomised designs were excluded (2) Participants: included adults (≥ 18 years) with any heart disease diagnosis, include coronary heart disease (CHD), heart failure (HF), valvular heart disease, and atrial fibrillation. (3) Interventions: participants participated in an exercise-based CR, (that included initial assessment and some form of structured exercise training either alone or in addition to psychosocial or educational intervention) that could be supervised or unsupervised and delivered in an outpatient, community or home-based programme (with or without digital support). The CR programme can consider all phases of CR delivery; (4) Control: control participants did not receive a structured exercise-based CR programme. Studies directly comparing different CR interventions were excluded; and (5) Setting: study undertaken in a LMIC as defined by the World Bank 2025.²³ Studies undertaken in low-resource settings of HICs or focusing on LMIC emigrants living in HICs were excluded. Two reviewers (JU and VJ) independently screened titles and abstracts based on the inclusion and exclusion criteria listed above. Disagreements were resolved via consensus or third reviewer (RST). The full texts of potentially relevant studies were assessed and excluded studies were documented.

5.3.3 Data extraction and risk of bias assessment

Data were extracted and risk of bias assessed using a standardised template by a single reviewer (JU) and then verified by a second reviewer (VJ). For each included study the following categories of information were sought: (1) study characteristics: date of publication,

country, trial design, duration of follow-up, and number of centres; (2) participants: number randomised, lost to follow-up, age, sex, diagnosis, and socioeconomic status; (3) intervention and control: CR components (exercise prescription according to FITT (frequency, intensity, duration, and type of exercise, including aerobic and resistance training framework),^{24,25} co-interventions, type of delivery (home-based/centre-based/hybrid), and comparator details.²⁶ Data was sought on the following outcomes: Primary - all cause or disease specific mortality, all cause or disease specific hospitalisation, HRQoL (assessed using validated disease specific e.g. Minnesota Living with Heart Failure Questionnaire,²⁷ or generic measures e.g. 36-item Short Form);²⁸ intervention components: exercise prescription, inclusion of health education and self-management, and delivery details (e.g. staff, home/centre/hybrid) and (5) CR costs and cost-effectiveness. Secondary - exercise capacity (e.g. peak oxygen uptake, incremental walk test (ISWT)),²⁹ mental health (e.g. Patient Health Questionnaire (PHQ 9),³⁰ General Anxiety Disorder-7 (GAD7)).³¹ As safety was inconsistently defined and reported across included studies it was operationalised for the purposes of this review as any non-fatal CVD event (e.g., myocardial infarction, percutaneous coronary intervention, or stroke) and/or other stated CR related events (e.g., musculoskeletal injury). Outcome data were extracted from all included studies at baseline and all follow-ups.

Based on recent publication, the Cochrane RoB-1 tool was used to assess risk of bias.³² This included assessment of random sequence generation, allocation concealment, outcome blinding, incomplete outcome data, and selective reporting. Bias was categorised as 'high', 'low', or 'unclear' and the justification of judgement recorded.

5.3.4 Data synthesis and statistical analysis

Given the likely level of clinical heterogeneity in this review (e.g., variation in included study population and CR intervention), outcomes were pooled across studies using the DerSimonian and Laird random-effects meta-analysis method, assuming that each study estimates a different underlying intervention effect. Outcomes were pooled at latest follow time. Binary outcomes (e.g., mortality) were expressed and pooled as risk ratios (RRs) with 95% confidence intervals (CIs). The continuous outcome of exercise capacity was pooled across studies reporting different measures using the standardised mean difference (SMD). For SMD, effect sizes were interpreted as 'small' (0.20 to 0.49), 'medium' (0.50 to 0.79), or 'large' (≥ 0.80).³³ Where ≥ 2 trials reported the same exercise capacity or HRQoL measures and domains, these continuous outcomes were pooled separately on their original scale and reported as the mean difference (MD) and 95% CI. The preferred metric for continuous outcomes was the baseline-follow up mean difference and standard deviation in both CR and control groups. Where not reported, an estimate of baseline-follow up standard deviation (SD) was calculated using the baseline and follow up SDs, assuming a within participant correlation of 0.50.³⁴ Otherwise, the outcome at follow up was used. Cost, cost-effectiveness,

and safety data were synthesised narratively. Statistical heterogeneity was considered substantial where I^2 statistic $>50\%$. For outcomes with ≥ 10 trials included in the meta-analysis, we used the funnel plot and Egger's test to examine small study (publication) bias and considered meta-regression.³⁴ For meta-regression the following pre-specified trial level covariates were considered: (1) type of rehabilitation (exercise only vs comprehensive CR), (2) type of exercise (aerobic only vs. aerobic plus resistance), (3) exercise dose (i.e. programme duration [weeks] $\times$ frequency [sessions per week] $\times$ length of session [in minutes]), (4) type of CR delivery (centre vs. home vs. hybrid), (5) number of centres (single vs. multicentre), (6) risk of bias (i.e. low risk for both random sequence generation and allocation concealment vs. not), (7) geographical location (lower-middle vs. and upper-middle income countries), (8) follow-up (months), and (9) sample size. Data analysis was undertaken using STATA v.18.0. Two-sided $p \leq 0.05$ were considered statistically significant.³⁵

5.3.5 Assessment of evidence certainty

Grading of Recommendations Assessment, Development and Evaluation (GRADE) were used to assess the certainty of evidence for primary and secondary outcomes. Evidence was downgraded from 'high' certainty by one level based on the following domains: limitations in study design or execution (ROB), inconsistency of results, indirectness of evidence, imprecision, and publication bias.³⁶

5.4 Results

5.4.1 Study selection

The study selection process is summarised in Figure 1. A Database searches identified 1,869 records of which 38 full papers were reviewed, and 10 RCTs included. (see MEDLINE search e-table 1) A total of 19 RCTs from the Mamataz (2022) met the eligibility of this review. Thus, a total of 29 RCTs, (6,489 participants) were included.³⁷⁻⁶⁵

5.4.2 Study characteristics

A summary of study, participant, intervention and comparator characteristics of the 29 RCTs is presented in Table 1 (see e-Table 2 for individual study details). All studies were published in the last two decades (2008 to 2024) and predominantly undertaken in central Asia (18 studies) and south Asia (10 studies). Twenty-eight were two-group RCTs (exercise CR vs. control), one study using quasi-randomisation.⁶⁴ Chaves et al (2019) used a 3-group design and compared two types of CR (comprehensive and exercise-only) to control.²⁶ Median sample size was 71 participants with one Indian multicentre RCT (Yoga-CaRe) contributing 3959 patients (61% of overall). Overall participant median age was 58.8 years, 21% were female, and primary diagnoses were CHD (post myocardial infarction and/or post-percutaneous intervention) and HF either alone or in combination. Median follow up across studies was 6 months (range 1.5 to 36 months).

5.4.3 Characteristics of CR intervention and comparator

CR programmes were predominantly comprehensive (19 studies) and undertaken in either a centre- (14 studies) or home-based (10 studies) settings. The nature of CR programmes varied widely across studies, with programme length of 2 to 104 weeks and a median of 36 sessions per programme; exercise session duration ranging from 15 to 75 minutes, exercise frequency from 3 to 7 sessions per week, and exercise intensity from 55 to 85% of maximum heart rate and Borg Scale ratings of 3-7 (on 0-10 scale) or 11-16 (on 6-20 scale). Where reported, most programmes were either research (11 studies) or publicly/government (10 studies) funded. Only seven studies reported on staffing details, with the professions involved being varied and multidisciplinary, including physiotherapists, nurses, physicians, researchers, dietitians, yoga instructors, rehabilitation therapists, and community health workers (see eTable 3). Most studies described their comparator arm as 'usual care' (15 studies).

5.4.4 Risk of bias assessment

Reporting was variable across the different seven risk of bias domains (see Figure 2). Sufficient and appropriate details of random sequence generation and concealment was reported by 16 and 11 studies respectively. Only one study was judged to have low risk of

performance bias, the remainder being unclear in their reporting. Eleven studies were assessed to have low risk of detection bias. The majority of studies had low risk of attrition (22 studies), reporting and 'other' bias (both 23 studies) categories.

5.4.5 Outcomes

A summary of the synthesis of primary and secondary outcome results and GRADE assessment is presented in Table 2 and summarised below.

Exercise capacity

A total of 16 studies (17 comparisons) reported exercise capacity using a range of outcome measures. As shown in Figure 3, pooled analysis showed a moderate effect size improvement with CR compared to control (SMD 0.71, 95% CI: 0.47 to 0.96) (see eFigure 1). There was evidence of high statistical heterogeneity (I^2 71.6%). A benefit in favour CR was also seen when studies were separately pooled by each exercise capacity measure. - peak VO_2 (MD 3.6 ml/kg/min, 95% CI: 2.8 to 4.5, $p < 0.0001$, I^2 5.4%, 2 studies), (see eFigure 2) 6-minute walk test (MD 40.9 metres, 95% CI: 21.3 to 60.2, $p = 0.003$, I^2 67.8%, 8 studies), (see eFigure 3) and incremental shuttle walk test (MD 74.6 metres, 95% CI: 6.9 to 142.3, $p = 0.031$, I^2 0%, 8 studies) (see eFigure 4).

HRQoL

HRQoL was reported using a range of generic measures that included SF-12 and SF-36, EQ-5D, and WHOQoL. There was evidence of improved HRQoL with CR in both SF-12/36 physical component (MD 5.0, 95% CI: 0.5 to 9.4, $p = 0.030$, I^2 0%, 5 studies) and mental health component (MD 4.1, 95% CI: -0.8 to 9.1, $p = 0.099$, I^2 0%, 5 studies) scores (see Figure 4A and 4B). Improvement with CR was also seen in the pooled analysis across six studies reporting the eight SF-12/36 domains (see e-Figure 5a-h). Two studies reporting the EQ-5D showed some evidence of an improvement with CR (MD 5.2, 95% CI: -3.2 to 13.7, $p = 0.227$, I^2 90%) (see e-Figure 6). Uddin et al⁶⁴ reported improvement ($p < 0.01$) in all WHOQoL domains with CR compared control at 12 months follow up.

Mental health

The meta-analysis revealed mixed mental health outcomes, where results for depression on the PHQ-9 were not significant (WMD = 1.66, 95% CI: -1.08 to 4.40, $p = 0.236$) with extreme heterogeneity ($I^2 = 99.6\%$), and anxiety on the GAD-7 was also non-significant (WMD = 0.39, 95% CI: -0.90 to 1.67, $p = 0.557$) with considerable heterogeneity ($I^2 = 87.3\%$). In contrast, anxiety measured by the HADS-A showed a statistically significant increase (WMD = 1.03, 95% CI: 0.20 to 1.85, $p = 0.015$) with moderate heterogeneity ($I^2 = 59.0\%$), and depression on the HADS-D was highly significant (WMD = 1.19, 95% CI: 0.97 to 1.42, $p < 0.001$) with no

heterogeneity ($I^2 = 0.0\%$). Forest plots for these meta-analyses are shown in (see e-Figure 7a-4d).

Mortality and hospitalisation

Given both the small number of included studies and small number of reported all-cause or CV-related mortality and hospitalisation events, the meta-analyses for these outcomes showed imprecise results (see e-Figure 8a-5d).

Safety

The pooled safety outcomes across the four studies^{38,39,49,65} demonstrated, non-fatal myocardial infarction and non-fatal stroke was similar between the CR (20 events) and control groups (24 events) (see e-table 4). Only one exercise-related adverse event (atrial fibrillation) was reported across all studies.

Costs and cost-effectiveness

Only one study reported costs or cost effectiveness. Simões et al. (2022)⁴⁴ at 6-months follow-up found a higher mean total healthcare cost per patient with CR compared to usual care control (\$11,629/patient vs \$3,031/patient in Purchasing Power Parity dollars, $P < 0.0001$). Based on mean improvement in peak VO_2 of +4.6 ml/kg/min. and difference in total healthcare cost, the authors reported an incremental cost-effectiveness ratio of \$1,874.3 PPP per 1.0 ml/kg/min⁻¹ increase in health benefit with CR (see e-Table 5).

5.4.6 Small study bias and meta-regression

Only the all exercise capacity measure analysis contained sufficient studies (≥ 10 RCTs) to allow robust assessment of small study (publication) bias and to undertake meta-regression. The funnel plot (see e-Figure 1) and the Egger test ($p = 0.013$) showed evidence of small study bias. There was no evidence from meta-regression of significant differences in the CR effect on all exercise capacity measures across any of the tested intervention or study characteristics (see e-Table 6).

5.4.7 GRADE assessment

Given the evidence of risk of bias across the 29 included studies (see Table 2) the GRADE rating for all primary and secondary outcomes was downgraded (from 'high' to 'moderate' certainty). All exercise capacity measures, was further downgraded for both high ($I^2 > 50\%$) statistical heterogeneity (inconsistency) and evidence of small study (publication) bias (to 'low' certainty). The rating of all other meta-analysed outcomes, ratings were downgraded where there was evidence of statistical heterogeneity ($I^2 > 50\%$) and/or imprecision (where the 95% CI included a null effect). As it is advised not to undertake statistical analysis of small study bias for < 10 studies, it was conservatively assumed that these outcomes were

not subject to publication bias and therefore not downgraded based on this criterion. For outcomes reported only by a single study, the lowest GRADE rating ('very low') was applied.

5.5 Discussion

This systematic review and meta-analysis of 29 studies involving 6,682 participants provides a contemporary synthesis of randomised trial evidence on exercise-based CR conducted in LMICs. Findings indicate that compared to no exercise control, CR may lead to moderate improvement in exercise capacity with supporting evidence of enhancement of generic HRQoL and mental health. However, given risk of bias and heterogeneity of included trials, these findings were of moderate to low certainty. Furthermore, due to the sparsity of data it is not possible to assess the effectiveness or safety in CR in LMICs in terms of fatal and non-fatal clinical event outcomes or to judge costs or cost-effectiveness in this setting.

Notwithstanding this uncertainty, the direction and magnitude of CR effects seen in this meta-analysis appear to be consistent with those seen in meta-analyses undertaken in HICs. An individual patient data meta-analysis of 18 RCTs in 3990 people with HF undertaken in North America and Europe reported a mean improvement of 21.0 metres (95% CI: 1.57 to 40.4) in 6MWT.⁶⁶ Similarly, a meta-analysis of 55 trials (7553 CHD and HF patients) reported CR to increase exercise capacity by a SMD of 0.95 (95% CI: 0.76 to 1.41) and peak VO₂peak by 3.3 ml/kg/min (95% CI: 2.6 to 4.0).⁶⁷ The most recent update of the Cochrane meta-analysis of CR for CHD (85 RCTs, 23 430 participants) reported improvements in SF-36 physical component (MD: 2.14, 95% CI: 1.07 to 3.22) and mental component MD: 1.70, 95% CI: -0.08 to 3.47).⁶⁸ However, great caution is needed directly extrapolating evidence from HIC to LMIC settings given their very different healthcare systems and funding landscapes, with variations in resource availability, infrastructure, workforce capacity, and population health needs that may substantially alter both the feasibility and the effectiveness of interventions.⁶⁹ Indeed, the International Council of Cardiovascular Prevention and Rehabilitation (ICCPR) consensus statement specifically calls for the development of affordable, scalable, and contextually relevant CR delivery models for low-resource settings.¹³

We believe this to be the most comprehensive and contemporary overview of RCT evidence of CR undertaken in LMIC to date and was undertaken using rigorous systematic review methods. . However, several limitations must be acknowledged. First, several RoB criteria were judged to be unclear or high risk, the majority of studies inadequately reporting their methodology. Second, high levels of statistical heterogeneity were seen across several outcomes. Whilst this likely reflects the clinical heterogeneity across studies in terms of their population, CR intervention, comparator, and outcomes this contributed to the downgrading of GRADE evidence certainty. Third, the presence of small-study (publication) bias may have led to an overestimation of the true benefit of CR on exercise capacity. Fourthly, the sparsity of fatal and non-fatal clinical event endpoint data prevented definitive conclusions about the effectiveness and safety of CR in the LMIC setting. Finally, whilst a central objective of this study, the absence of details (including staffing and costs), we were unable judge if there has

been adaptation in the model of CR delivery when undertaken in LMICs compared to that traditionally seen in HICs.

That the RCT evidence base around the use of CR of in LMIC had not substantially improved since the last systematic review by Manataz et al (literature searches undertaken up to 2020) points to the urgent need for a develop a coordinated strategy around the future collection of evidence and conduct of research. Such strategy needs a multifaceted approach that should include: (1) conduct of large multicentre/multi-LMIC RCTs adequately powered to assess the impact of CR on patient relevant outcomes that can include fatal and non-fatal clinical events and patient-reported outcomes; (2) incorporate innovative clinical methodology including effectiveness-implementation designs in order to maximise the likelihood of impact on practice and policy;⁷⁰ (3) consistency in outcome collection to facilitate comparison across studies and enable trial level and individual participant meta-analyses. Such future data collection should be driven by international accepted core outcome set for use in CR trials.⁷¹ In order to assess affordability and value for money such outcomes need to include health/social care utilisation to allow calculation of costs and cost-effectiveness; (3) improved study reporting to enable transparent risk of bias assessment. Future reporting should include the Template for Intervention Description and Replication (TiDER) tool ⁷² to better understand the nature of CR programmes and enable future analysis of the evolution of sustainable models of CR delivery in LMIC settings.

5.6 Conclusion

This review demonstrates that CR undertaken LMICs is associated with improved exercise capacity and HRQoL that appears to align with findings from high-income settings.

Nonetheless, substantial clinical and statistical heterogeneity, potential risk of bias, and inconsistent data collection limit the certainty of this evidence. A strategy of rigorous, well-designed RCTs capturing patient-centred outcomes and tailored to the resource constraints and cultural contexts of LMICs is urgently needed.

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5.8: Tables and figures

Table 1. Summary of study, population, intervention, and comparator characteristics

Characteristics	Number of studies (%) or median of study means (range)
Trial characteristics	
Continent	
Central Asia	18 (49%)
South Asia	10 (27%)
Africa	3 (8%)
South America	6 (16%)
Publication date	
2001-2010	5 (17%)
2011-2020	20 (71%)
2021-2025	4 (13%)
Single centre	25 (89%)
Sample size	71 (26 to 3,959)
Follow up (months)	6 (1.5 to 36)
Participant characteristics	
Sex (female)	1369/6489 (21%)
Age (years)	58.8 (50 to 65.2)
Diagnoses	
CHD only	17 (59%)
HF only	8 (28%)
Both CHD and HF	5 (17%)
CR programme characteristics	
Type	
Exercise only	10 (35%)
Comprehensive	19 (65%)
Core Components	
Structured training programme	29 (100%)
Risk factor management	16 (57%)
Psychological counselling	14 (50%)
Setting	
Centre-based	14 (48%)
Home-based	10 (35%)
Hybrid	5 (17%)

Programme length (weeks)	4 to 104
Exercise sessions	
Total number	4 to 104
Duration (min/session)	15 to 75
Frequency (sessions/week)	3 to 7
Length (weeks)	2 to 104
Intensity	
% HRmax	55 to 85%
% VO ₂ peak	Not consistently reported
RPE	3-7 (0-10)/11-16 (6-20)
Programme funding	
Government/public	10 (33%)
Research	11 (37%)
Private	0 (0%)
Not stated	9 (30%)
Comparator	
Usual care	25 (88%)
Usual care plus	1 (4%)
No exercise	2 (8%)

RPE: Rate of Perceived Exertion ; VO₂ peak: peak oxygen consumption

Table 2. Summary of impact of exercise-based CR versus control on outcomes

	Study N (N patients)	Pooled effect Metric - Mean (95% CI), p-value	I² statistic	GRADE assessment of certainty
Exercise capacity				
All measures	17 (1165)	SMD 0.71 (0.47 to 0.96), p<0.0001	71.6%	Low ^{1,4}
ISWT (metres)	2 (81)	MD 74.6 (6.9 to 142.3), p=0.031	0.0%	Medium ¹
6-MWT (metres)	8 (709)	MD 40.9 (21.3 to 60.5), p=0.003	67.8%	Low ^{1,4}
Peak VO ₂ (ml/kg/min)	7 (375)	MD 3.6 (2.8 to 4.5), p=0.001	5.4%	Medium ¹
HRQoL				
EQ-5D (0-100 scale)	2 (3991)	MD 5.2 (-3.2 to 13.7), p=0.227	89.6%	Very low ^{1,2,4}
SF-12/36 PCS	5 (741)	MD 5.0 (0.5 to 9.4), P= 0.03	0.0%	Medium ¹
SF-12/36 MCS	5 (741)	MD 4.1 (-0.8 to 9.1), P= 0.09	0.0%	Low ^{1,2}
SF-12/36 domains				
Bodily pain	6 (336)	MD 4.2 (-1.7 to 10.02), p= 0.167	18.5%	Low ^{1,2}
General Health	6 (336)	MD 0.9 (-0.1 to 1.9), p=0.08	0.0%	Low ^{1,2}
Physical Functioning	6 (336)	MD 1.8 (1.04 to 2.58), p=0.001	0.0%	Medium ¹
Role-Physical	6 (336)	MD 9.3 (-2.1 to 20.6), p = 0.109	63%	Very low ^{1,2,4}
Vitality	6 (336)	MD 3.2 (-1.2 to 7.6), p=0.153	10.6%	Low ^{1,2}
Social Functioning	6 (336)	MD 0.45 (-0.3 to 1.2), p=0.213	0.0%	Low ^{1,2}
Role- Emotional	6 (336)	MD 5.2 (-2.9 to 13.3), p=0.210	36.9%	Low ^{1,2}
Mental Health	6 (336)	MD 1.47 (0.73 to 2.21), p = 0.001	0.0%	Medium ¹
WHOQOL	1 (101)	MD 0.71 (0.37 to 1.05) p= <.01	Not applicable	Low ⁵
Mental health				
PHQ-9	3 (749)	MD 1.7 (-1.1 to 4.4), p<0.236	99.6%	Very low ^{1,2,4}
GAD-7	2 (378)	MD 0.39 (-0.9 to 1.7), p=0.557	87.3%	Very low ^{1,2,4}
HADS-Anxiety	2 (256)	MD 1.03 (0.2 to 1.9), p=0.02	59.0%	Low ^{1,4}

HADS-Depression	2 (256)	MD 1.2 (0.96 to 1.4), p=0.001	0.0%	Medium ¹
Mortality				
All-cause	6 (4473)	RR 0.7 (0.43 to 1.12), p=0.14	28.7%	Low ^{1,2}
CVD specific	3 (138)	RR 0.33 (0.06 to 1.95), p= 0.22	0.0%	Low ^{1,2}
Hospitalisation				
All-cause	5 (4126)	RR 0.88 (0.55 to 1.41), p= 0.589	0.00%	Low ^{1,2}
CVD specific	2 (3951)	RR 1.46 (0.23 to 9.42), p= 0.691	52.2%	Very low ^{1,2,4}
Safety	4 (4,206)	Narrative synthesis (see e-Table 4)	Not applicable	Very Low ^{1,3,4}
Cost/cost effectiveness	1 (30)	Narrative synthesis (see e-Table 5)	Not applicable	Very Low ⁵

SMD: Standardised Mean Difference; MD: Mean Difference; RR: Risk Ratio; VO₂: peak oxygen uptake; PHQ9: Patient Health Questionnaire; GAD7: General Anxiety Disorder; SF12/36-Short-Form 12 or 36; WHOQoL; The World Heart Organisation Quality of Life; CVD: cardiovascular disease

GRADE downgrading: ¹risk of bias; ²95% CI includes no effect (imprecision); ³Publication bias; ⁴Statistical heterogeneity, I²>50% (inconsistency); ⁵from a single study

Figure 1. PRISMA flow diagram

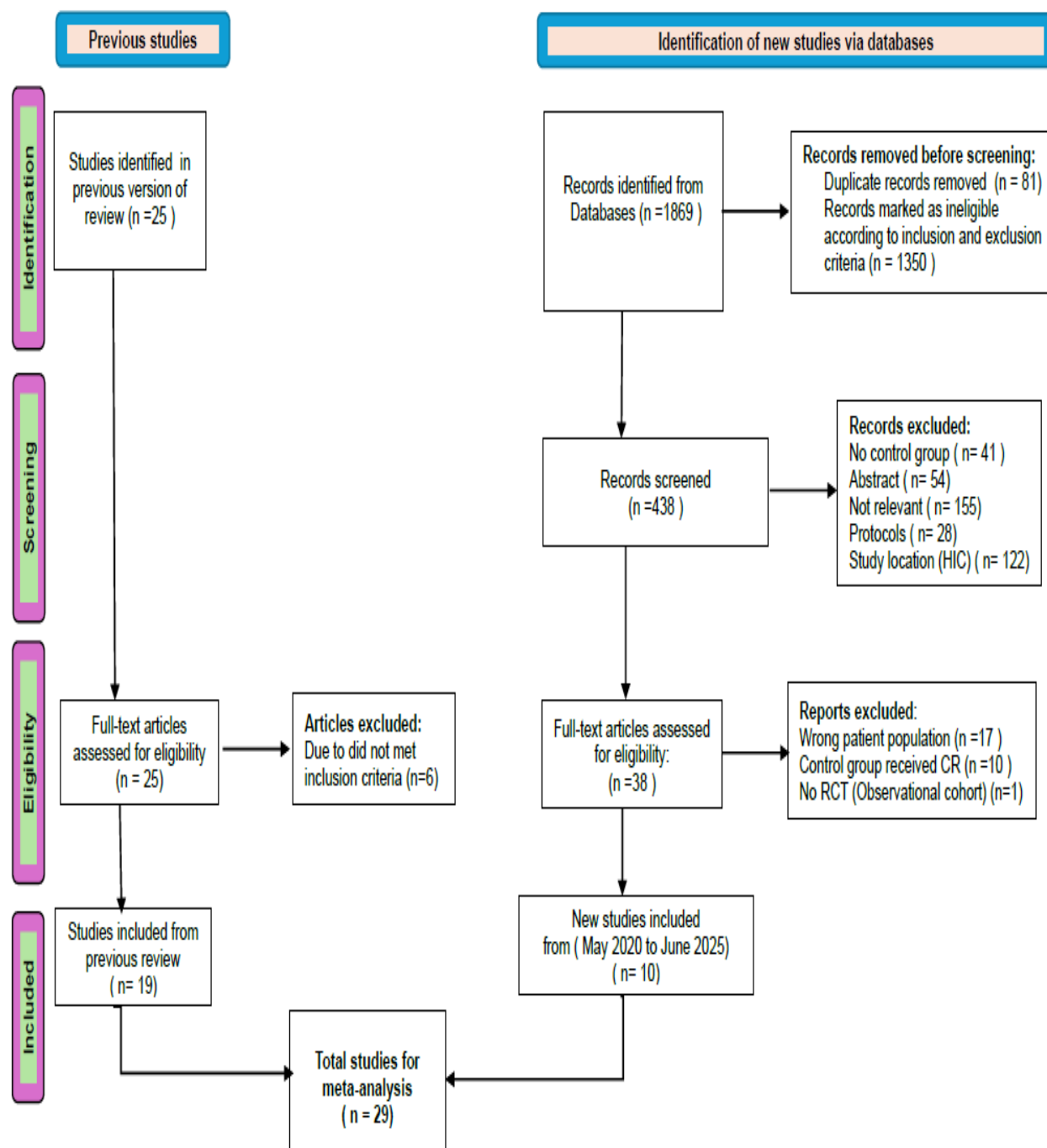


Figure 1: PRISMA flow diagram

Figure 2. Summary of risk of bias across included studies

Risk of bias: Traffic signal light

Author (Year)	Selection bias (Random sequence)	Selection bias (Allocation concealment)	Performance bias	Detection bias	Attrition bias	Reporting bias	Other bias
Naser 2008	Green	Red	Yellow	Red	Green	Green	Green
Salveti 2008	Green	Green	Green	Red	Green	Green	Green
Babu 2010	Yellow	Yellow	Yellow	Red	Green	Green	Yellow
Babu 2011	Green	Green	Yellow	Red	Red	Green	Green
Mehani 2013	Yellow	Yellow	Yellow	Green	Yellow	Red	Red
Ajiboye 2015	Green	Green	Yellow	Green	Red	Green	Green
Yadav 2015	Green	Red	Yellow	Green	Green	Green	Green
Hassan 2016	Red	Red	Yellow	Red	Green	Green	Green
Zhang 2017	Yellow	Yellow	Yellow	Green	Green	Red	Yellow
Jafari 2018	Red	Yellow	Yellow	Red	Green	Red	Green
Mehani 2018	Green	Green	Yellow	Red	Green	Green	Green
Soleimani 2018	Red	Red	Yellow	Red	Green	Green	Green
Zolfaghari 2018	Green	Green	Red	Green	Green	Green	Green
Dorje 2019	Green	Green	Yellow	Green	Green	Green	Green
Chaves 2019	Green	Green	Yellow	Green	Red	Green	Green
Ul-Haq 2019	Green	Green	Yellow	Green	Green	Green	Green
Khalid 2019	Yellow	Red	Yellow	Red	Green	Green	Green
Prabhakaran 2020	Green	Green	Red	Green	Green	Green	Green
Song 2020	Green	Red	Yellow	Red	Yellow	Green	Green
Hasanpour 2020	Red	Red	Yellow	Red	Green	Green	Green
Jena 2020	Red	Red	Red	Red	Green	Green	Green
Mendes 2020	Green	Green	Red	Green	Green	Green	Green
Uddin 2020	Yellow	Red	Yellow	Red	Yellow	Red	Green
Ma 2021	Green	Green	Yellow	Red	Green	Green	Red
Hisam 2022	Green	Red	Yellow	Green	Yellow	Yellow	Green
Simões 2022	Red	Red	Yellow	Red	Green	Green	Red
Heidari 2023	Yellow	Red	Yellow	Yellow	Green	Red	Yellow
Kayhan 2024	Green	Green	Yellow	Red	Green	Green	Green
Zhang 2024	Yellow	Yellow	Yellow	Red	Green	Green	Green

*Low risk of bias (Green)= 1, High risk of bias (Yellow)= 2, Unclear risk of bias (Red) = 3

Figure 3. Forest plot for all exercise capacity measures

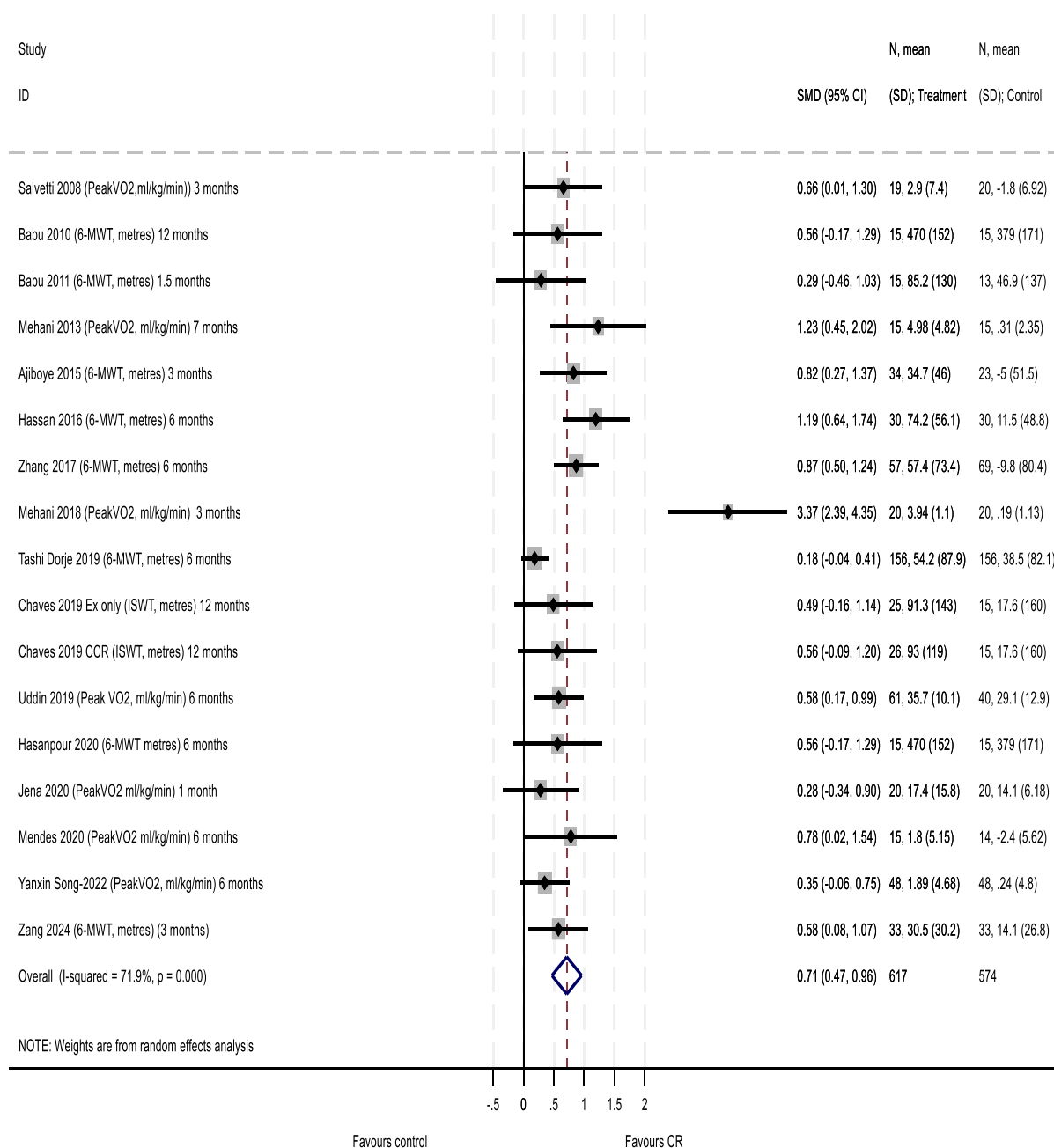
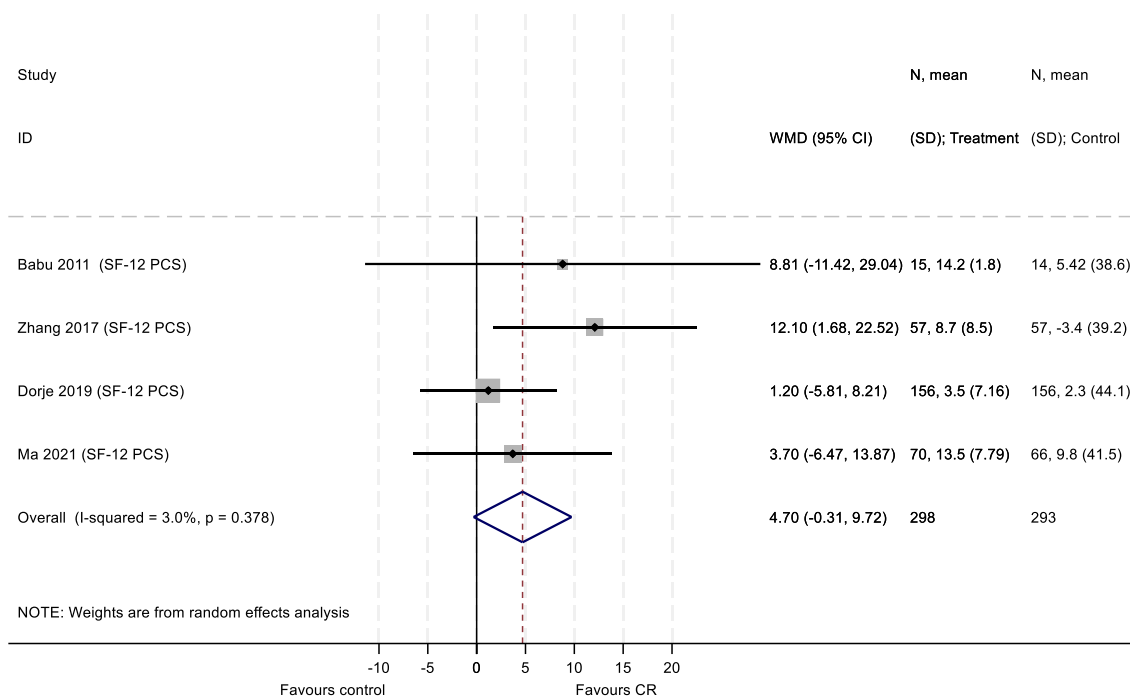
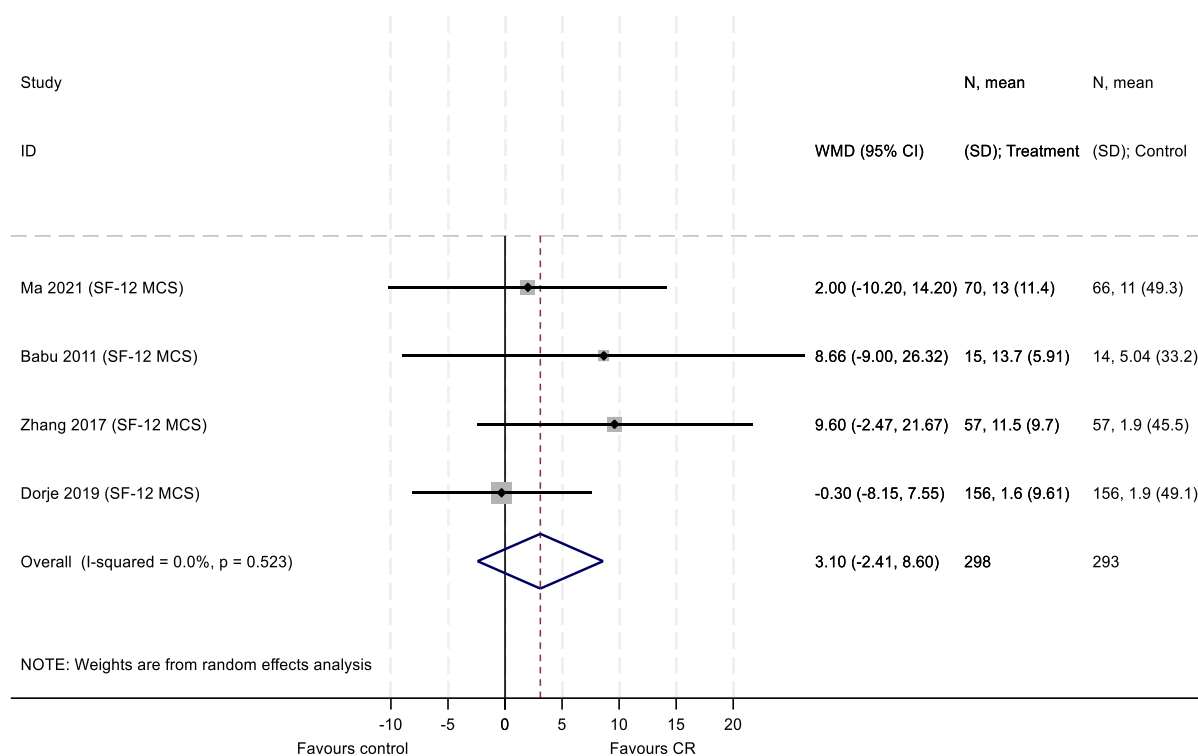


Figure 4. Forest plot for SF12/36 physical and mental component scores

A. Physical component score



B. Mental component scale



Chapter 6

Thesis Discussion

Chapter 6

6.1 Thesis discussion

CVD continues to be the leading cause of mortality and disability worldwide, with the burden increasingly concentrated in LMICs, where more than three-quarters of CVD deaths now occur, and where health systems face persistent structural, financial, and workforce challenges.^{1, 2} Within the broader CVD spectrum, CHD accounts for the greatest proportion of morbidity and mortality, driven by demographic transition, epidemiological shifts, and the rising prevalence of modifiable risk factors including hypertension, diabetes, smoking, physical inactivity, and unhealthy diet.^{3, 4} Bangladesh exemplifies these patterns, experiencing rapid urbanisation, population ageing, and a marked increase in CVD prevalence, alongside continuing inequities in access to preventive and rehabilitative services.⁵⁻⁸ Although CR is internationally endorsed as a Class I, Level A secondary prevention intervention that improves survival, functional capacity, psychological wellbeing, and HRQo and has been shown to be cost-effective,⁹⁻¹⁴ its availability and uptake remain critically limited across LMICs. Barriers occur at multiple levels, including health systems, providers, programmes, and patients.¹⁵⁻¹⁷ Robust evidence from randomised controlled trials and systematic reviews demonstrates that home-based CR, including programmes such as the Heart Manual, delivers outcomes comparable to centre-based CR and may enhance access and participation, particularly in contexts where distance, cost, and workforce shortages constrain service provision.¹⁸⁻²¹

In Bangladesh, specialised cardiac care remains predominantly hospital-centred, heavily concentrated in the capital city (Dhaka), and largely focused on acute treatment, secondary prevention and CR services remain underdeveloped despite the substantial burden of disease.²²⁻²⁶ At the same time, the central role of families in caregiving and shared health decision-making provides an important sociocultural resource, offering opportunities to support adherence and sustainability through family-oriented, home-based approaches.²⁷⁻³¹ Within this context, the adaptation and evaluation of a culturally appropriate home-based CR intervention, the Bangla Heart Manual addresses a critical service and evidence gap. Informed by established adaptation frameworks, this doctoral research programme sought not only to establish feasibility and acceptability in a resource-constrained setting, but also to contribute to the wider methodological and implementation science underpinning the transfer of complex interventions to LMIC contexts.³²⁻³⁶ Overall, the findings of this thesis should therefore be interpreted within the dual context of a global imperative to expand access to CR and the specific structural realities of the Bangladeshi health system, with important implications for policy development, service planning, and future scale-up of accessible and sustainable secondary prevention models in LMICs.

The overarching aim of this thesis was to examine the potential role of home-based CR as a model of service delivery in LMICs. The specific objectives were to:

- (1) conduct a scoping review of adaptation studies undertaken in LMICs;
- (2) culturally adapt the UK-developed Heart Manual home-based intervention for Bangladesh;
- (3) evaluate the acceptability and feasibility of the adapted Bangla Heart Manual; and
- (4) undertake an updated systematic review and meta-analysis assessing the effectiveness, safety, cost-effectiveness, and delivery models of CR in LMICs.

Collectively, this programme of research sought to strengthen the evidence base for scalable, context-sensitive CR interventions appropriate for resource-limited settings. This discussion chapter: (1) synthesises the key findings from empirical Chapters 2, 3, 4, and 5; (2) considers the overarching strengths and limitations of the research; (3) outlines clinical and policy implications; and (4) identifies priorities for future research in this field.

6.2 Overview of findings

Adaptation of complex interventions for people with long-term conditions: a scoping review: This study (presented in Chapter 2) examined the methodological foundations underpinning the adaptation of previously developed complex health interventions for long-term conditions (LTCs) when transferred to new implementation contexts. Although the literature widely acknowledged adaptation as necessary, the scoping review revealed substantive methodological limitations across existing studies. In total, 25 adaptation studies across 21 LTCs were identified, spanning a diverse range of complex interventions including psychological therapies, behaviour-change programmes, and self-management and adherence interventions. The majority of these studies undertook macro-level (transferring interventions from one country to another) adaptation, most commonly transferring interventions from high-income to low- and middle-income settings, yet predominantly focused on surface-level modifications, including linguistic translation or cultural tailoring, with limited theoretical justification, weak stakeholder engagement, and generally poor reporting of adaptation processes.^{37, 38} These findings mirror broader critiques of global health intervention transfer, where interventions are frequently 'exported' from high-income contexts without sufficient consideration of contextual complexity.³⁹ In this PhD research programme, context is the key concept to emphasis is operationalised through the systematic cultural and linguistic adaptation of the Heart Manual for use in Bangladesh, resulting in the development of the Bangla Heart Manual. The programme then proceeded to examine the feasibility and acceptability of this adapted resource within the local healthcare setting, with the overarching aim of strengthening the delivery of cardiac rehabilitation in low- and middle-income countries. As a direct methodological response to these gaps,

subsequent empirical studies within this PhD adopted the ADAPT Guidance and the updated MRC/NIHR Framework for the Development and Evaluation of Complex Interventions as core methodological foundations, ensuring structured, transparent, and theoretically informed adaptation within an LMIC context.^{39, 42} Accordingly, this scoping study offers an important contribution by providing a contemporary and methodologically focused synthesis of intervention adaptation studies, thereby supporting researchers, policymakers, and clinicians undertaking the design and implementation of complex interventions in resource-constrained settings.

Critical appraisal of the ADAPT framework

The ADAPT framework provided a structured, transparent, and practical approach for culturally adapting the UK Heart Manual to the Bangladeshi context. Its four-step process—context assessment, adaptation planning, piloting, and implementation—facilitated a systematic translation of intervention components while maintaining fidelity to core functions.³⁹ A key strength was its emphasis on early and iterative stakeholder engagement, which enabled the identification of important cultural and contextual mismatches beyond linguistic translation. For instance, adaptations addressing low literacy through pictorial materials, incorporation of family caregivers, and delivery via mobile phones rather than home visits reflected locally relevant needs identified through this process.³⁹ Despite these strengths, several limitations were evident. The framework does not sufficiently address power dynamics among stakeholders, which in this study occasionally privileged clinical authority over patient and caregiver perspectives. Additionally, economic constraints critical in low- and middle-income country (LMIC) settings were not fully integrated into the framework's analytical structure, despite their significant influence on intervention feasibility. ADAPT also lacks guidance on managing responsive adaptations during implementation, which are often necessary in dynamic contexts affected by infrastructural and environmental disruptions. Furthermore, limited attention is given to oral literacy, dialectal variation, and the relational work required to build trust and engagement in low-resource healthcare settings. Overall, while ADAPT offers a robust foundation for cultural adaptation, its application in LMICs may benefit from integration with complementary implementation science frameworks to better capture contextual complexity and relational processes.³⁹

Adaptation of an evidence-based home cardiac rehabilitation programme for people with coronary heart disease in Bangladesh:

Building on the methodological foundations of the previous study, the second study (Chapter 3) undertook a comprehensive cultural and contextual adaptation of the home-based CR intervention the Heart Manual previously developed and evaluated in the UK for implementation in Bangladesh. This adaptation went beyond linguistic translation and incorporated substantial stakeholder engagement with patients, caregivers, cardiologists, physiotherapists, nurses and policymakers. As a result, the original UK Heart Manual was reshaped into the Bangla Heart Manual to reflect local understandings of illness and recovery, family roles, literacy levels and service-delivery constraints.⁴³

Two key intervention adaptation decisions warrant emphasis. First, the inclusion of pictorial and audiovisual materials addressed marked variability in literacy, a recognised barrier to CR engagement in LMICs.^{44, 45} Similar strategies have been employed in CR programmes in India and Latin America, where simplified educational materials enhanced comprehension and adherence.^{46, 47} Second, structured involvement of family members aligns with Bangladesh's collectivist sociocultural context, in which care and health decision-making are typically shared within reciprocal family support systems rather than occurring individually. This approach is consistent with emerging LMIC evidence that family-supported CR may improve adherence and psychosocial outcomes.⁴⁸

Importantly, core evidence-based components of CR including structured exercise progression, patient education and psychosocial support were preserved. This reflects the growing consensus that cultural adaptation and fidelity to core intervention mechanisms are not mutually exclusive but complementary when guided by theory and stakeholder input.⁴⁹ As shown in the systematic review of CR in LMICs (Chapter 5), few CR programmes have demonstrated comparable depth or transparency of adaptation processes. This second study therefore provides a case study of how complex interventions can be appropriately localised without diluting their core therapeutic components.

Assessment of the Bangla Heart Manual in patients with coronary heart disease and their caregivers in Bangladesh: a feasibility study:

The third study (Chapter 4) addressed a critical gap identified in the scoping review (Chapter 2) i.e. the lack of feasibility testing prior to definitive trials.⁴¹ Using a mixed-methods design, the study evaluated recruitment, retention, adherence, acceptability and delivery requirements of the Bangla Heart Manual. The findings demonstrated that home-based CR is both feasible and acceptable in Bangladesh. Recruitment, retention and adherence rates of 46%, 91% and 75%, respectively, were comparable to outcomes reported in other LMIC feasibility and pilot studies.²⁵ Participants valued the flexibility of home-based delivery, reduced travel costs and the opportunity to involve family members. These findings echo studies from Brazil and China, indicating that home- and community-based CR models

achieve higher uptake than centre-based programmes.^{50, 51} Healthcare professionals, including physiotherapists and nurses, reported that the Bangla Heart Manual could be delivered within current roles, given appropriate training and institutional support, aligning with WHO recommendations on task-sharing strategies to address workforce shortages in LMIC health systems.⁵²

Effectiveness, safety, costs and delivery considerations of exercise-based cardiac rehabilitation in low- and middle-income countries: a systematic review and meta-analysis of randomised controlled trials. The final study (Chapter 5) synthesised global RCT evidence on exercise-based CR in LMICs through an updated systematic review and meta-analysis. A total of 29 RCTs (6,489 participants) comparing CR to no exercise control were identified, most undertaken in South and Central Asia. The majority of interventions (14 trials) were supervised, centre-based programmes, (10 trials) were hybrid (Hybrid (hospital + home) with only a minority (5 trials) were evaluating home-based CR models. Pooled analyses demonstrated moderate effect size improvements in exercise capacity (SMD 0.71, 95% CI 0.47 to 0.96). Consistent benefits in HRQoL were also seen, particularly in SF-12/36 physical component scores (mean difference 5.0, 95% CI 0.5 to 9.4). Adverse cardiovascular events rare and comparable between CR and control groups. Cost-effectiveness data were limited to a single study, and a lack of evidence long-term outcomes, including hospital admission.

Overall, findings confirm that exercise-based CR in LMIC settings is both effective and safe, with magnitudes of benefit comparable to those reported in high-income countries.^{41, 53}

Nevertheless, persistent evidence gaps were identified, including scarce economic evaluations, limited follow-up beyond 12 months and minimal evaluation of scalable delivery models suitable for routine implementation in resource-constrained settings.⁵⁴ That approximately half of LMIC trials were centre-based and delivered in urban tertiary hospitals, raises concerns around scalability and equitable access. When considered alongside findings from Chapters 2-4, these results reinforce the need for contextually appropriate, decentralised, home-based CR models, such as the Bangla Heart Manual to expand access beyond tertiary centres and align with global priorities for universal and affordable cardiovascular care.

6.3 Strengths and Limitations

The individual strengths and limitations of each of the four studies have been discussed in detail within the corresponding chapters. However, several overarching strengths and limitations characterise the doctoral research as a whole. These include : (1) the deliberately linked and programmatic structure of the research; (2) the application of theoretically informed and robust methodological approaches; and (3) considerations regarding the representativeness and generalisability of the study samples.

A major strength of this doctoral programme is its coherent and sequential design. The studies were intentionally organised to build cumulatively, progressing from conceptual and scoping work to intervention adaptation and feasibility evaluation. This ensured that learning from each stage informed the next, avoiding fragmentation and supporting the development of a clear translational pathway in home-based cardiac rehabilitation in LMICs. Such a structured research trajectory strengthens internal coherence and maximises the potential for meaningful impact on practice and policy.

The programme of research is underpinned by its methodological rigour. Established and internationally recognised frameworks were explicitly adopted, including the ADAPT framework for intervention adaptation,³⁹ the Medical Research Council (MRC) guidance for the development and evaluation of complex interventions,⁴³ and the CONSORT extensions for pilot and feasibility studies.⁵⁵ The use of these frameworks enhanced transparency, reproducibility, and alignment with best practice standards. When appropriate, mixed-methods designs were used to integrate quantitative outcomes with qualitative insights, thereby anchoring interpretation in lived experience rather than solely in theoretical assumptions.

Alternative cultural adaptation framework:

Several cultural adaptation frameworks could have been used to inform this PhD in addition to the primary use of the ADAPT guidance.³⁹ The FRAME framework is designed for documenting and reporting adaptations, with a focus on what changes were made, who made them, and whether they were planned or unplanned.⁵⁶ While this enhances transparency during implementation, it is less suitable for guiding the prospective, decision-making stages of intervention adaptation. In contrast, the ADAPT-ITT model (offers a structured, multi-phase process that includes assessment, adaptation, and iterative pretesting of modified interventions.⁵⁷ Although particularly useful for sensitive health areas, its complexity and resource demands can be challenging in doctoral research contexts. Similarly, Intervention Mapping (IM adapt) provides a highly systematic and theory-driven approach that integrates needs assessment with logic modelling of behavioural determinants and change processes.⁵⁸ however, its comprehensiveness requires substantial time,

expertise, and implementation capacity. Against this backdrop, the ADAPT framework ³⁹ was selected because it provides a pragmatic, stepwise structure that supports systematic adaptation while maintaining a balance between fidelity to core intervention components and contextual flexibility. Its emphasis on stakeholder engagement and careful assessment of intervention–context fit made it particularly appropriate for the Bangladeshi setting, where substantial cultural, linguistic, and health system differences from the UK needed to be considered. Nevertheless, a limitation of ADAPT is its relatively limited explicit guidance on evaluating fidelity to core mechanisms following adaptation. This limitation was addressed in this thesis through complementary methodological approaches, including mixed-methods feasibility testing and a systematic review, to ensure both adaptation processes and intervention integrity were adequately examined.

Extensive stakeholder engagement represents another important strength. This included involvement of patients, caregivers, clinicians, rehabilitation professionals, and institutional partners, supporting cultural appropriateness and practical feasibility. The active inclusion of family caregivers is particularly significant in LMIC contexts, where collective decision-making and shared caregiving roles are central to health management. ⁵⁹⁻⁶¹ This participatory approach aligns with contemporary principles of co-production and patient and public involvement (PPI), strengthening the relevance and acceptability of the intervention. ⁶² The applied orientation of the programme also merits emphasis. The research progressed beyond conceptual development to implementation of a feasibility study in a real clinical environment. Although not powered for definitive effectiveness testing, this work generated important early evidence regarding acceptability, adherence, safety, and preliminary clinical outcomes, thereby establishing a foundation for subsequent large-scale trials. The findings carry practical implications for service provision and cardiac rehabilitation models in resource-constrained settings.

Several limitations must also be acknowledged. Recruitment was primarily undertaken through tertiary cardiac centres in Dhaka, which may not reflect the broader experiences of patients in rural or primary care settings. This urban sampling frame may restrict generalisability to the wider Bangladeshi population and to other LMIC contexts with differing service structures. Future studies would benefit from including more diverse geographic and service-level representation.

PPI critically strengthens health service research by integrating lived experiences, improving relevance, and enhancing engagement and dissemination. ^{63, 64} The ethical principle “*nothing about us without us*” highlights the importance of including those directly affected in decision-making. ⁶⁵ In this thesis, PPI supported the adaptation of the Bangla Heart Manual; however, its absence in the other three studies is acknowledged as a limitation. Structured tools such as the Involvement Matrix can guide systematic planning of PPI in future work. ⁶⁶

The feasibility study employed a non-randomised design. While appropriate for its exploratory objectives, this limits causal inference and increases the potential for selection bias. As such, findings should be interpreted as preliminary indicators rather than conclusive evidence of effectiveness. A fully powered randomised controlled trial will be required to determine clinical and economic impact. Reliance on patient self-reported measures represents a further potential limitation, particularly for adherence and psychosocial outcomes. Such reporting may be vulnerable to recall or social desirability bias, especially in sociocultural contexts where reporting dissatisfaction or non-adherence may be sensitive. Although steps were taken to minimise such bias, it cannot be eliminated entirely.

Finally, although adaptation processes followed recognised frameworks, adaptation remains inherently context dependent. The Bangla Heart Manual may therefore require further tailoring before implementation in other LMICs with different cultural, organisational, or economic conditions. Nonetheless, the principles and methodological processes described here are likely to be transferable, even if specific content requires modification.

In summary, the doctoral programme is characterised by a strong sequential design, rigorous methodology, and meaningful stakeholder engagement, offering an important contribution to the development of culturally attuned home-based CR in LMICs. The limitations primarily relating to sampling, study design, and scope of outcomes serve to delineate clear directions for future research.

6.4 Implications for practice and policy

The findings presented in this thesis have important implications for clinical practice, health service organisation, and policy development in the LMIC context. These implications can be considered in relation to five overarching domains: (1) reconfiguring CR delivery in resource-limited settings; (2) workforce development and task-sharing; (3) patient empowerment and family engagement; (4) policy integration and financing; and (5) building an enabling implementation environment.

Reconfiguring CR delivery in resource-limited settings

The Bangla Heart Manual illustrates a feasible and contextually appropriate strategy for decentralising CR beyond tertiary cardiac centres and into patients' homes. By transitioning rehabilitation from hospital-based programmes to supported home-based delivery, the model directly addresses structural barriers common in LMICs, including geographical distance from specialist facilities, travel time, transport costs, income loss, and shortages of specialist staff.^{67, 68} Such barriers are among the principal explanations for the extremely low global CR participation and enrolment rates reported in LMICs.⁶⁹ Home-based CR therefore represents not only a service delivery alternative, but a necessary reconfiguration of care pathways to promote equity of access.

This approach is also aligned with international recommendations advocating differentiated models of non-communicable disease care that are responsive to local health system capacity and social conditions.⁷⁰ By embedding CR within communities and households, the intervention challenges assumptions that technologically intensive or centre-based models are the only credible mode of CR delivery. Instead, it positions CR as a flexible continuum of self-management support, risk factor modification, and psychosocial recovery that can be delivered safely with structured guidance outside specialist facilities. The Bangla Heart Manual may therefore function as an adaptable 'blueprint' for other similar LMIC contexts where specialist infrastructure is scarce, and demand for secondary prevention services is increasing rapidly.

Workforce development and task-sharing

Scaling CR within resource-constrained health systems necessitates reorientation of traditional professional roles. Reliance on cardiologist- or specialist-led CR programmes is neither feasible nor efficient in many LMICs due to workforce shortages and uneven geographical distribution of specialists.^{71, 72} This thesis supports a task-sharing model in which physiotherapists, nurses, and allied health professionals assume central roles in delivering CR components, supported by clear protocols and referral pathways. Such approaches are consistent with WHO recommendations for managing chronic conditions in settings where specialist supply cannot meet population need.

Successful task-sharing depends on robust training, competency development, and clearly defined responsibilities to ensure safety and treatment fidelity. Structured facilitator training, supported supervision, and ongoing professional development are therefore essential. Beyond increasing service capacity, this strategy promotes professional empowerment, enabling non-specialist providers to contribute meaningfully to secondary prevention and long-term chronic disease management. Development of multidisciplinary CR teams also encourages more holistic care, integrating physical reconditioning with psychological support, lifestyle counselling, and social care key domains often underdeveloped in physician-centric models.

Patient empowerment and family engagement

A further implication of this research concerns the centrality of patient empowerment and family participation in CR outcomes. The intervention's focus on culturally appropriate education materials, self-management skills, and caregiver involvement supports patient confidence, autonomy, and adherence to lifestyle changes.⁷³ Such approaches acknowledge that behaviour change following CHD events is rarely achieved through clinical instruction alone, but through sustained psychosocial support and facilitated understanding of illness and recovery processes.

In Bangladesh and comparable collectivist societies, the integration of family members into care processes is particularly salient. Health decision making and emotional coping are often shared across households rather than experienced individually.⁷⁴ Positioning rehabilitation as a household activity therefore aligns with prevailing social structures and may enhance long-term sustainability of lifestyle modification, medication adherence, and risk reduction. It also recognises that recovery from CHD affects employment roles, caregiving arrangements, and financial security across families, not only the patient. Strengthening family engagement within CR may therefore contribute to improved psychosocial wellbeing and decrease stigma and anxiety commonly associated with cardiac events.

Policy integration and financing

For CR models such as the Bangla Heart Manual to progress beyond research implementation and achieve national coverage, integration within existing health policy frameworks is essential. CR must be formally recognised as a core component of secondary prevention for cardiovascular disease within national non-communicable disease strategies and clinical guidelines.^{10, 75, 76} Without such recognition, service provision remains fragmented and dependent on individual institutions. National endorsement would legitimise investment, standard setting, and workforce planning.

Home-based CR is likely to be cost-effective relative to centre-based models, particularly when considering reduced travel expenses, service delivery costs, and infrastructure demands.^{77, 78} However, sustainability depends on development of appropriate financing mechanisms. Blended arrangements incorporating government funding, health insurance, and social protection measures may help reduce out-of-pocket expenditure, which remains a major barrier to participation in Bangladesh and other LMICs.⁷⁹ Clear referral pathways from acute cardiac care to rehabilitation services are also required to ensure CR becomes a routine, rather than optional, component of post-event care.

Building an enabling implementation environment

Finally, scaling CR requires supportive system-level infrastructure. Development of national CR standards, accreditation systems, and competency frameworks is crucial to ensure consistency, safety, and equity of provision. Investment in digital health records and health information systems would enable monitoring of CR enrolment, adherence, and outcomes, providing essential data for quality improvement and policy evaluation. Implementation research also remains vital to understand contextual barriers, facilitators, and mechanisms of change across diverse settings.⁸⁰

An enabling environment further depends on political commitment, intersectoral collaboration, and public awareness of CR benefits. Advocacy from professional societies, patient organisations, and academic institutions can generate visibility and prioritisation of CR within national health agendas. By integrating the Bangla Heart Manual within broader

system strengthening efforts, there is potential not only to improve CR access, but to contribute to more comprehensive chronic disease management models across Bangladesh and similar LMICs.

6.5 Future research directions to cardiac rehabilitation in LMICs

This doctoral research has established a strong and coherent foundation for advancing equitable access to CR in LMICs. As outlined earlier in this chapter, CVD remains the leading cause of mortality and disability globally, with the greatest proportional burden experienced in LMICs where health systems are constrained by limited infrastructure, financing, and workforce capacity.⁸¹ Although CR is recognised as an effective component of secondary prevention, associated with reductions in mortality, hospital readmission and improvements in functional status and quality of life provision remains significantly under-developed and inequitably distributed.⁸²⁻⁸⁴ The findings of this thesis directly address this gap by demonstrating the feasibility of culturally adapted home-based CR models specifically designed for LMIC contexts.

Contribution of the current thesis

The research presented in this thesis contributes to the emerging evidence base supporting contextually tailored, decentralised models of CR delivery. Through the systematic development, cultural adaptation and feasibility testing of the Bangla Heart Manual, the thesis shows that CR can be reconfigured in ways that are both acceptable to patients and compatible with LMIC health system structures. This work aligns with a growing international consensus that traditional, centre-based CR models alone are insufficient to meet population needs and tend to exclude those facing socioeconomic, geographic or gendered barriers.⁸⁵
⁸⁶ The studies reported here illustrate that when CR is linguistically accessible, culturally attuned and embedded within existing referral pathways, meaningful engagement is achievable in Bangladesh.

Priority areas for future research

Drawing upon the findings presented across the thesis, several priority areas for future research are evident.

Fully powered randomised controlled trials

Fully powered

RCTs are needed to evaluate the clinical and cost-effectiveness of the Bangla Heart Manual. While feasibility findings presented in this thesis are encouraging, definitive policy-relevant evidence requires robust estimates of effect size and health economic value. This is particularly important in LMICs, where opportunity costs associated with allocating scarce resources must be carefully justified.^{87 84} Future RCTs should incorporate long-term follow-

up and assess outcomes such as mortality, rehospitalisation, functional capacity, medication adherence and health-related quality of life. A recent UK National Institute for Health Research (NIHR)-funded initiative, the Affordable Cardiac Rehabilitation: An Outreach Interdisciplinary Strategic Study (ACROSS), is set to implement a culturally adapted, home-based cardiac rehabilitation programme across low- and middle-income countries (LMICs), including Bangladesh, India and Pakistan.²³ Involvement as a researcher in the ACROSS programme, offers me the opportunity build on my PhD work.

Implementation science to support scale-up

The second priority relates to the systematic application of implementation science approaches to inform integration of home-based CR into routine clinical practice. Implementation frameworks enable structured examination of factors affecting adoption, fidelity, sustainability and scale.⁸⁸ Within LMIC settings, this includes attention to referral mechanisms, workforce skill mix, task-sharing models, policy contexts and organisational readiness for change. Redfern Gallagher and colleagues emphasise that CR should increasingly be conceptualised as part of a lifelong cardiovascular health pathway, rather than solely as a discrete post-event programme.⁸⁹ Accordingly, future research should incorporate implementation outcomes including reach, acceptability, feasibility, cost and sustainability.

Adaptation for multimorbidity and other chronic conditions

A third priority concerns adaptation of CR interventions for patients with multimorbidity (2 or more long-term conditions) and for other chronic disease populations. As demonstrated in earlier chapters, multimorbidity is common in LMICs, and CR programmes focusing narrowly on a single cardiac diagnosis may inadequately address the clinical realities experienced by patients. Further refinement and testing of adaptation frameworks will strengthen methodological rigour when tailoring interventions across diverse cultural and healthcare contexts.⁹⁰ The adaptation work undertaken in this thesis provides an initial model upon which future research may build.

Digital augmentation and equity-focused innovation

A fourth emerging area relates to digital augmentation of CR delivery, including mobile health (mHealth) applications, remote monitoring and tele-rehabilitation. Digital health approaches hold substantial potential to increase reach and personalisation, particularly for patients who are geographically remote.⁹¹ However, sustainability and equity considerations must remain central. As Gallagher and colleagues caution, digital models can inadvertently widen inequities where access to devices, connectivity and digital literacy is uneven.^{92, 93} Future research should therefore focus not only on clinical effectiveness but also on digital inclusion, affordability and gendered access patterns.

Overall implications and concluding reflections

Taken together, the programme of work undertaken in this PhD supports a paradigm shift towards inclusive, decentralised and contextually responsive CR models in LMICs. The development of the Bangla Heart Manual serves as a demonstration of what can be achieved when global evidence is contextually localised through partnership with patients, clinicians and policymakers. More broadly, the research work of thesis highlights the value of integrating adaptation science, stakeholder engagement and feasibility testing within a coherent research trajectory addressing CVD in resource-constrained settings.

In conclusion, this thesis seeks to provide a robust platform upon which future LMIC-focused CR research may build. The future research agenda—fully powered RCTs, implementation science research, cross-condition adaptation and digitally enabled innovation offers a pathway for advancing future equitable access to CR. By continuing to prioritise contextual relevance and equity, future research can contribute to ensuring that CR becomes a realistic option for those most affected by the global burden of CVD rather than remaining a service predominantly accessed in high-income settings.

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Chapter 7

Conclusion

Chapter 7:

7.1 Conclusion

Cardiac rehabilitation has strong evidence demonstrating its clinical and cost-effectiveness in high-income countries; however, access remains limited in low- and middle-income countries (LMICs). The research presented in this thesis contributes new and valuable knowledge to the adaptation of cardiac rehabilitation interventions in LMICs. First, a scoping review established the methodological foundation, identifying the need for more rigorous approaches to intervention adaptation. Second, this informed the systematic cultural and contextual adaptation of the UK Heart Manual into the Bangla Heart Manual, undertaken through extensive stakeholder involvement. Third, a feasibility study showed that the adapted programme is feasible and acceptable for patients, caregivers, and healthcare professionals in Bangladesh. Finally, the wider role of exercise-based cardiac rehabilitation in LMICs was explored through a systematic review and meta-analysis of randomised controlled trial, assessing its effectiveness, safety, cost implications, and delivery considerations.

This research programme has several notable strengths, including its coherent and sequential design, guided by contemporary methodological standards across the scoping review, adaptation study, feasibility trial, and systematic review. Strong stakeholder involvement—encompassing patients, caregivers, multidisciplinary clinicians, and international experts—ensured cultural appropriateness, clinical relevance, and meaningful end-user engagement, particularly within Bangladesh's family-oriented context. The studies were also intentionally structured to generate clinically and policy-relevant evidence to support the development and scale-up of home-based cardiac rehabilitation in resource-limited settings. However, limitations include the recruitment of participants mainly from tertiary centres in Dhaka, which may reduce generalisability to rural or underserved populations, and the single-centre, non-randomised feasibility study with a small sample, limiting causal inference. Questions also remain regarding long-term sustainability, given the absence of national policy, structured referral pathways, and secure funding mechanisms, and further adaptation may be needed as healthcare systems and digital access evolve. Nonetheless, these limitations largely highlight priorities for future research rather than detracting from the programme's overall contribution.

Overall, this thesis demonstrates that a decentralised, home-based cardiac rehabilitation model—such as the Bangla Heart Manual—offers a practical, culturally appropriate and potentially cost-effective solution for improving secondary prevention services in Bangladesh and similar LMICs. Its successful integration into routine care will depend on strengthened referral pathways, task-sharing across the multidisciplinary workforce, structured facilitator training, investment in patient and family education, and formal recognition of cardiac

rehabilitation within national non-communicable disease policies, financing mechanisms and clinical standards. To sustain and scale such programmes, further research is required, including a fully powered randomised controlled trial, implementation science exploring optimal delivery and scale-up strategies, long-term outcome evaluations, methodological work to refine adaptation frameworks for LMIC contexts, and health system and economic analyses to inform national planning and resource allocation.

e-Appendix A: Chapter 2 (Paper 1)

(Adaptation of complex interventions for people with long-term conditions: a scoping review)

eTable 1. Eligibility criteria & definitions

Criteria	Inclusion	Exclusion
Study type	Any primary peer-reviewed journal publication irrespective of study design.	Incomplete publication (e.g., conference abstracts, guidelines and reviews will be excluded.
Study focus	Studies describing a process of adaptation of a health intervention to a new context . Primary studies evaluating an evidence-informed intervention adapted to a new context (e.g., process and/or outcome evaluation).	Primary studies evaluating an evidence-informed intervention adapted to a new context (e.g., process and/or outcome evaluation). Implementation studies and process evaluations without a clear adaptation focus.
Population	People with long-term conditions (LTC) [see e-Table 2]	Acute conditions
Interventions	Complex intervention	Drugs, medical devices, and surgical procedures
Comparator	Any comparator	No exclusions
Outcomes	Any healthcare outcomes	No exclusions
Definitions		
'Adaptation'	Modifications made to the content of interventions AND/OR Modifications made to the delivery of interventions AND/OR Modifications made to the context in which interventions are delivered AND/OR Modification made to alternative study population or disease group.	
'Context'	Drawing on the context and implementation of complex interventions (CICI) framework dimensions, ¹⁹ i.e., context is characterised by differences in geographical, epidemiological, sociocultural, socioeconomic, ethical, legal, and/or political determinants.	
'Complex intervention'	"An intervention might be considered complex because of properties of the intervention itself, such as the number of components involved; the range of behaviours targeted; expertise and skills required by those delivering and receiving the intervention; the number of groups, settings, or levels targeted; or the permitted level of flexibility of the intervention or its components."	

eTable 2: List of included long-term conditions (LTCs)

Alcohol problems	Chronic fatigue syndrome	Depression	Inflammatory bowel disease	Parkinson's disease	Stroke or TIA
Anorexia nervosa or bulimia	Chronic kidney disease	Diabetes mellitus	Irritable bowel syndrome	Peripheral vascular disease	Thyroid disease
Anxiety	Chronic liver disease	Diverticular disease	Long-COVID	Pernicious anaemia	Treated constipation
Arthritis	Chronic obstructive pulmonary disease	Endometriosis	Meniere's disease	Polycystic ovarian syndrome	Treated dyspepsia
Asthma	Chronic sinusitis	Epilepsy	Migraine	Prostate disorders	Viral hepatitis
Atrial fibrillation	Connective tissue disease	Glaucoma	Multiple sclerosis	Psoriasis or eczema	
Bronchiectasis	Coronary heart disease	Heart failure	Osteoporosis	Psychoactive substance misuse	
Cancer	Dementia	Hypertension	Painful condition	Schizophrenia or bipolar affective disorder	

Listing based on Cambridge Multimorbidity Score¹⁸ and Barnett et al 2012.¹⁹

eTable 3a: Ovid MEDLINE(R) and In-Process, In-Data-Review & Other Non-Indexed Citations Search Strategy

1	Evidence-Based Medicine/or Evidence-Based Practice/
2	Health Promotion/
3	(evidence-based or evidence-informed or EBP or EBI or EBT).ab, kw,ti.
4	(health promotion or population impact).ab, kw,ti.
5	((effective or efficacious) adj3 (program* or programme* or intervention* or treatment*)).ti, ab.
6	1 or 2 or 3 or 4 or 5
7	Program evaluation.ab, kw,ti.
8	(method* or guideline? or guidance or guide or framework? or system? or tool? or process*2 or approach*2 or best practice? or good practice? or model? or recommendation? or step? or challenge? or principle? or standard?).ti.
9	(method* or guideline? or guidance or guide or framework? or system? or tool? or process*2 or approach*2 or best practice? or good practice? or model? or recommendation? or step? or challenge? or principle? or standard?).ab./freq=3
10	7 or 8 or 9
11	6 and 10
12	Program Development/
13	Cultural Diversity/
14	(implement* or develop* or prevent* or disseminat*).ti.
15	(implement* or develop* or prevent* or disseminat*).ab./freq=3
16	((new or diverse or different or other) adj (context? or population? or communit* or culture? or setting?)).ti, ab.
17	((ethnocultural or ethno-cultural) adj (group* or context* or population* or communit* or setting*)).ab, ti.
18	((Program or programme) adj development).ab, ti.
19	12 or 13 or 14 or 15 or 16 or 17 or 18
20	11 and 19
21	Diffusion of Innovation/
22	((intervention? or program? or programme? or policy or policies or treatment? or guideline? or psychotherapy*3) adj5 (adapt* or modif* or transfer* or transport* or translat* or replicat* or tailor*)).ti.
23	((intervention? or program? or programme? or policy or policies or treatment? or guideline? or psychotherp*3) adj5 (adapt* or modif* or transfer* or transport* or translat* or replicat* or tailor*)).ab./freq=2

24	(intervention fidelity or implementation fidelity or external validity or scaling-out or scale-out or transferability).ti, ab.
25	((ethnic* or cultural* or transcultural* or crosscultural*) adj (difference* or adapt* or modif* or relevan* or competen* or tailor* or appropriat* or sensitiv* or novel or context or transporting or variation*)).ti, ab.
26	21 or 22 or 23 or 24 or 25
27	20 and 26
28	Alcohol-Related Disorders/or Bulimia/or Anorexia Nervosa/or Anxiety/or Arthritis/or Asthma/or Atrial Fibrillation/or Bronchiectasis/or Neoplasms/or Fatigue Syndrome, Chronic/or Renal Insufficiency, Chronic/or Liver Diseases/or Pulmonary Disease, Chronic Obstructive/or Sinusitis/or Connective Tissue Diseases/or Coronary Disease/or Dementia/or Depression/or Diabetes Mellitus/or Diverticular Diseases/or Endometriosis/or Epilepsy/or Glaucoma/or Heart Failure/or Hypertension/or Inflammatory Bowel Diseases/or Irritable Bowel Syndrome/or Meniere Disease/or Migraine Disorders/or Multiple Sclerosis/or Osteoporosis/or Chronic Pain/or Parkinson Disease/or Peripheral Vascular Diseases/or Anemia, Pernicious/or Polycystic Ovary Syndrome/or Prostatic Diseases/or Psoriasis/or Eczema/or Substance-Related Disorders/or Schizophrenia/or Bipolar Disorder/or Stroke/or Ischemic Attack, Transient/or Thyroid Diseases/or Hepatitis/or Dyspepsia/or Constipation/
29	(Alcohol-Related Disorders or Bulimia or Anorexia Nervosa or Anxiety or Arthritis or Asthma or Atrial Fibrillation or Bronchiectasis or Neoplasms or Chronic Fatigue or Renal disease or Liver Diseases or Chronic Pulmonary Disease or Sinusitis or Connective Tissue Diseases or Coronary Disease or Dementia or Depression or Diabetes Mellitus or Diverticular Diseases or Endometriosis or Epilepsy or Glaucoma or Heart Failure or Hypertension or Inflammatory Bowel Diseases or Irritable Bowel Syndrome or Meniere Disease or Migraine Disorders or Multiple Sclerosis or Osteoporosis or Chronic Pain or Parkinson Disease or Peripheral Vascular Diseases or Anaemia or Polycystic Ovary Syndrome or Prostatic Diseases or Psoriasis or Eczema or Substance-Related Disorders or Schizophrenia or Bipolar Disorder or Stroke or Thyroid Diseases or Hepatitis or Dyspepsia or Constipation).ab, kw,ti.
30	(chronic disease* or long term condition*).ab, kw,ti.
31	Chronic Disease/
32	Noncommunicable Diseases/
33	(non communicable disease* or non-communicable disease).ab, kw,ti.
34	28 or 29 or 30 or 31 or 32 or 33
35	27 and 34
36	limit 36 to yr="2012 -Current"

eTable 3b: PsycINFO Search Strategy

#	Query
S35	S27 AND S33 limit year = 2012-2022
S34	S27 AND S33
S33	S28 OR S29 OR S30 OR S31 OR S32
S32	TI ((Alcohol-Related Disorders or Bulimia or Anorexia Nervosa or Anxiety or Arthritis or Asthma or Atrial Fibrillation or Bronchiectasis or Neoplasms or Chronic Fatigue or Renal disease or Liver Diseases or Chronic Pulmonary Disease or Sinusitis or Connective Tissue Diseases or Coronary Disease or Dementia or Depression or Diabetes Mellitus or Diverticular Diseases or Endometriosis or Epilepsy or Glaucoma or Heart Failure or Hypertension or Inflammatory Bowel Diseases or Irritable Bowel Syndrome or Meniere Disease or Migraine Disorders or Multiple Sclerosis or Osteoporosis or Chronic Pain or Parkinson Disease or Peripheral Vascular Diseases or Anaemia or Polycystic Ovary Syndrome or Prostatic Diseases or Psoriasis or Eczema or Substance-Related Disorders or Schizophrenia or Bipolar Disorder or Stroke or Thyroid Diseases or Hepatitis or Dyspepsia or Constipation)) OR AB ((Alcohol-Related Disorders or Bulimia or Anorexia Nervosa or Anxiety or Arthritis or Asthma or Atrial Fibrillation or Bronchiectasis or Neoplasms or Chronic Fatigue or Renal disease or Liver Diseases or Chronic Pulmonary Disease or Sinusitis or Connective Tissue Diseases or Coronary Disease or Dementia or Depression or Diabetes Mellitus or Diverticular Diseases or Endometriosis or Epilepsy or Glaucoma or Heart Failure or Hypertension or Inflammatory Bowel Diseases or Irritable Bowel Syndrome or Meniere Disease or Migraine Disorders or Multiple Sclerosis or Osteoporosis or Chronic Pain or Parkinson Disease or Peripheral Vascular Diseases or Anaemia or Polycystic Ovary Syndrome or Prostatic Diseases or Psoriasis or Eczema or Substance-Related Disorders or Schizophrenia or Bipolar Disorder or Stroke or Thyroid Diseases or Hepatitis or Dyspepsia or Constipation))
S31	((DE "Alcohol Use Disorder") OR (DE "Bulimia")) OR (DE "Anorexia Nervosa")) OR (DE "Anxiety" OR DE "Anxiety Disorders")) OR (DE "Asthma")) OR (DE "Fibrillation (Heart")) OR (DE "Neoplasms")) OR (DE "Chronic Fatigue Syndrome")) OR (DE "Liver Disorders")) OR (DE "Chronic Obstructive Pulmonary Disease")) OR (DE "Cardiovascular Disorders")) OR (DE "Dementia")) OR (DE "Depression (Emotion")) OR (DE "Diabetes")) OR (DE "Epilepsy")) OR (DE "Glaucoma")) OR (DE "Hypertension")) OR (DE "Irritable Bowel Syndrome")) OR (DE "Menieres Disease")) OR (DE "Migraine Headache")) OR (DE "Multiple Sclerosis")) OR (DE "Osteoporosis")) OR (DE "Chronic

	Pain")) OR (DE "Parkinson's Disease")) OR (DE "Anemia")) OR (DE "Eczema")) OR (DE "Substance Related and Addictive Disorders")) OR (DE "Schizophrenia")) OR (DE "Bipolar Disorder")) OR (DE "Cerebrovascular Accidents")) OR (DE "Thyroid Disorders")) OR (DE "Hepatitis")) OR (DE "Dyspepsia")) OR (DE "Constipation")
S30	TI (non communicable disease* or noncommunicable disease) OR AB (non communicable disease* or noncommunicable disease)
S29	TI (chronic disease or chronic illness or long term conditions or chronic conditions) OR AB (chronic disease or chronic illness or long term conditions or chronic conditions)
S28	DE "Chronic Illness"
S27	S25 AND S26
S26	TI (adaptation or spread or modification or adjustment or variation or novel) OR AB (adaptation or spread or modification or adjustment or variation or novel)
S25	S13 AND S18 AND S24
S24	S19 OR S20 OR S21 OR S22 OR S23
S23	TI ((difference* or adapt* or modif* or relevan* or competen* or tailor* or appropriat* or sensitiv* or novel or context or transporting or variation*)) OR AB ((difference* or adapt* or modif* or relevan* or competen* or tailor* or appropriat* or sensitiv* or novel or context or transporting or variation*))
S22	TI ((cultural* or transcultural* or crosscultural*) N1 (difference* or adapt* or modif* or relevan* or competen* or tailor* or appropriat* or sensitiv* or novel or context or transporting or variation*)) OR AB ((cultural* or transcultural* or crosscultural*) N1 (difference* or adapt* or modif* or relevan* or competen* or tailor* or appropriat* or sensitiv* or novel or context or transporting or variation*))
S21	TI ((intervention fidelity or implementation fidelity or external validity or scaling-out or scale-out or transferability)) OR AB ((intervention fidelity or implementation fidelity or external validity or scaling-out or scale-out or transferability))
S20	TI ((intervention* or program* or programme* or policy or policies or treatment* or guideline* or psychotherapy) N3 (adapt* or modif* or transfer* or transport* or translat* or replicat* or tailor*)) OR AB ((intervention* or program* or programme* or policy or policies or treatment* or guideline* or psychotherapy) N3 (adapt* or modif* or transfer* or transport* or translat* or replicat* or tailor*))

S19	TI (innovation or diffusion of innovation*) OR AB (innovation or diffusion of innovation*)
S18	S14 OR S15 OR S16 OR S17
S17	TI ((Program or programme) N1 development)) OR AB ((Program or programme) N1 development))
S16	TI ((new or diverse or different or other) N1 (context* or population or communit* or culture* or setting*))
S15	TI (implement* or develop* or prevent* or disseminat*)
S14	DE "Cultural Diversity" OR TI ((ethnocultural or ethno-cultural) N3 (group* or context* or population* or communit* or setting*) OR AB ((ethnocultural or ethno-cultural) N3(group* or context* or population* or communit* or setting*))
S13	S9 AND S12
S12	S10 OR S11
S11	TI ((method* or guideline* or guidance or framework* or system* or tool* or process or approach* or best practice or good practice or model or recommendation* or challenge* or standard*)) OR AB ((method* or guideline* or guidance or framework* or system* or tool* or process or approach* or best practice or good practice or model or recommendation* or challenge* or standard*))
S10	TI (program evaluation or programme evaluation) OR AB (program evaluation or programme evaluation)
S9	S1 OR S2 OR S3 OR S4 OR S5 OR S6 OR S7 OR S8
S8	TI ((effective or efficacious) n3 (program* or programme* or intervention* or treatment*)) OR AB ((effective or efficacious) n3 (program* or programme* or intervention* or treatment*))
S7	TI population impact OR AB population impact
S6	TI (EBP or EBI or EBT) OR AB (EBP or EBI or EBT)
S5	TI health promotion OR AB health promotion
S4	TI (evidence-based or evidence-informed) OR AB (evidence-based or evidence-informed)
S3	DE "Health Promotion"

S2	TI (evidence-based medicine OR evidenced-based medicine) OR AB (evidence-based medicine OR evidenced-based medicine)
S1	TI (evidence-based practice or evidenced-based practice) OR AB (evidence-based practice or evidenced-based practice)

eTable 3c: CINAHL Search Strategy

#	Query
S33	S33 limit year = 2012-2022
S32	S25 AND S31
S31	S26 OR S27 OR S28 OR S29 OR S30
S30	TI ((Alcohol-Related Disorders or Bulimia or Anorexia Nervosa or Anxiety or Arthritis or Asthma or Atrial Fibrillation or Bronchiectasis or Neoplasms or Chronic Fatigue or Renal disease or Liver Diseases or Chronic Pulmonary Disease or Sinusitis or Connective Tissue Diseases or Coronary Disease or Dementia or Depression or Diabetes Mellitus or Diverticular Diseases or Endometriosis or Epilepsy or Glaucoma or Heart Failure or Hypertension or Inflammatory Bowel Diseases or Irritable Bowel Syndrome or Meniere Disease or Migraine Disorders or Multiple Sclerosis or Osteoporosis or Chronic Pain or Parkinson Disease or Peripheral Vascular Diseases or Anaemia or Polycystic Ovary Syndrome or Prostatic Diseases or Psoriasis or Eczema or Substance-Related Disorders or Schizophrenia or Bipolar Disorder or Stroke or Thyroid Diseases or Hepatitis or Dyspepsia or Constipation)) OR AB ((Alcohol-Related Disorders or Bulimia or Anorexia Nervosa or Anxiety or Arthritis or Asthma or Atrial Fibrillation or Bronchiectasis or Neoplasms or Chronic Fatigue or Renal disease or Liver Diseases or Chronic Pulmonary Disease or Sinusitis or Connective Tissue Diseases or Coronary Disease or Dementia or Depression or Diabetes Mellitus or Diverticular Diseases or Endometriosis or Epilepsy or Glaucoma or Heart Failure or Hypertension or Inflammatory Bowel Diseases or Irritable Bowel Syndrome or Meniere Disease or Migraine Disorders or Multiple Sclerosis or Osteoporosis or Chronic Pain or Parkinson Disease or Peripheral Vascular Diseases or Anaemia or Polycystic Ovary Syndrome or Prostatic Diseases or Psoriasis or Eczema or Substance-Related Disorders or Schizophrenia or Bipolar Disorder or Stroke or Thyroid Diseases or Hepatitis or Dyspepsia or Constipation))

S29	MH "Dyspepsia") OR (MH "Constipation") OR (MH "Thyroid Diseases") OR (MH "Bipolar Disorder") OR (MH "Schizophrenia") OR (MH "Behavior, Addictive") OR (MH "Substance Abuse") OR (MH "Eczema") OR (MH "Prostatic Diseases") OR (MH "Cardiovascular Diseases") OR (MH "Osteoporosis") OR (MH "Migraine") OR (MH "Irritable Bowel Syndrome") OR (MH "Hypertension") OR (MH "Glaucoma") OR (MH "Epilepsy") OR (MH "Dementia") OR (MH "Liver Diseases") OR (MH "Neoplasms") OR (MH "Diabetes Mellitus") OR (MH "Heart Diseases") OR (MH "Liver Diseases") OR (MH "Fatigue Syndrome, Chronic") OR (MH "Bronchiectasis") OR (MH "Atrial Fibrillation") OR (MH "Asthma") OR (MH "Anxiety") OR (MH "Anxiety Disorders") OR (MH "Bulimia") OR (MH "Bulimia Nervosa") OR (MH "Arthritis") OR (MH "Anorexia") OR (MH "Anorexia Nervosa") OR (MH "Alcohol Abuse") OR (MH "Hepatitis") OR (MH "Pulmonary Disease, Chronic Obstructive") OR (MH "Sinusitis") OR (MH "Connective Tissue Diseases") OR (MH "Coronary Disease") OR (MH "Dementia") OR (MH "Depression") OR (MH "Diverticular Diseases") OR (MH "Endometriosis") OR (MH "Heart Failure") OR (MH "Inflammatory Bowel Diseases") OR (MH "Meniere's Disease") OR (MH "Multiple Sclerosis") OR (MH "Chronic Pain") OR (MH "Parkinson Disease") OR (MH "Peripheral Vascular Diseases") OR (MH "Anemia, Pernicious") OR (MH "Polycystic Ovary Syndrome") OR (MH "Prostatic Diseases") OR (MH "Psoriasis") OR (MH "Substance Use Disorders") OR (MH "Bipolar Disorder") OR (MH "Stroke")
S28	TI (non-communicable disease* or noncommunicable disease) OR AB (non-communicable disease* or noncommunicable disease)
S27	TI (chronic disease or chronic illness or long term conditions or chronic conditions) OR AB (chronic disease or chronic illness or long term conditions or chronic conditions)
S26	(MH "Chronic Disease")
S25	S13 AND S19 AND S24
S24	S20 OR S21 OR S22 OR S23
S23	TI ((cultural* or transcultural* or crosscultural*) N1 (difference* or adapt* or modif* or relevan* or competen* or tailor* or appropriat* or sensitiv* or novel or context or transporting or variation*)) OR AB ((cultural* or transcultural* or crosscultural*) N1 (difference* or adapt* or modif* or relevan* or competen* or tailor* or appropriat* or sensitiv* or novel or context or transporting or variation*))
S22	TI ((intervention fidelity or implementation fidelity or external validity or scaling-out or scale-out or transferability)) OR AB ((intervention fidelity or implementation fidelity or external validity or scaling-out or scale-out or transferability))

S21	TI ((intervention* or program* or programme* or policy or policies or treatment* or guideline* or psychotherapy) N3 (adapt* or modif* or transfer* or transport* or translat* or replicat* or tailor*)) OR AB ((intervention* or program* or programme* or policy or policies or treatment* or guideline* or psychotherapy) N3 (adapt* or modif* or transfer* or transport* or translat* or replicat* or tailor*))
S20	TI (innovation or diffusion of innovation*) OR AB (innovation or diffusion of innovation*)
S19	S14 OR S15 OR S16 OR S17 OR S18
S18	TI ((Program or programme) N1 development)) OR AB ((Program or programme) N1 development))
S17	TI ((new or diverse or different or other) N1 (context* or population or communit* or culture* or setting*))
S16	TI (implement* or develop* or prevent* or disseminat*)
S15	TI ((ethnocultural or ethno-cultural) N3 (group* or context* or population* or communit* or setting*) OR AB ((ethnocultural or ethno-cultural) N3 (group* or context* or population* or communit* or setting*))
S14	(MH "Cultural Diversity")
S13	S9 AND S12
S12	S10 OR S11
S11	TI ((method* or guideline* or guidance or framework* or system* or tool* or process or approach* or best practice or good practice or model or recommendation* or challenge* or standard*))
S10	TI (program evaluation or programme evaluation) OR AB (program evaluation or programme evaluation)
S9	S1 OR S2 OR S3 OR S4 OR S5 OR S6 OR S7 OR S8
S8	TI ((effective or efficacious) n3 (program* or programm* or intervention* or treatment*)) OR AB ((effective or efficacious) n3 (program* or programm* or intervention* or treatment*))
S7	TI population impact OR AB population impact
S6	TI (EBP or EBI or EBT) OR AB (EBP or EBI or EBT)
S5	TI health promotion OR AB health promotion

S4	TI (evidence-based or evidence-informed) OR AB (evidence-based or evidence-informed)
S3	(MH "Health Promotion")
S2	TI (evidence-based medicine OR evidenced-based medicine) OR AB (evidence-based medicine OR evidenced-based medicine)
S1	TI (evidence-based practice or evidenced-based practice) OR AB (evidence-based practice or evidenced-based practice)

eTable 4: Template of checklist developed from ADAPT guidance to assess quality of reporting of adaptation studies

	Wording in the original ADAPT guidance*	Wording for the ADAPT reporting checklist	Criterion fully met (score 2)	Criterion partially met (score 1)	Criterion not reported (score 0)
1.	Forming an evaluation team	Forming an adaptation team			
A	Have you involved an appropriate range of stakeholders, including those with expertise in the intervention and its evidence base, and those with knowledge of the new context?	Was there involvement of an appropriate range of stakeholders, including those with expertise in the intervention and its evidence base, and those with knowledge of the new context?			
B	Is your team clear on roles, including who will make decisions on adaptations, when, and how?	Were the team clear on roles, including who would make decisions on adaptations, when and how?			
C	Will you work with the developers of the intervention? If so, how will you manage any conflicts of interest arising from this?	Did they work with the developers of the original intervention? If so, do they state how they managed any interest arising from this?			

D	How might the membership of your adaptation team need to evolve as adaptation progresses?	Did they consider whether the membership of the adaptation team needed to evolve as the adaptation progressed? Furthermore, do they state how this was done?			
2.	Assessing the rationale for intervention, and considering intervention-context fit	Assessment of the rationale for the intervention, and consideration of the intervention-context fit			
A	What is the problem that an intervention seeks to improve in the target population?	Is the problem that the intervention seeks to improve in the target population, stated?			
B	Is there more than one potential evidence informed intervention? If so, are there reasons one might be more suitable than others, such as the relevance of its programme theory and change mechanisms?	If there was more than one potential evidence informed intervention so they state, are the reasons one might be more suitable than others, such as the relevance of its programme theory and change mechanisms, stated?			
C	What is known about the selected intervention(s) in terms of programme theory, process, effectiveness, cost effectiveness and implementation in other contexts?	Is what is known about the selected intervention(s) in terms of programme theory, process, effectiveness, cost effectiveness and implementation in other contexts, stated?			
D	How robust are any claims that the	How robust are any claims that the intervention(s) has worked elsewhere?			

	intervention(s) has worked elsewhere?				
E	How similar and different are original and new contexts, in terms of issues likely to affect implementation and effectiveness?	Have similarities and difference of the original and new contexts, in terms of issues likely to affect implementation and effectiveness, been considered?			
F	Are there any intellectual property issues which limit use and adaptation of the intervention(s)?	Are any intellectual property issues which limit use and adaptation of the intervention(s), stated?			
3.	Planning for and undertaking adaptations	Planning and undertaking the adaptation			
A	What adaptations can you make to respond to constraints and facilitators, while maintaining consistency with intended intervention functions?	What adaptations were made to respond to constraints and facilitators, while maintaining consistency with intended intervention functions?			
B	What adaptations need to be made to intervention materials, such as manuals, to capture changes made to the intervention?	Are any adaptations needed to be made to intervention materials, such as manuals, to capture changes made to the intervention, stated?			
C	Might interactions with aspects of the new context lead to any new unintended consequences?	Are interactions with aspects of the new context which led to any new unintended consequences, stated?			

D	What costs and resources are needed to deliver the adapted intervention?	Are the costs and resources needed to deliver the adapted intervention stated?			
E	Who will deliver the adapted intervention, and how will you recruit them?	Is who will deliver the adapted intervention, and how will you recruit them, stated?			
4.	Planning for and undertaking evaluation	Planning and undertaking the evaluation			
A	Given what is known about the intervention and the likely transferability of previous evidence, what type and extent of re-evaluation is warranted?	Given what is known about the intervention, and the likely transferability of previous evidence, is it stated what type and extent of re-evaluation is warranted?			
B	What will be the value of new information to policymakers, practitioners, and other stakeholders?	Is the value of new information to policymakers, practitioners, and other stakeholders, stated?			
C	What resources are available for re-evaluation?	Are resources are available for re-evaluation stated?			
D	Does initial feasibility testing indicate that any further adaptations are needed?	Is it stated whether or not initial feasibility testing indicated that any further adaptations are needed?			
E	How will you capture responsive adaptations and decide whether the intervention remains consistent with intended functions and change mechanisms?	Have responsive adaptations been captured and decisions whether the intervention remained consistent with intended functions and change mechanisms, been stated?			

F	How will you evaluate effectiveness, cost effectiveness, and process, if this is warranted by uncertainty about whether existing evidence will transfer?	Was effectiveness, cost effectiveness, and process evaluated if this was warranted by uncertainty about whether existing evidence will transfer?			
5.	Implementing and maintaining the intervention at scale	Implementing and maintaining the intervention at scale			
A	What long term partnerships and capacity will be needed for maintenance of the intervention?	Was long term partnerships and capacity will be needed for maintenance of the intervention, stated?			
B	How will you monitor whether the intervention continues to be delivered, and maintains its effectiveness, over time in real world practice?	Was monitoring of whether the intervention continues to be delivered, and maintains its effectiveness, over time in real world practice, stated?			

eTable 5: Exemplars of good reporting practice by ADAPT domain and item (achieved a ‘criterion fully met’/score of 2)

1. Forming an adaptation team		
Items	Example 1	Example 2
Item 1A: Was there involvement of an appropriate range of stakeholders, including those with expertise in the intervention and its evidence base, and those with knowledge of the new context?	"Stakeholders covered including (project principle investigator, research team, expert panel, client, service providers, and peer advocates. Stakeholder participants (n=25) included 6 clients, 7 peer advocates, and 12 mental health providers of a CMH setting in Michigan." ³³ [Bornheimer et al. 2022]	"The steering committee for the ASHP adaptation included the directors of the three senior centre research sites, two program directors from the senior centres, a member of the Visiting Nurse Service of New York City, and an individual with chronic arthritis pain who regularly attended one of the partner senior centres. Experts on the EBI on the steering committee were a national Arthritis Foundation board member and two ASHP instructors. The four members of the research team (a geriatrician with research experience in pain management, a sociologist with expertise in the design of interventions for older populations, a health education researcher with particular expertise regarding the ASHP, and a gerontologist with experience delivering health promotion programs in community settings)

		were also members of the steering committee." ²⁶ [Chen et al. 2013]
Item 1B: Were the team clear on roles, including who would make decisions on adaptations, when and how?	"Findings were discussed amongst members of the panel, also including study Co-Investigators and the CMH research site Medical Director, who provided feedback regarding emerging themes from the data and stakeholder suggestions for modifications. Additional modification suggestions were offered based upon panel members' areas of expertise and beyond what was initially proposed by the PI and research team and/ or suggested by stakeholders." ³³ [Bornheimer et al. 2022]	"The steering committee meets to review all feedback and make choices about how to adapt the EBI. The steering committee evaluates each response to the open-ended questions and all suggestions and ideas are raised in the focus group for importance, feasibility, and congruence." ²⁶ [Chen et al. 2013]
Item 1C: Did they work with the developers of the original intervention? If so, do they state how they managed any interest arising from this?	"Developers involved and worked as co-authors of CBSPp project." ³³ [Bornheimer et al. 2022]	"Experts on the EBI on the steering committee were a national Arthritis Foundation board member and two ASHP instructors." ²⁶ [Chen et al. 2013]
Item 1D: Did they consider whether the membership of the adaptation team needed to evolve as the adaptation progressed? Further, do they	"All level of stakeholders were involve with this project from beginning to implementation stage by troubleshooting is essential to combat this barrier and increase the feasibility and sustainability of CBSPp in CMH." ³³ [Bornheimer et al. 2022]	"The steering committee familiarizes itself with the original (un-adapted) EBI to coordinate a high-quality implementation of the program. The steering committee should meet 1 or 2 times to review the program curriculum and instructional materials of the EBI to ensure that all

state how this was done?		members are familiar with the program's protocol, core components, theory of change, and impact on outcomes.” ²⁶ [Chen et al. 2013]
2. Assessment of the rationale for the intervention, and consideration of the intervention-context fit		
Item 2A: Is the problem that the intervention seeks to improve in the target population, stated?	“The aim of the intervention is to treat and prevent suicide thoughts in individuals with schizophrenia spectrum disorders.” ³³ [Bornheimer et al. 2022]	“A couple of CST studies was conducted, but not with PwD and with no cultural adaptation process described (Apóstolo, Cardoso, Marta, & Amaral, 2011; Apóstolo, Cardoso, Rosa, & Paúl, 2014). The present study aims to present the cultural adaptation process of the CST manual, “Making a Difference” (Spector et al., 2006), for the Portuguese population.” ³⁹ [Alvares Pereira et al. 2022]
Item 2B: If there was more than one potential evidence informed intervention so they state, are the reasons one might be more suitable than others, such as the relevance of	“Cognitive behavioural therapy for psychosis (CBTp) has been widely used among individuals with SSPDs yet has not been empirically shown to improve hopelessness, suicidal thoughts, or behaviours. Similarly, cognitive behavioural therapy for suicide prevention (CBTSP) has demonstrated effectiveness in reducing suicide outcomes; however, research to date has not performed examinations among individuals with psychosis symptoms. Finally they selected the CASPP program because this preliminary data show that CBSPp improves global functioning and reduces depression, hopelessness, positive	“Research in this area remains relatively scarce in Portugal. A couple of CST studies was conducted, but not with PwD and with no cultural adaptation process described (Apóstolo, Cardoso, Marta, & Amaral, 2011; Apóstolo, Cardoso, Rosa, & Paúl, 2014). It has already been translated and adapted to other cultures and currently

its programme theory and change mechanisms, stated?	and negative symptoms, suicidal ideation, and suicide attempt by targeting the three cognitive components: information processing biases, appraisals, and schemas.” ³³ [Bornheimer et al. 2022]	offered in more than 25 countries (Rai et al., 2018), namely in Japan where improvements in cognitive function and quality of life were also found (Yamanaka et al., 2013), and more recently in Sub-Saharan Africa (Mkenda et al., 2016), Italy (Capotosto et al., 2017), India (Raghuraman, Lakshminarayanan, Vaitheswaran, & Rangaswamy, 2017), China (Wong, Yek, Zhang, Lum, & Spector, 2017) and Brazil (Bertrand et al., 2018).” ³⁹ [Alvares Pereira et al. 2022]
Item 2C: Is what is known about the selected intervention(s) in terms of programme theory, process, effectiveness, cost effectiveness and implementation in other contexts, stated?	“CBSPp in addition to TAU successfully, and significantly, reduced the estimated primary outcome measures of the probability of suicide and suicidal ideation (as measured by the ASIQ but not the BSS) compared to TAU alone. Associated secondary outcomes of depression, self-esteem, psychotic symptoms overall, positive and general psychotic symptoms, supported by a previous RCT undertaken in UK”. (https://pubmed.ncbi.nlm.nih.gov/24853059/).” ³³ [Bornheimer et al. 2022]	“Cognitive Stimulation Therapy (CST) was developed in the United Kingdom (UK) and is one of the most popular and worldwide used evidence-based (Spector et al., 2003) and cost-effective (Knapp et al., 2006) programs to improve cognitive function and quality of life for people with mild to moderate dementia (Woods, Aguirre, Spector, & Orrell, 2012). Cognitive stimulation is

		recommended by Alzheimer's Disease International [ADI] in the World Alzheimer's Reports (2011, 2014); and by the National Institute for Health and Clinical Excellence and the Social Care Institute for Excellence [NICE-SCIE] (2006, 2011)." ³⁹ [Alvares Pereira et al. 2022]
Item 2D: How robust are any claims that the intervention(s) has worked elsewhere?	"Cognitive behavioral therapy for suicide prevention (CBTSP) has demonstrated effectiveness in reducing suicide outcomes; however, research to date has not performed examinations among individuals with psychosis symptoms. Preliminary data show that CBSPp improves global functioning and reduces depression, hopelessness, positive and negative symptoms, suicidal ideation, and suicide attempt by targeting the three cognitive components: information processing biases, appraisals, and schemas (Pratt et al., 2015; Tarrier et al., 2014; Haddock et al., 2016)." ³³ [Bornheimer et al. 2022]	"It has already been translated and adapted to other cultures and currently offered in more than 25 countries (Rai et al., 2018), namely in Japan where improvements in cognitive function and quality of life were also found (Yamanaka et al., 2013), and more recently in Sub-Saharan Africa (Mkenda et al., 2016), Italy (Capotosto et al., 2017), India (Raghuraman, Lakshminarayanan, Vaitheswaran, & Rangaswamy, 2017), China (Wong, Yek, Zhang, Lum, & Spector, 2017) and Brazil (Bertrand et al., 2018)." ³⁹ [Alvares Pereira et al. 2022]
Item 2E: Have similarities and	"To work towards offsetting provider identified training barriers of time constraints, motivation,	"Similar to other CST cultural adaptations, there

difference of the original and new contexts, in terms of issues likely to affect implementation and effectiveness, been considered?	and distractibility in the virtual on-demand nature of CBSPP training, provider stakeholders recommended the training.” ³³ [Bornheimer et al. 2022]	was an obvious need to replace some British terms and stimuli to Portuguese equivalents easily recognizable by participants. Therefore, Portuguese linguistic and cultural aspects were introduced in 11 of the 14 CST sessions.” ³⁹ [Alvares Pereira et al. 2022]
Item 2F: Are any intellectual property issues which limit use and adaptation of the intervention(s), stated?	No study found that achieved full or partial scoring.	No study found that achieved full or partial scoring.
3. Planning and undertaking the adaptation		
Item 3A: What adaptations were made to respond to constraints and facilitators, while maintaining consistency with intended intervention functions?	“Institute for Healthcare Improvement’s Going to Scale Framework, we also created local stakeholder groups to support the tailoring process [58]. Implementation factors from each of the seven TICD domains (guideline factors, individual health professional factors, patient factors, professional interactions, incentives, and resources, capacity for organisational change, and social, political, and legal factors) were reviewed and rated by the research team according to their relevance for this specific project (see supplementary materials). Certain guideline factors were rated as not requiring further action due to the strength of existing international evidence demonstrating their effectiveness”. “In response, for providers, we developed an extra training package session	“The current study examined these cultural and contextual factors in relation to Scotland (with individual cities/areas also considered), related barriers and facilitators, and recommendations for policy, practice and research that are relevant to Scotland and beyond. Our study highlights the key considerations in implementing the IM in Scotland, which is essential in adapting interventions to new

	focusing on mental health and resilience amongst PHC clinicians. For patients, we amended the clinical pathway, to give increased priority to depression screening and care in the intervention package. This meant that all consulting patients would be screened for both depression and heavy drinking.”³² [O'Donnell et al, 2022]	cultures and contexts. if implemented, the IM would need to: be Scotland-specific; be adequately funded over the long-term; involve clear professional roles and responsibilities and leadership; involve a range of holders, including young people; and have cross party support locally and nationally. Participants were clear that, while current prevention work in Scotland is lacking, there are examples of good relevant services and work is therefore needed to foster collaborative partnership working between a range of organisations.”³⁴ [Carver et al. 2021]
Item 3B: Are any adaptations needed to be made to intervention materials, such as manuals, to capture changes made to the intervention, stated?	“Stakeholders in all three countries also helped identify relevant contact details that could be added to the clinical materials to help signpost patients to appropriate specialist services or information sources. Next, we gathered qualitative feedback on all intervention materials via facilitated discussions with Patient and Clinical Provider User Panels established in each municipality. For the alcohol information leaflets, User Panel discussions focused on the need to translate some core concepts and terminology to better suit the local implementation context”. “Our training package was therefore adapted for online delivery, meaning it could be accessed remotely,	“Iceland is typically seen as different to Scotland in terms of its normative culture, use of substances, schooling system, provision of services, and welfare provision [26, 30]. This perception led participants to reflect on the need for the IM to be adapted for use in Scotland.”³⁴ [Carver et al. 2021]

	and repeatedly, at no additional cost. In Peru specifically, the intervention package was also translated for online implementation, automating the clinical care pathway, and facilitating access to electronic versions of the patient materials. This was not possible in Colombia and Mexico, primarily due to lack of internet connection in the PHCUs.”³² [O’Donnell et al, 2022]	
Item 3C: Are interactions with aspects of the new context which led to any new unintended consequences, stated?	“This resulted in a process of trial and error as the local project team learned how to navigate the system. To mitigate this unforeseen issue, we engaged a content editor experienced in technology and digital communications to ensure that our team developed and followed robust system user guides. Involving the UK developers of the original MyDESMOND platform in the project from the outset also provided an additional source of knowledge and expertise to overcome this issue.”⁴⁶ [Olson et al, 2022]	Only one study met full reporting criteria.
Item 3D: Are the costs and resources needed to deliver the adapted intervention stated?	“Intensive data collection from so many program participants and compensation for staff both add to the cost of the method. Program participants were compensated, if modestly, for the time spent being interviewed. Appropriate percentages of staff time were also paid by the federal grant that funded this research. Compared to a program adaptation that is done by one or two individuals using no stakeholder feedback, we acknowledge that M-PACE may be a more costly method for determining how to adapt an EBI. Because cost certainly affects the feasibility of undertaking program adaptation, future research should estimate the cost of program adaptation in light of outcomes associated with the adapted program.”²⁶ [Chen et al. 2013]	“Cost was exclusively referred to as a barrier to implementation, most notably as an opportunity cost for physicians, who do not perceive they had the time to educate patients in their busy clinical facilities. Additionally, various patient costs were identified, including the cost of seeking treatment at a clinical facility, particularly the cost of having to renew their antihypertensive medication prescriptions every month. Although medications are supported

		by insurance provided by the NHIS, clinicians reported many people do not register for insurance due to a sense of fatalism or mistrust of the health system. Nurses and doctors should make [the intervention available at hospitals. Public health and community nurses will make it available within the communities.” ⁴⁴ [Ojo et al, 2020]
Item 3E: Is who will deliver the adapted intervention, and how will you recruit them, stated?	“Intervention municipal area. 58 PHC [primary health care] units (PHCUs) were recruited across these municipal areas. Half of these PHCUs (29) were in municipal areas which did not benefit from additional community support measures. Of these, 14 PHCUs comprised our control (Arm 1) and 15 PHCUs received a brief clinical intervention and provider training package alone (Arm 2). The remaining 29 PHCUs received additional community action and support measures with 15 PHCUs randomly allocated to receive a brief (less intensive) tailored clinical intervention and provider training package (Arm 3) and 14 PHCUs to receive a standard (more intensive) version of this package.” ³² [O’Donnell et al, 2022]	“Nurses and doctors should make [the intervention available at hospitals. Public health and community nurses will make it available within the communities. We go from house-to-house to visit the aged, people with communicable and NCD conditions, and provide education. There are some NGOs in the communities giving home visits and give health services.” ⁴⁴ [Ojo et al, 2020]
4. Planning and undertaking the evaluation		
Item 4A: Given what is known about the intervention, and the likely transferability of	“The study intervention is a multicomponent and multilevel program to improve hypertension control over 18 months. Core intervention: protocol-based hypertension treatment. The study team and Ministry of Health officials designed a standardized stepped-care	“This research is precursory to our planned investigations to eventually test an obesity prevention program in Hawaii’s Samoan churches and

previous evidence, is it stated what type and extent of re-evaluation is warranted?	hypertension treatment protocol summarized in an algorithm, based on the American Heart Association (AHA) Hypertension Guidelines 2017 and the Guatemala Ministry of Health Healthcare Norms 2018 [22,23]. An individualized treatment plan for the participant to reach a BP target < 130/80 mmHg, with a combination of antihypertensive medications offered by the Ministry of Health: hydrochlorothiazide, enalapril and losartan. The study team provided educational materials and pocket cards summarizing the hypertension treatment algorithm to health care provider.” ³⁷ [Fort et al. 2019]	assess the program’s suitability for dissemination to Samoan churches across the United States.” ³⁴ [Carver et al. 2021]
Item 4B: Is the value of new information to policymakers, practitioners, and other stakeholders, stated?	“Will disseminate the study findings, promote scale up, and scale out of the program, if proven effective. This study will generate urgently needed data on effective, adoptable, and sustainable intervention and implementation strategies to improve hypertension control in Guatemala and other low- and middle-income countries.” ³⁷ [Fort et al. 2019]	“This study laid a foundation for the adaption of Body and Soul, a proven faith-based, health promotion program for use in Hawaii’s Samoan churches (Resnicow et al., 2004). The findings from our investigation demonstrated the value of qualitative research methods to inform the adaptation of evidence-based health promotion programs for populations experiencing health disparities. In addition, the methods used in this study can help guide the cross cultural adaptation of other existing health promotion interventions. Finally, this research identifies potential

		intervention strategies that might be useful with migrant populations.” ³⁴ [Carver et al. 2021]
Item 4C: Are resources available for re-evaluation stated?	“The intervention and study outcomes are patient-centred, and patients, Ministry of Health provider-teams, and other stakeholders have been engaged at every step of the proposed study. The proposed study will test whether an evidence-based, multilevel and multicomponent intervention program can be translated to and is feasible in the primary healthcare systems of this region.” ³⁷ [Fort et al. 2019]	Only one study met full reporting criteria.
Item 4D: Is it stated whether or not initial feasibility testing indicated that any further adaptations are needed?	“Further work is needed to ensure the feasibility of delivering MyDESMOND in the Australian setting in addition to establishing the acceptability and potential effectiveness of the program among Australian people with T2DM.” ⁴⁶ [Olson et al, 2022]	“The pilot study phase included a final set of focus groups in which the CHC intervention was delivered to focus group participants.” “Following the pilot test and based on participants’ suggestions about the need for reference materials for the lessons learned, the project team developed a handbook for couples that reiterated the core elements of the CHC intervention and contained activities in which couples could practice together the skills taught during the intervention.” ²⁹ [Wechsberg et al, 2015]
Item 4E: Have responsive adaptations	"The decision was made to drop the use of the standard (more intensive) package previously implemented in Arm 4, in favour of the brief (less	Only one study met full reporting criteria.

been captured and decisions whether the intervention remained consistent with intended functions and change mechanisms, been stated?	intensive) alternative used in Arm 3. This was partially based on feedback from local providers responsible for implementing the package, who reported that they found the standard version excessively time-consuming and thus impractical for delivery in routine practice.” ³² [O'Donnell et al, 2022] No studies judged to be fully reported. This study provided a partial report.	
Item 4F: Was effectiveness, cost effectiveness, and process evaluated if this was warranted by uncertainty about whether existing evidence will transfer?	“In keeping with MRC recommendations (33), we are currently conducting a randomized controlled trial of the effectiveness of the intervention in reducing anxiety in the prenatal period as well as preventing depression postnatally in Rawalpindi, Pakistan (see https://clinicaltrials.gov/ct2/show/NCT03880032).” Not stated explicitly if the RCT will have a parallel economic evaluation to assess cost effectiveness or a parallel process evaluation.” ³¹ [Atif et al, 2020]	“In LMICs such as Thailand, where mental health professional resources are limited, it is crucial to identify evidence-based intervention programs that can be culturally adapted and implemented using the available workforce in the existing service system and that can be scaled up with the support necessary for expanding service capacity.” ⁴⁷ [Tongsiri et al, 2022]
5. Implementing and maintaining the intervention at scale		
Item 5A: Was long term partnerships and capacity will be needed for maintenance of the intervention, stated?	“Implications for policy, practice and research: the study findings suggest that long term funding and strategic leadership is required to prevent substance use in Scotland.” ³⁴ [Carver et al. 2021]	“Consequently, we recommend involving original program developers as stakeholders when adapting digital programs to new settings, where possible. Although the adaptation of MyDESMOND Australia

		involved a collaborative approach and extensive stakeholder engagement, program users.” ⁴⁶ [Olson et al, 2022]
Item 5B: Was monitoring of whether the intervention continues to be delivered, and maintains its effectiveness, over time in real world practice, stated?	“Using a theory-based approach to data collection and analysis, such as the CFIR, would be beneficial to further elaborate on barriers and facilitators moving into implementation. Importantly, young people should be involved in research and evaluation concerning the IM and how it might make a difference to their experiences.”³⁴ [Carver et al. 2021]	“The Data Safety and Monitoring Board met twice during 2019: prior to study enrolment and during the first semester of enrolment. Intervention educational materials for healthcare providers and patients were adapted and finalized.”³⁷ [Fort et al. 2019]

e-Appendix B: Chapter 3 (Paper 2)

**(Adaptation of an Evidence-Based Home Cardiac
Rehabilitation Programme for People with Coronary Heart
Disease in Bangladesh)**

e-Appendix 1: Details of the seven-phase procedure.

Phase 1: Select evidence-based intervention

We selected 'The Heart Manual' intervention, originally designed and evaluated in the UK given its very widespread use and citation in over 500 peer-reviewed publications.²⁶ It is an individually tailored 6-week home-based CR programme for patients recovering from acute MI and/or revascularisation and is available in either paper or digital format. Founded on cognitive behavioural principles, it provides patients with a tailored approach to promote their self-management and well-being.²⁷ As a trained healthcare professional guided programme, the Heart Manual addresses cardiac misconceptions and enables individuals to use effective coping strategies and techniques throughout their recovery. The health professional visits the patient (and their caregiver) at their home or alternative suitable venue and introduces the manual. This is followed by 5-10 minute telephone calls/home visits at weeks 2, 3, 4, and 6 to check the patient's progress. The final contact at week 6 is used to agree on future self-management goals going forward. The Heart Manual programme is summarized using the TIDieR (Template for Intervention Description and Replication) checklist in (e-Table 3).^{28, 29}

Phase 2: Review of the UK Heart Manual (phase 2) with intervention developers

Hard copies of UK Heart Manual with relaxation CD materials were obtained and a web-meeting held with the developers to determine the core intervention components of the intervention. One member of the study team (JU) attended the online two-day UK Heart Manual facilitator training event (August 17th-18th, 2023) to clarify the intervention delivery and check context fit.

Phase 3: Translation of intervention materials

The Heart Manual was translated from English into Bangla by a translator. A backward translation was checked for translation accuracy by a second translator.

Phase 4: Map similarity and difference between original and new contexts and identification of intervention adaptations

We checked the potential mismatch and differences between the original and adapted settings of UK and Bangladesh including the intervention population and health setting (see e-Table 4). The expert group consultation meeting was held on 10th October 2023 and included a cardiologist, cardiac surgeon, senior physiotherapist, senior nutritionist, senior staff nurses, public health expert. Following this meeting, the 'Bangla Heart Manual' version was drafted. - In addition to that, one consultative workshop was organised (10th January 2024) including the relevant professional experts i.e. cardiology medical officer, cardiac physiotherapists, cardiac staff nurses, nutritionist who are the service providers and with patients and their caregivers to adapt and check the Bangla Heart Manual understandability and deliverability.

Phase 5: Summarizing feedback from consultation meeting and workshop for further revision.

The draft Bangla Heart Manual materials were further reviewed by the expert group. This group identified intervention elements that might need adaptation to the context of resources and structure limitations of the Bangladesh health care system and the needs of patients and their caregivers. Feedback from the expert group consultation meeting and workshop were summarized, combined and used to inform a further round of Bangla Heart Manual revision.

Phases 6 and 7: External review and finalisation of adapted intervention.

The draft Bangla Heart Manual and the feedback from both expert group consultation meeting and consultative workshop were brought together and the final version of the Bangla Manual produced.

e-Table 1: Potential matches and mismatches with original and adapted intervention and population.

Adaptation characteristics	Original UK Heart Manual	Bangla Heart Manual,
Population characteristics:		
Language	English	Bangla
Ethnicity	Diverse (White British, European, African etc..)	Primarily Bengali
Economic status & funding	Funded by the public National Health Service (NHS)	Mostly, patient out of pocket expenditure)
Educational level	The literacy rate for adults (15+) in the UK is 99%	The literacy rate for adults (15+) in Bangladesh is 75.6%
Major CHD risk factors (Chronologically):	1) High BP; 2) high blood cholesterol levels; 3) smoking; 4) diabetes; 5) overweight or obesity; 6) lack of physical activity; 7) unhealthy diet and stress	1) Hyperlipidemia (83%) 2) Physical inactivity (51%) 3) Obesity (46%) 4) Smoking (44%) 5) Family history of CAD (22%) 6) Diabetes (15%) 7) Unhealthy diet.
Intervention delivery characteristics		
Healthcare staff	Great access to experienced and trained nurses and physiotherapists	Limited number of experienced of allied health care staff.
Community context		
Transportation status	Usually good local and timely transportation access	Transportation system more limited and time consuming.
Family structure	Some patients are self-dependent and some are family dependent.	Most of them are family oriented and dependent on family.
Personal management culture	Most of them have their individual responsibility	Predominantly family responsibility culture.

eTable 2: Adaptation of the Bangla Heart Manual semi structured questionnaire

S/L	Open-ended questionnaire Items	Your opinions/suggestions
01.	Content of the ‘Bangla Heart Manual’. ▪ Readability ▪ Consistency ▪ Navigability	
02.	Language /pictures understand ability. ▪ Structural proficiency ▪ Understand ability according to context. ▪ Visual clearance	
03.	Bangla Heart Manual-type of materials ▪ One original reference book ▪ One mini version booklet ▪ 6 weeks home-based exercise program with animated video ▪ Relaxation audio and video version	
04.	Mode of delivery: ▪ Hybrid -centre based and ▪ Weekly phone call	
05	Role of patients and caregivers to increase the acceptability of this Heart Manual	

eTable 3: Expert group consultation meeting and consultative workshop for adaptation of the Bangla Heart Manual.

A.	Methods of adaptation process: 1) Selection of the eligible participants, 2) Invitation for a prescheduled meeting and 3) Provide Bangla Heart Manual to the stakeholders prior to the meeting.		
	Expert group Meeting and consultative workshop	Stakeholders	Questionnaire
B.	International expert group consultation meeting ‘Heart Manual’ UK expertise and Bangladeshi expertise		
	International consensus meeting. (Via Zoom)	Three experts from UK and three from Bangladesh	Discussed content rearrangement of the original “Heart Manual”) and combined both MI and revascularization heart manual and making it a single manual as CHD ‘ Bangla Heart Manual. We discussed the service provider and the mode of delivery of the intervention.
C.	Expert group consultation meeting in Bangladesh (Held on 10th October’2023)		
	Expert group consultation meeting	1) Consultant Cardiologist (ICHRI, BSMMU; NHFH&RI, NICVD) 2) Cardiac Surgeon (From ICHRI) 3) Psychiatrist (from National Institute of Mental Health) 4) Public Health Specialist (from BUHS) 5) Senior Physiotherapist (from ICHRI, BSMMU and NHFH&RI) 6) Senior staff nurse (from ICHRI, BSMMU and NHFH&RI). 7) Senior Nutritionist (from ICHRI, BSMMU and NHFH&RI). 8) Academician of rehabilitation science (Bangladesh open university and Jessore	<u>Open-ended questionnaire:</u> 1) Contents of ‘ Bangla Heart Manual’ 2) Sequence of materials of contents 3) Language /pictures understandability 4) Service providers (Who would be the potential CR service provider) 5) Mode of delivery (Center based or Hybrid -Centre and centre monitored home based via Phone call)

		University of Science & Technology).	
D	Consultative workshop in Bangladesh (Held on 10th January'2024		
	Consultative workshop	1) Medical officer (Cardiology and cardiac surgery department of ICHRI) 2) Physiotherapist (From ICHRI and BSMMU) 3) Nutritionist (From ICHRI) 4) Staff nurse (From ICHRI and BSMMU) 5) Medical technologist (From ICHRI) 6) Patient counselor (From ICHRI). 7) Patients and patients caregivers (From ICHRI and BSMMU).	<u>Open ended questionnaire:</u> 1. Content of the ‘ Bangla Heart Manual’. ▪ Readability ▪ Consistency ▪ Navigability 2. Language /pictures understand ability. ▪ Structural proficiency ▪ Understand ability according to context. ▪ Visual clearance 3. Bangla Heart Manual-type of materials ▪ One original reference book ▪ One mini version booklet ▪ Animated 6 weeks home-based exercise ▪ Relaxation audio-visual version 4. Mode of delivery: ▪ Hybrid -centre based and Weekly phone call 5. Role of patients and caregivers to increase the acceptability of this Heart Manual
E.	Record keeping: By Tap recorder and manual note keeping		
	Finalize and summarized by making meeting minutes		

eTable 4: Description of original UK Heart Manual' programme based on the TIDieR checklist

NO.	Item		Item description of 'Heart Manual'
1.	Brief Name	Provide the name or a phrase that describes the intervention	'The Heart Manual' intervention for patients with MI and revascularization
2.	Why	Describe any rationale, theory, or goal of the elements essential to the intervention	The 'Heart Manual' is designed to guide the patient and (their) family caregivers to use for a six-week home-based CR programme consisting of written materials, sections to record progress, a Q&A audio and relaxation programme facilitated by a specially trained clinician. The 'Heart Manual' not only focuses on short-term recovery but aims to assist the patient to adopt and maintain self-management skills, promoting the maintenance of well-being from their event or intervention on to long-term self-management. It also contains all the elements of a comprehensive rehabilitation programme: Health behaviour change and education, lifestyle risk management, exercise, medical risk management and psychological health. National Institute for Health and Care Excellence (NICE) has identified the Heart Manual as a comprehensive, validated home-based cardiac rehabilitation programme in its clinical guidelines for secondary prevention since 2007.³⁶ Robust evidence found in a different systematic review, the home-based programmes using the Heart Manual were as equally effective as hospital-based rehabilitation.³⁷ It also concluded that the Heart Manual is as effective as hospital-based cardiovascular rehabilitation on a number of psychological, behavioural, biological, service and cost outcomes.³⁸ The Heart Manual included in a review of home-based and recently developed telehealth programmes, was identified as an

			effective alternative to hospital-based programmes. 39
3.	What	Materials: Describe any physical or informational materials used in the intervention, including those provided to participants or used in intervention delivery or in training of intervention providers. Provide information on where the materials can be accessed (such as online appendix, URL)	The Heart Manual intervention package is written in simple language and laid out in three, easy-to-follow parts: Part 1: Your Heart Condition: The Facts. This part contains important information for the patient to read during the initial phase of their recovery. Part 2: The Weekly Programme: This part consists of six weekly sections, each containing important information to aid the patient's recovery, a graded exercise programme and a focus each week on a lifestyle risk factor. Part 3: Facts and Advice to Help Your Recovery: This part contains important information about the patient's recovery, medication, and other significant issues relating to their condition such as hospital investigations and treatments.

4.		Procedures: Describe each of the procedures, activities, and/or processes used in the intervention, including any enabling or support activities	The key components and activities for a comprehensive cardiac rehabilitation programme are included in the Heart Manual supported by a specially trained clinician: ➤ An exercise programme ➤ Lifestyle and risk factor education ➤ Advice about safe and unsafe activities including pacing ➤ The common psychological responses and their management ➤ Stress management and relaxation Information about frequently prescribed medications ➤ Event and intervention specific information, investigations and treatments. Patients should be encouraged to use the Heart Manual daily to help identify, plan and monitor weekly targets and pacing activities. Psychological support and health behavior change activities are imbedded throughout the manual.
5.	Who provided	For each category of intervention provider (such as psychologist, nursing assistant), describe their expertise, background, and any specific training given	Patients should be assessed by a registered practitioner (nurse or AHP) as suitable to commence the programme. Non-registered/ non-regulated health care workers such as exercise specialist or health care support workers may be trained in the resources and deliver aspects of the programme under the supervision of a registered practitioner according to each individuals clinical competence.

6.	How provided	Describe the modes of delivery (such as face to face or by some other mechanism, such as internet or telephone) of the intervention and whether it was provided individually or in a group	In hospital: The 'Heart Manual' first given in the Hospital through face-to-face communication. Initial in hospital approach for recruitment-referral made /cardiac rehab (CR) team visit. Other form-CR practitioner picks up referral and approach to made first contact with the patients by physically or phone for initial assessment confirmation and then send 'Heart Manual' to patient. Consultation format: Formal assessment and consultation, information given/objective settings in clinic/ home/ or by phone/video call. Follow up: Phone follow-up, e.g., week 2/4. Tailored lifestyle content, objective and behaviour change by Phone/Video call. Final consultation check: Understanding, long term plan, emergency information by clinic/ home/ or by phone/video call.
7.	Where	Describe the type(s) of location(s) where the intervention occurred, including any necessary infrastructure or relevant features	Its flexibility: 1. In hospital/ Clinic 2. Home or alternative/suitable venue-e.g. community centre/hall 3. Phone/ video call
8.	When and how much	Describe the number of times the intervention was delivered and over what period of time including the number of sessions, their schedule, and their duration, intensity, or dose	Initial assessment consultation will take about 1 hour. ➤ Subsequent contacts are likely to average about 30-45 mins. ➤ Recovery program: Following 6-week recovery programme: Week-1 Program: ▪ Answer some more questions about your condition ▪ Introduce you to the Exercise and Relaxation Plans which will play an important part in your recovery and afterwards.

			▪ Look at some of the things which might be worrying you, and show you how you can fight back. ▪ If you live with someone, get them to read this section - it can help them as much as it helps you. Week-2 program: ▪ Try to carry on with the Exercise/Activity Plan. ▪ Don't forget to fill in your walking, exercise and activity record sheets. If you do this, you'll be able to look back at them in a few weeks and see how much you have improved. ▪ You will keep listening to the relaxation audio and get some tips about what to do if you are worried. ▪ You will learn about your coronary artery disease and the risk factors that contributed to it. ▪ You will find out what happened to John McKay (case study). ▪ You will read about the biggest risk factor of all - smoking. Week-3 program: ▪ Keep on building up your Exercise/Activity Plan. If you didn't start regular walking last week, try to do so now, as advised. If you did start regular walking, you should be building up the distance. ▪ Don't forget to fill in your walking, exercise and activity record sheets. ▪ Try to keep listening to the relaxation audio and get some information about stress and how to control it ▪ This week's risk factor is diet. Most people find that healthy food is also tasty - try it!
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			Week-4 program: ▪ Keep building up your Exercise/Activity Plan. You should also be walking daily and increasing the frequency, speed and distance as advised. ▪ Remember to fill in your walking, exercise and activity record sheets. ▪ Keep listening to the relaxation audio. ▪ There's more this week about stress. A stressful lifestyle can play a big part in building up risk factors so it's helpful to learn ways to manage it. ▪ This week's risk factor is being overweight – a major problem for some people. But getting control of your weight can have a big benefit in reducing the risk of further heart problems in the future. Week-5 program: ▪ You'll keep building up your Exercise/Activity Plan. ▪ Remember to fill in your walking, exercise and activity record sheets. ▪ Keep listening to the relaxation audio. ▪ You'll hear more about stress. If you are thinking more and more about diving back into a busy lifestyle, you'll find some very useful advice about speeding, overworking and driven behaviour. ▪ This week's risk factor is lack of exercise. If you have been following the Exercise/Activity Plan you should already be seeing benefits from regular exercise, but this section goes into a little more detail about why it's so important. ▪ There's a section about sex (if you're interested).
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			Week 6 - the last week of the Manual program: ▪ You'll keep building up your Exercise/Activity Plan. ▪ Remember to fill in your walking, exercise and activity record sheets. ▪ Keep listening to the relaxation audio. ▪ We'll be looking at hostility and anger. ▪ We will think about going back to work. You may wish to discuss this with your GP or facilitator. ▪ This week's risk factor is high blood pressure. ▪ We shall bring together the different aspects of the stress control programs ▪ We shall review what has happened over the last 6 weeks and provide a checklist for future actions. ▪ Contacts can be face to face at home or in clinic, by telephone or video call (first contact benefits from being face to face if service provision allows) ▪ Phone calls are useful for checking in on patients between longer consultations. If visiting patients at home, allow time for travel, record keeping etc.
9.	Tailoring	If the intervention was planned to be personalised, titrated or adapted, then describe what, why, when, and how	Be flexible: ➤ shorter, more frequent consultations may be useful for some patients ➤ some patients will need minimal input, shorter and/ or fewer sessions

eTable 5: Comparison between the original and the modified intervention with rational for adaptations of the Heart Manual (HM) for home-based CR of Bangladeshi patients with CHD.

S/ N	Heart Manual content themes	Original Heart Manual, UK (Three parts)	Adaptation-Bangla Heart Manual - Bangladesh (Four parts)	
1.	Part of Heart Manual			
1.(A)	Part-1: Section A: Your Heart Attack- the Facts:	This section is for you to read while you are recovering from heart attack- It tells you the plain facts about your heart condition after procedures. Focused on: ▪ Discuss about heart and coronary heart disease ▪ Intervention procedures (Angioplasty and CABG). Some general tips: What to do and what not to do after procedure	Part-1: Rules of using the Bangla Heart Manual (How to use the Cardiac Rehabilitation Programme book?) ▪ Discuss about heart and coronary heart disease ▪ Intervention procedures (Angioplasty and CABG). ▪ Some general tips: What to do and what not to do after procedure (During recovery phase after procedures).	
1.(B)	Part 2: The Weekly Program me and risk factors of CHD and its manage ment	This part consists of six weekly sections: Each weekly section has important to help you to recover, and an exercise programme to help you back to fitness in easy stages. ✓ Follow your plan morning and evening as advised by your facilitator ✓ Each time marks your activities in the chart provided	Part-2: Weekly exercise programme and stress management through relaxation. ▪ Wach week formative home exercise programme (week 1-6) ▪ Record keeping or mark your activities in the chart provided of walking, exercise and daily activities records. ▪ Stress management and relaxation practice (by using relaxation audiovisual version)	

		Practice relaxation by listening to tracks 1 and 2 on the relaxations CD or audio.		
1.(C)	Part 3: Facts and Advice to Help Your Recovery.	This part provides extra information about your recovery, medications and other things you might want to know. ▪ Wound healing. ▪ Swollen hands or feet. ▪ Reasons for using drugs. ▪ Some routine tests in the hospital. ▪ Why does angina or chest pain occur? ▪ Other chest pains. ▪ Shortness of breath. ▪ Hyperventilation. ▪ Chest palpitations ▪ Depression following procedures. ▪ Sleep problems and so on.	Part-3: Information and advice to help you ▪ Wound healing. ▪ Swollen hands or feet. ▪ Reasons for using drugs. ▪ Some routine tests in the hospital. ▪ Why does angina or chest pain occur? ▪ Other chest pains. ▪ Shortness of breath. ▪ Hyperventilation. ▪ Chest palpitations ▪ Depression following procedures. ▪ Sleep problems. ▪ Some practical examples of mental problems and overcoming these conditions	
1.(D)	Don't have part-4 (Original UK Heart Manual)	Risk factor's part has been laps with (part 2) the weekly programme section.	Part-4: Risk factors of CHD and its management. (Make an individual part as part 4)	
2.	Mode of delivery			
	Home visit	Home visit (Nurses/physiotherapist)	No home visit (Phone/mobile call from institute)	
	Hospital setting	Hospital setting cardiac rehab intervention facilities	Hospital setting (Monitored-intervention delivered before or during discharge)	
	Telephone call	Phone call from hospital	Weekly phone call from hospital	

3.	Responsible personnel (Health Care Staff)			
	Nurses driven	Nurse driven (Cardiac rehab team) Team consist of: ▪ Cardiologist ▪ Staff CR nurse ▪ Physiotherapist/exercise physiologist ▪ Occupational therapist ▪ Nutritionist ▪ Patient counselor	Physiotherapist driven (Cardiac rehab team) Team consist of: ▪ Cardiologist ▪ Physiotherapist (Cardiac rehab expert) ▪ Cardiac staff nurse ▪ Medical technologist ▪ Nutritionist	

eFigure 1: The original UK and Adapted Bangla Heart Manual materials (Supplementary illustrations)

Original English Heart Manual page	Adapted Bangla Heart Manual Page	Adapted back translated Bangla Heart Manual page
How to use the Manual Part 1: Your Heart Condition: the Facts (pages 9-22) This part is for you to read in the first days after your angioplasty (stent), or bypass operation. It is called: It tells you the plain facts about your heart condition. You should read this section first, and you might want to come back to it a few times over the coming weeks. If you live with someone, get them to read this section, too. It can help them just as much as it helps you. Part 2: The Weekly Programme (pages 23-118) This part consists of six weekly sections. The weeks are clearly labelled like this: Each weekly section has important information to help you to recover, and an exercise programme to help you back to fitness in easy stages. Every day: ■ follow your plan morning and evening as advised by your facilitator ■ each time mark your activities in the charts provided ■ practise relaxation by listening to tracks 1 and 2 on the relaxation CD or audio. You can access the audio online here: www.heartmanual.scot.nhs.uk/index.php/download/resources or download the HM Relax app via Apple or Google Play stores or scan the QR code. Please ask your facilitator for the username. The password is relax. Part 3: Facts and Advice to Help Your Recovery (pages 139-175) This part provides extra information about your recovery, medicines, wound healing, and other things you might want to know. You can read it right through or dip into it to answer your questions.	১.১ এই বাংলা হার্ট ম্যানুয়ালটি নিম্নলিখিত বিষয়গুলি বুঝতে সাহায্য করবে: ■ কেন আপনার হার্ট এটাক হয়েছিল বা হৃদরোগে আক্রান্ত হয়েছিলেন? ■ আপনার চিকিৎসা পদ্ধতি ওলোর মধ্যে এঞ্জিওপ্লাস্টি (স্টেন্ট বা ব্রিজ পড়ানো) এবং কাইপাস অপারেশন কি এবং কেন করা প্রয়োজন সে সম্পর্কে আপনাকে ধারণা দিবে। ■ আপনি কিভাবে ক্রত ও সিরামপে সুস্থ হয়ে উঠবেন সে সম্পর্কে আপনাকে ধারণা দিবে। ■ আপনি যে সব ঔষধ গ্রহণ করছেন তার সম্পর্কেও সঠিক ধারণা পাবেন। ■ এই ম্যানুয়ালটি আপনার পরিচর্যাকারীকে আপনার অবস্থা পরিদৃষ্ট করে বুঝতে সহায়তা করবে। ■ এই প্রোগ্রামটিকে ৬টি সপ্তাহিক অংশে ভাগ করা হয়েছে। ■ এখানে কিছু সহজ ব্যায়াম এবং রিল্যাক্সেশন করার কৌশল দেখানো হয়েছে। ■ প্রতি সপ্তাহে কি কি করণীয় তা দেয়া আছে। ১.২ হার্টের রক্তনালীর (ধমনীর) সরু হওয়া রোগ এবং এর কারণ: আপনার যদি হৃদরোগ হয় এর অর্থ হল আপনার হার্ট এর নিজস্ব রক্তনালীর (ধমনীর) দেওয়াল বা ভেতরের চার পর্শে চর্বির স্তর জমে ক্রমাগত সরু বা চিকন হয়ে যাচ্ছে। কয়েক বছর ধরে ধমনী এমন সরু হতে থাকে অনেকেরই জানেন না যে তিনি হৃদরোগে আক্রান্ত হচ্ছেন সবারগত এতে আপনি বাহ্যিকভাবে তেমন কোন অসুবিধা অনুভব করতে পারেন না। বেশিরভাগ সময় কোলেস্টেরল দিয়ে তৈরী ষাট জমে ধমনীর ভেতরের দেওয়াল সরু হয়ে যায়। আপনার ধমনীর একটা সংকীর্ণ অংশ ক্রত গ্রন্থ বা স্ফীত হলে এটা গুরুতর ঝাপসা হতে পারে। এমনকি চিকিৎসার মাধ্যমে এটি নিরাময় হলেও এর ক্ষতিকর হয়ে যায় এবং পরে এই ক্ষতই ধমনীকে আরো সরু করে দিতে পারে। কখনো কখনো ধমনীর কোন কোন অংশ এত সরু হয়ে যায় যে	Part - 1 Rules for using Bangla Heart Manual This program is called the Heart Manual: 1.1: How to use the Cardiac Rehabilitation Program book? This Bangla Heart Manual will help you understand the following topics: ▲ Why did you have a heart attack or heart attack? ▲ Give you an idea of what and why angioplasty (stent) and bypass surgery are needed in your treatment procedures. ▲ Gives you an idea of how you can recover quickly and safely. ▲ You will also get a proper idea about all the medicines you are taking. ▲ This manual will help your caregiver fully understand your condition. ▲ This program is divided into 6 weekly segments. ▲ Here are some simple exercises and relaxation techniques. ▲ What to do each week is given. You and your heart condition: The first part of this manual will give you an idea of your heart condition and the treatments you have received for it, and it answers some of the questions that people often ask. We recommend that you read these sections thoroughly from the first days of your treatment and that your caregiver should read them as well. We recommend that you read this manual thoroughly as soon as you go home after heart attack treatment (angioplasty or bypass). (See part-2 and start the weekly program.) But please note that do not show or ask anyone else with heart disease to wear this manual, because: their heart disease may be different. They may have more serious problems than you. Your suggestion may be wrong or even bad for them. A physician will best understand to whom this manual applies. But everyone can read it to know about the causes of heart disease and its treatment because the main causes of heart disease and its problems are same for almost everyone. 1.2: Narrowing of the blood vessels (arteries) of the heart and its causes:

eFigure 2: Front covers (original Heart Manual)

Front covers (adapted Bangla Heart Manual)



e-Appendix C: Chapter 4 (Paper 3)

**Assessment of the Bangla heart manual in patients with
coronary heart disease and their caregivers in Bangladesh:
A feasibility study**

e Table 1. Description of Bangla Heart Manual intervention according to the TIDieR checklist:

Item			Item description
1.	Brief Name	Provide the name or a phrase that describes the intervention	'The Bangla Heart Manual' intervention for patients with MI and revascularization
2.	Why	Describe any rationale, theory, or goal of the elements essential to the intervention	The 'Heart Manual' is designed to guide the patient and (their) family caregivers to use a six-week home-based CR programme consisting of written materials, sections to record progress, a Q&A audio, and relaxation programme facilitated by a specially trained physiotherapist. The 'Bangla Heart Manual' not only focuses on short-term recovery but aims to assist the patient in adopting and maintaining self-management skills, promoting the maintenance of well-being from their event or intervention to long-term self-management. It also contains all the elements of a comprehensive rehabilitation programme: Health behaviour change and education, lifestyle risk management, exercise, medical risk management and psychological health and wellbeing. Surveillance report 2017, National Institute for Health and Care Excellence (NICE) has identified the Heart Manual as a comprehensive, validated home-based cardiac rehabilitation programme in its clinical guidelines for secondary prevention since 2007.⁵⁰ Robust evidence found in a different systematic review, the home-based programmes using the Heart Manual were as equally effective as hospital-based rehabilitation.⁵¹ It also concluded that the Heart Manual is as effective as hospital based cardiovascular rehabilitation on a number of psychological, behavioural, biological, service and cost outcomes.⁵² The Heart Manual included in a review of home-based and recently developed

			telehealth programmes, was identified as an effective alternative to hospital-based programmes. ⁵³
3.	What	Materials: Describe any physical or informational materials used in the intervention, including those provided to participants or used in intervention delivery or the training of intervention providers. Provide information on where the materials can be accessed (such as online appendix, URL)	The Heart Manual intervention package is written in simple language and laid out in four, easy-to-follow parts: Part 1: Your Heart Condition: The Facts. This part contains important information for the patient to read during the initial phase of their recovery. Part 2: The Weekly Programme: This part consists of six weekly sections, each containing important information to aid the patient's recovery, a graded exercise programme, and a focus each week on a lifestyle risk factor. Part 3: information and advice to help you out after (post myocardial infarction and revascularization): This part contains important information about the patient's recovery, medication, and other significant issues relating to their condition such as mental health and well-being, hospital investigations, and treatments. Par 4: Cardiac risk factors and their management (Facts and advice to help you further prevention and control): this part contains important information about how to prevent and control of heart disease risk factors.
4.		Procedures: Describe each of the procedures, activities, and/or processes used in the intervention, including any enabling or support activities	The key components and activities for a comprehensive cardiac rehabilitation programme are included in the Heart Manual supported by a specially trained physiotherapist, nurses and medical technologist: ➤ An exercise programme ➤ Lifestyle and risk factor education ➤ Advice about safe and unsafe activities including pacing ➤ The common psychological responses and their management

			➤ Stress management and relaxation Information about frequently prescribed medications ➤ Event and intervention-specific information, investigations, and treatments. Patients should be encouraged to use the Heart Manual daily to help identify, plan, and monitor weekly targets and pacing activities. Psychological support and health behavior change activities are imbedded throughout the manual.
5.	Who provided	For each category of intervention provider (such as physiotherapist, psychologist, or nursing assistant), describe their expertise, background, and any specific training given	Patients should be assessed by a registered practitioner (nurse or AHP) as suitable to commence the programme. Non-registered/ non-regulated health care workers such as physiotherapists or health care support workers may be trained in the resources and deliver aspects of the programme under the supervision of a registered practitioner according to each individual's clinical competence.
6.	How provided	Describe the modes of delivery (such as face to face or by some other mechanism, such as internet or telephone) of the intervention and whether it was provided individually or in a group	In hospital: The 'Heart Manual' was first given in the Hospital through face-to-face communication. Initial in-hospital approach for recruitment-referral made /cardiac rehab (CR) team visit. Other form-CR practitioner picks up referrals and approaches to make first contact with the patients by physical or phone for initial assessment confirmation and then send a 'Heart Manual' to the patient. Consultation format: Formal assessment and consultation, information given/objective settings in clinic/ home/ or by phone/video call. Follow-up: Phone follow-up, e.g., week 2/4. Tailored lifestyle content, objective, and behavior change by Phone/Video call. Final consultation check: Understanding, long-term plan, emergency information by clinic/ home/ or by phone/video call.

7.	Where	Describe the type(s) of location(s) where the intervention occurred, including any necessary infrastructure or relevant features.	Its flexibility: 4. In hospital 5. Clinic 6. Home or alternative/suitable venue-e.g. community centre/hall 7. Phone call 8. Video call
8.	When and how much	Describe the number of times the intervention was delivered and over what period of time including the number of sessions, their schedule, and their duration, intensity, or dose	Initial assessment consultation will take about 1 hour. ➤ Subsequent contacts are likely to average about 30-45 mins. ➤ Recovery program: Following 6-week recovery programme: Week-1 Program: ▪ Answer some more questions about your condition and why you feel the way you do. ▪ Introduce you to the Exercise and Relaxation Plans which will play an important part in your recovery and afterwards. ▪ Look at some of the things which might be worrying you, and show you how you can fight back. ▪ If you live with someone, get them to read this section - it can help them as much as it helps you. Week-2 program: ▪ Try to carry on with the Exercise/Activity Plan. ▪ Don't forget to fill in your walking, exercise and activity record sheets. If you do this, you'll be able to look back at them in a few weeks and see how much you have improved. ▪ You will keep listening to the relaxation audio and get some tips about what to do if you are worried.

			▪ You will learn about your coronary artery disease and the risk factors that contributed to it. ▪ You will find out what happened to John McKay (case study). ▪ You will read about the biggest risk factor of all - smoking. Week-3 program: ▪ Keep on building up your Exercise/Activity Plan. If you didn't start regular walking last week, try to do so now, as advised. If you did start regular walking, you should be building up the distance. ▪ Don't forget to fill in your walking, exercise and activity record sheets. ▪ Try to keep listening to the relaxation audio and get some information about stress and how to control it ▪ This week's risk factor is diet. Most people find that healthy food is also tasty - try it! Week-4 program: ▪ Keep building up your Exercise/Activity Plan. You should also be walking daily and increasing the frequency, speed and distance as advised. ▪ Remember to fill in your walking, exercise and activity record sheets. ▪ Keep listening to the relaxation audio. ▪ There's more this week about stress. A stressful lifestyle can play a big part in building up risk factors so it's helpful to learn ways to manage it. ▪ This week's risk factor is being overweight – a major problem for some people. But getting control of your weight can have a big benefit in reducing the risk of further heart problems in the future.
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			Week-5 program: ▪ You'll keep building up your Exercise/Activity Plan. ▪ Remember to fill in your walking, exercise and activity record sheets. ▪ Keep listening to the relaxation audio. ▪ You'll hear more about stress. If you are thinking more and more about diving back into a busy lifestyle, you'll find some very useful advice about speeding, overworking and driven behaviour. ▪ This week's risk factor is lack of exercise. If you have been following the Exercise/Activity Plan you should already be seeing benefits from regular exercise, but this section goes into a little more detail about why it's so important. ▪ There's a section about sex (if you're interested). Week 6 - the last week of the Manual program: ▪ You'll keep building up your Exercise/Activity Plan. ▪ Remember to fill in your walking, exercise and activity record sheets. ▪ Keep listening to the relaxation audio. ▪ We'll be looking at hostility and anger. ▪ We will think about going back to work. You may wish to discuss this with your GP or facilitator. ▪ This week's risk factor is high blood pressure. ▪ We shall bring together the different aspects of the stress control programs ▪ We shall review what has happened over the last 6 weeks and provide a checklist for future actions.
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			➤ Contacts can be face to face at home or in clinic, by telephone or video call (first contact benefits from being face to face if service provision allows) ➤ Phone calls are useful for checking in on patients between longer consultations. If visiting patients at home, allow time for travel, record keeping etc.
9.	Tailoring	If the intervention was planned to be personalised, titrated or adapted, then describe what, why, when, and how	Be flexible: ➤ shorter, more frequent consultations may be useful for some patients ➤ some patients will need minimal input, shorter and/ or fewer sessions

eTable 2: Primary (Feasibility and acceptability) outcome measures criteria.

Outcomes	Assessment measure	Success criteria	Time point
Feasibility	Number of eligible patients, number of patients screened, number of patients invited to take part, actual number of participants who consent to take part		After end of 6 weeks home based cardiac rehabilitation programme
Recruitment	Number of consented participants relative to the total number of eligible patients approached for consent	Recruitment rate of $\geq 30\%$	During study period
Retention	Number of participants who complete the final study assessment relative to the total number of participants enrolled for pilot trial.	Retention rate of $\geq 80\%$	During study period
Adherence	Percentage of completion of the Bangla Heart Manual intervention components according to training logs.	Intervention adherence of $\geq 75\%$	During study period
Adverse events	Adverse events reported during 6 weeks (walking, exercise and daily activities time) and weekly check-in sessions	No study-related adverse events	During (6 weeks follow-up) study period
Acceptability outcome:	Participating patients and their caregivers will include a short questionnaire at a 6-week follow-up. This will also be supported by qualitative interviews with a subgroup of patients		After end of 6 weeks home based cardiac rehabilitation programme
Satisfaction	Patients and their caregivers (by using (0 to 5 Likert scale)	$\geq 80\%$ reporting above-average or excellent satisfaction on a Likert scale	After end of 6 weeks home based cardiac rehabilitation programme

eTable 3: Secondary outcome measures by time points.

Secondary outcomes	Assessment measure	Time points
Sociodemographic characteristics	Descriptive	At Baseline
Clinical	Descriptive	At Baseline
Exercise and functional capacity	Incremental Shuttle Walk Test (ISWT)	Baseline and at the last follow-up time point
Hospitalisations:	number, reason and duration	During 6 weeks follow-up period
Mortality	reason and how many days later after procedure.	During 6 weeks follow-up period
Patient reported outcome		
Disease-specific Health-Related Quality of Life, (HRQoL)	Measured using the HeartQoL Bangla version questionnaire.	Baseline and at the last follow-up time point
EQ-5D-5L	Generic quality of life five-dimension EuroQol (EQ-5D-5L) Scale	Baseline and at the last follow-up time point
HADS	Psychological well-being: Hospital Anxiety and Depression Scale (HADS).	Baseline and at the last follow-up time point

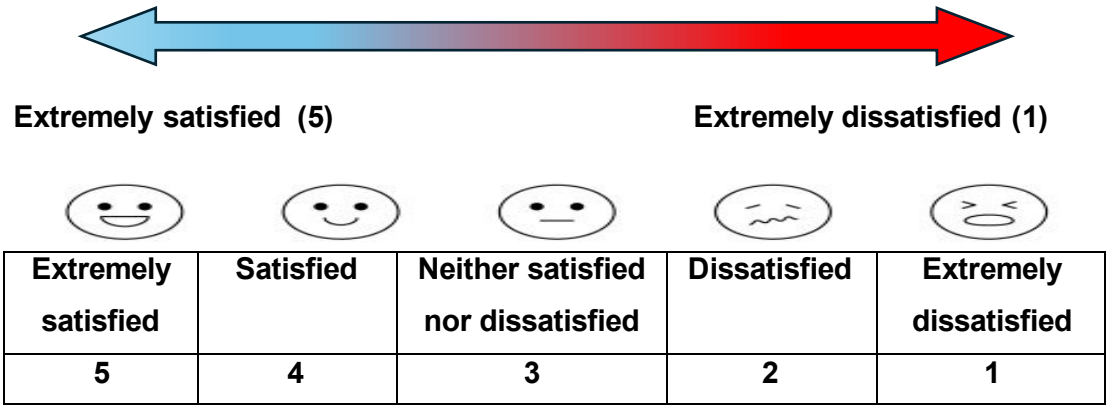
e-Figure 1: Schedule of study procedures:

	Feasibility Study period and visit								
	Enrolment	Baseline (in-hospital)	6 weeks (each week mobile call) follow-up						Final follow-up outcome
Time point	-t₁	T1	Wk-1	Wk-2	Wk-3	Wk-4	Wk-5	Wk-6	T2
Enrolment	x								
Eligibility screen (Inclusion/exclusion criteria)	x								
Informed consent	x	x							
Allocation		x							
Intervention									
Baseline assessment (demographic and clinical variables from hospital record files)	x	x							
Exercise capacity and patient reported outcomes. (pre and post procedure, In hospital and follow-up by mobile call)									
✓ Incremental shuttle walk test		x							x
✓ Bangla HeartQoL questionnaire		x							x
✓ EQ-5D-5L questionnaire		x							x
✓ Hospital Anxiety and Depression (HADS) questionnaire		x							x
✓ Serious adverse events (hospitalization/death)		x							x
✓ Patients and their caregivers satisfaction									x

e-Figure 2. Patient and caregiver treatment satisfaction questionnaire.

Question: How satisfied are (patients with coronary heart disease) after CABG and or PCI received home based Cardiac rehabilitation intervention with weekly mobile call for 6 weeks?

Please chose the option that most closely matches your response.



The face scale has five grades [1=extremely dissatisfied) to 5=extremely satisfied].

e-APPENDIX D: Chapter 5 (Paper 4)

**Effectiveness, safety, costs, and delivery considerations of
exercise-based cardiac rehabilitation in low- and middle-
income countries: A systematic review and meta-analysis
of randomised controlled trials**

Content of systematic review and meta-analysis of randomised controlled trial

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eTable 1: MEDLINE search

Ovid MEDLINE(R) ALL <1946 to March 17, 2025>

<https://ovidsp.ovid.com/ovidweb.cgi?T=JS&NEWS=N&PAGE=main&SHAREDSEARCHID=54DaN8SZJydVtaQBLmGsicyzkLr3cNFaN8Sp7fmVQcoom1Sc644QAI0c7NMDkxTav>

1	(afghan* or africa* or albania* or algeria* or angola* or antigua* or barbuda* or argentin* or armenia* or aruba* or azerbaijan* or bahrain* or bangladesh* or bengal* or bangal* or barbados* or barbadian* or bajan or bajans or belarus* or belorus* or byelarus* or byelorus* or belize* or benin* or dahomey or bhutan* or bolivia* or bosnia* or herzegovin* or botswan* or batswan* or bechuanaland* or brazil* or brasil* or bulgaria* or burkina* or burkinese* or upper volta* or burundi* or urundi* or cabo verde* or cape verde* or cambodia* or kampuchea* or khmer* or cameroon* or cameroun* or ubangi shari* or chad* or chile* or china* or chinese or colombia* or comoro* or comore* or comorian* or mayotte* or congo* or zaire* or costa rica* or "cote d'ivoir*" or "cote d' ivoir*" or cote divoir* or cote d ivoir* or ivory coast* or ivorian* or croatia* or cuba or cuban or cubans or "cuba's" or cyprus* or cypriot* or czech* or djibouti* or french somaliland* or dominica* or ecuador* or egypt* or united arab republic* or el salvador* or salvadoran* or guinea* or equatoguinea* or eritrea* or estonia* or eswatini* or swaziland* or swazi* or swati* or ethiopia* or fiji* or gabon* or gabonese* or gabonaise* or gambia* or ((georgia or georgian or georgians) not (atlanta or california or florida)) or ghana* or gibraltar* or greece* or greek* or grecian* or grenada* or grenadian* or guam* or guatemala* or guyana* or guiana* or guyanese* or haiti* or hispaniola* or hondura* or hungary* or hungarian* or india* or indonesia* or iran* or iraq* or isle of man* or jamaica* or jordan* or kazakh* or kenya* or karabati* or korea* or kosovo* or kosova* or kyrgyz* or kirgiz* or kirghiz* or laos or lao or laotian* or latvia* or lebanon* or lebanese* or lesotho* or lesothan* or lesothonian* or basutoland* or mosotho* or basotho* or liberia* or libya* or jamahiriya* or lithuania* or macedonia* or madagasca* or malagasy* or malawi* or nyasaland* or malaysia* or malay* federation or maldives* or maldivian* or indian ocean or mali or	3568217
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	malian* or "mali's" or malta or maltese* or "malta's" or micronesia* or marshallese* or kiribati* or marshall island* or nauru or nauran or nauruans or "naurian's" or mariana or marianas or palau or paluan* or tuvalu* or mauritania* or mauritan* or mauritius* or mexico* or mexican* or moldova* or moldovia* or mongol* or montenegr* or morocco* or moroccan* or ifni or mozambique* or mozambican* or myanmar* or burma* or burmese or namibia* or nepal* or new caledonia* or netherlands antill* or nicaragua* or niger* or oman or omani or omanis or "oman's" or pakistan* or palestin* or gaza* or west bank* or panama* or paraguay* or peru or peruvian* or "peru's" or philippine* or philipine* or phillipine* or phillippine* or filipino* or filipina* or poland* or polish or pole or poles or portugal* or portuguese or puerto ric* or romania* or russia* or ussr* or soviet* or rwnda* or rwandese or ruanda* or ruandese or samoa* or navigator island* or pacific island* or polynesia* or sao tome* or santomean* or saudi arabia* or saudi or saudis or senegal* or serbia* or seychell* or sierra leone* or slovak* or sloven* or melanesia* or solomon island* or norfolk island* or somali* or sri lanka* or ceylon* or saint kitts or st kitts or kittian* or nevisian* or saint lucia* or st lucia* or saint vincent* or st vincent* or vinentian* or grenadine* or sudan* or surinam* or syria* or tajik* or tadjik* or tadjhik* or tanzania* or tanganyika* or thai* or timor leste* or east timor* or timorese* or togo or togoles* or "togo's" or tonga* or trinidad* or tobago* or tunisia* or turkiy* or turkey* or turk or turks or turkish or turkmen* or uganda* or ukraine* or uruguay* or uzbek* or vanuatu* or new hebrides* or venezuela* or vietnam* or viet nam* or yemen* or yugoslav* or zambia* or zimbabwe* or rhodesia* or arab* countr* or middle east* or global south or sahara* or subsahara* or magreb* or maghrib* or west indies* or caribbean* or central america* or latin america* or south america* or asia central or central asia* or asia northern or north asia* or northern asia* or asia southeastern or southeastern asia* or south eastern asia* or southeast asia* or south east asia* or asia western or west asia* or western asia* or europe eastern or east europe* or eastern europe* or developing countr* or developing nation* or developing population* or developing world or less developed countr* or less developed nation* or less developed world or lesser developed	
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2	exp Heart Diseases/	1327076
3	exp Myocardial Revascularization/	99360
4	((heart or cardiac or coronary) adj3 (disease* or disorder* or patient*)).ab,kf,ti.	559135
5	acute coronary syndrome.ab,kf,ti.	33884
6	((heart or cardiac) adj3 (arrest* or infarct* or failure)).ab,kf,ti.	322192
7	(myocardi* adj3 (infarct* or ischemi* or ischaemi* or revascularization or revascularisation)).ab,kf,ti.	288885
8	(coronary adj3 (bypass or angioplast* or percutaneous or acute)).ab,kf,ti.	154705
9	(angina* or ischaemi* or ischemi* or carditis* or atherosclero*).ab,kf,ti.	702218
10	(implant* adj3 (ventricular or VAD?)).ab,kf,ti.	5359
11	(ventricular adj3 (revascularization or revascularisation)).ab,kf,ti.	337
12	(rehab* adj3 (cardiac or cardiovascular)).ab,kf,ti.	10900
13	2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12	2101765

14	Cardiac Rehabilitation/	4369
15	exp Exercise/	269110
16	exp Exercise Movement Techniques/	11422
17	exp Exercise Therapy/	69962
18	(exercis* or kinesiotherap* or kinesitherap*).ab,kf,ti.	404814
19	(training adj4 (resistanc* or weight* or strength* or interval* or intermittent* or cardio* or aerobic)).tw,kw.	42968
20	(rehab* adj3 (cardiac or cardiovascular)).ab,kf,ti.	10900
21	14 or 15 or 16 or 17 or 18 or 19 or 20	582299
22	13 and 21	81508
23	1 and 22	4538
24	exp clinical trial/	1018518
25	random*.mp.	1867478
26	(trial* adj5 (random* or control*)).mp.	1193644
27	(clinical trial, all or clinical trial or controlled clinical trial or pragmatic clinical trial or randomized controlled trial or randomised controlled trial or "research support, non us gov't").pt.	9314021
28	24 or 25 or 26 or 27	10246208
29	23 and 28	1699
30	limit 29 to yr="2020 - 2025"	602

The LMIC search #1 is a Cochrane filter.

eTable 2: All study country, participant, intervention, comparator characteristics and follow-up details

Author, year	Country	Population details	Intervention	Control	Follow-up
Naser 2008	Iran	100 CHD patients post-first MI, mean age ~54 years	Intensive multifactorial lifestyle modification (IMLM): exercise, counseling, telephone follow-ups	Usual care	24 months
Salveti 2008	Brazil	39 low-risk coronary disease patients (mean age ~53-54 years; 74-75% male)	Home-based exercise training for 3 months with biweekly telephone monitoring.	Standard care, encouraged to improve physical activity.	3 months
Babu 2010	India	30 patients with ST-Elevation Myocardial Infarction (STEMI).	Protocol-guided, Phase-1 in-patient cardiac rehabilitation.	Historical controls who received physician-guided ambulation only.	At discharge (approx. 5 days)
Babu 2011	India	30 admitted patients with congestive heart failure (NYHA II-IV).	Phase-1 in-patient CR followed by a structured 8-week home-based program.	Physician-directed advice on ambulation and staying active.	8 weeks post-discharge
Mehani 2013	Egypt	40 male patients with dilated cardiomyopathy (DCM), NYHA class II–III, age 50–65 years	Circuit-interval aerobic training (55–80% HR reserve)	Disease information sessions only	7 months

Ajiboye 2015	Nigeria	66 patients with chronic biventricular heart failure (NYHA II-III).	Aerobic and resistance training 3 times/week for 12 weeks.	Usual medical care and encouraged to continue usual activity levels.	3 months
Yadav 2015	India	80 stable CAD patients (mean age 55.78 years; gender not specified)	3-month yoga regimen (postures, pranayama, diet, holistic teaching) + conventional medicine.	Conventional medicine only.	3 months
Hassan 2016	Egypt	60 patients post-PCI; Mean age ~53 years; ~68% male.	Aerobic exercise on bicycle ergometer 3x/week for 6 months + educational program on secondary prevention.	Single instruction session on risk factors post-PCI.	12 months
Zhang 2017	China	126 CHD patients post-MI/PCI/CABG (mean age 63.1 years; 29.5% female)	CHSC-based CR: home visits, individualized exercise plan, counseling, phone calls, group activities.	Usual care for chronic disease management by community physicians.	6 months
Jafari 2018	Iran	104 patients with CHF (Class II/III); Mean age ~65 years; 55.8% male.	Three 30-minute evidence-based education sessions during hospitalization + booklet + 3 follow-up phone calls over 2 months.	Routine oral education at discharge.	2 months

Mehani 2018	Egypt	40 male patients with stable angina pectoris, NYHA class I–II, age 40–50 years	Cardiac rehabilitation program (aerobic + resistance circuit training)	No exercise training; maintained ordinary activities	3 months
Soleimani 2018	Iran	101 MI patients, mean age ~51 years	Person-centered nursing (individualized education, partnership, follow-up)	Usual care	2 months
Zolfaghari 2018	Iran	50 patients post-CABG (mean age 62.08 years; 66% male)	16 sessions of classic physiotherapy (chest PT, breathing exercises, mobilization).	Standard post-CABG care + 4 sessions of quiet time.	1 month
Dorje 2019	China	n=312 CHD patients post-PCI; Mean age 60.5 years; 81% male	SMART-CR/SP: Comprehensive CR/SP delivered via WeChat for 2 months (intensive) + 4 months (step-down). Included education modules, remote monitoring (BP, steps), and coach feedback.	Usual care: Standard outpatient cardiology follow-up without formal CR/SP. WeChat used only for visit reminders.	12 months
Chaves 2019	Brazil	115 coronary patients post-MI, PCI, or CABG.	1. Comprehensive CR (exercise + education). 2. Exercise-only CR. Program duration: 6 months.	Wait-list control (usual care, offered CR after 6 months).	12 months
UI-Haq 2019	Pakistan	195 patients post-MI; Mean age 53.6	Hospital-based CR: Phase 1 (1-2 weeks	Usual care (standard	2 months

		±8.3 years; 76.9% male.	inpatient) & Phase 2 (6-7 weeks outpatient structured exercise). Multidisciplinary team.	communication, routine follow-up, medications).	
Khalid 2019	Pakistan	26 MI patients (16M, 10F), mean age ~56.5 years	Resistance interval training + aerobic interval training (AIT)	Aerobic interval training (AIT) only	1.5 months
Prabhakaran 2020	India	3,959 AMI patients (mean age 53.4±10.9; 86% male)	Yoga-CaRe: 13 sessions of yoga-based CR over 12 weeks	Enhanced standard care (educational advice)	Median 22 months
Song 2020	China	n=96 stable CHD patients; Mean age ~54 years; 83-90% male	Smartphone-based telemonitored exercise rehabilitation for 6 months. Used a dedicated app and heart rate belt for monitoring, with weekly feedback from staff.	Routine discharge education and outpatient follow-up, which included advice to exercise regularly.	6 months
Hasanpour 2020	Iran	52 patients with CHF Class II & III; Age 60 ±5 years.	Supervised aerobic exercise 3x/week for 24 weeks (5-10 min warm-up, 20-30 min walking, 5 min cool-down).	Educational support only; no exercise protocol.	6 months
Jena 2020	India	40 patients with HF (Class I/II); 45% >60 years; 62.5% male.	30 minutes of daily aerobic exercises (stretching, walking, bicycling) for 30 days.	Conventional treatment only (conservative)	1 month

				managem nt).	
Mendes 2020	Brazil	30 patients with Chagas heart disease (HD), LVEF <45% or HF symptoms (NYHA I-II).	Supervised exercise training (aerobic + strength) 3 times/week for 6 months.	Usual care (monthly pharmaceutical and nutritional counseling).	6 months
Uddin 2020	Bangladesh	142 patients post-CABG (mean age 54-55 years; 89-93% male)	Home-based CR: in-hospital class, educational booklet, monthly telephone calls for 12 months.	Usual care (drug treatment and routine follow-up visits).	12 months
Ma 2021	China	140 ULMCAD patients post-CABG (mean age ~65 years; ~80% male)	WERP: WeChat-based education, rehab guidance, exercise supervision, psychological care	Monthly telephone-based rehab guidance	12 months
Hisam 2022	Pakistan	160 post-ACS patients (mean age 52.66±8.46; 78.75% male)	MCard: mHealth augmented CR (counseling, self-monitoring devices, SMS) + standard care	Standard post-ACS care	3 and 6 months
Simões 2022	Brazil	n=30 patients with Chronic Chagas Cardiomyopathy (CCC); Median age 61 years; 67% male	Supervised exercise-based CR: 3 weekly sessions for 6 months, including aerobic, strength, and stretching exercises.	Usual care: Monthly nutrition and pharmaceutical counselling, without formal exercise prescription.	6 months

Heidari 2023	Iran	70 ICD patients (age 35–75; 58.6% male in intervention)	HBCR: 4 training sessions, home visits, telephone/SMS follow-up	Conventional hospital care	3 months
Kayhan 2024	Turkey	n=70 CAD patients; Mean age ~50-62; Predominantly male (94-97%)	Web-based education + telephone counseling for 12 weeks. Education via a custom website ("Cardiac Rehabilitation Support Program") on diet, exercise, risk factors, etc.	Standard care: Education from physicians and nurses before discharge (medicines, nutrition, exercise, follow-up).	3 months
Zhang 2024	China	70 post-PCI patient-spouse dyads (mean age ~59; 81.8% male patients)	Couple-Based Exercise Program: dyadic education, exercise planning, monitoring	Standard cardiac rehab exercise advice	3 months

eTable 3. Summary of reported details of CR delivery across included studies

Author, year	Staffing	Funding	Setting (centre/home/hybrid)
Naser et al., 2008	Not reported	Tabriz University of Medical Sciences; National Public Health Management Center (NPMC)	Hybrid (Hospital centre + telephone follow-up)
Salveti et al., 2008	Doctor, physiotherapist	Not reported	Home-based
Babu et al., 2010	Physical therapist, physician	Not reported	Centre (rural hospital)
Babu et al., 2011	Physical therapist, physician	Not reported	Hybrid (hospital + home-based)
Mehani et al., 2013	Not reported	Not reported	Centre (National Heart Institute)
Ajiboye et al., 2015	Physiotherapist, research assistant	Not reported	Centre (hospital)
Yadav et al., 2015	Yoga instructor, dietician, researchers	Government (CCRYN, Ministry of Health)	Centre-based (Yoga Lab)
Hassan et al., 2016	Not reported	Not reported	Centre (hospital)
Zhang et al., 2017	Community physicians, nurses, multidisciplinary team (dietitian, psychologist, physiotherapist, cardiologist)	Not reported	Community health service centre-based
Jafari et al., 2018	Not reported	Public/Government	Centre (hospital)
Mehani et al., 2018	Not reported	Not reported	Centre (National Heart Institute)
Soleimani et al., 2018	Nurses (Bachelor's degree)	Not reported	Hybrid (Hospital centre + telephone follow-up + clinic visits)
Zolfaghari et al., 2018	Qualified physiotherapists	University (Shahid Sadoughi University of Medical Sciences)	Centre-based (hospital)

Dorje et al., 2019	Cardiac rehabilitation coach, research coordinators, cardiology staff	Curtin University	Home (via WeChat)
Chaves et al., 2019	Physician, physiotherapists, health educator, research staff	Public/Government	Centre (hospital)
Ul-Haq et al., 2019	Not reported	Not reported	Centre (hospital)
Khalid et al., 2019	Not reported	None reported	Centre (Railway General Hospital)
Prabhakaran et al., 2020	Yoga teachers, research staff, independent committee	Public/Government	Centre (hospital)
Song et al., 2020	Medical staff, researchers	National Natural Science Foundation of China; Beijing Municipal Science and Technology Commission	Home (telemonitored)
Hasanpour et al., 2020	Not reported	Public/Government	Centre (hospital)
Jena et al., 2020	Not reported	Not reported	Centre (hospital)
Mendes et al., 2020	Cardiologist, research staff	Public/Government	Centre (hospital)
Uddin et al., 2020	Qualified physiotherapists, cardiologists, cardiac surgeons, specialist nurse	Not reported	Home-based
Ma et al., 2021	Nurses, surgeons	Not reported	Hybrid (hospital + home)
Hisam et al., 2022	Research associate, medically supervised team	Not reported	Hybrid (hospital + home)
Simões et al., 2022	Physicians, physical therapists, nurses, nutritionists, pharmacists	Not reported	Centre (hospital-based)
Heidari et al., 2023	Nurse, researcher's assistant	Public/Government	Home

Kayhan et al., 2024	Nurse researcher, physicians, nurses, specialists (cardiology, CV surgery)	Not reported	Hybrid (website + telephone)
Zhang et al., 2024	Nurse-led multidisciplinary team (nurses, physicians, rehabilitation therapist)	Institutional grant	Hybrid (hospital + home)

eTable 4. Safety outcomes for CR vs control

Author, year	Non-fatal MI	Non-fatal stroke	Repeat revascularisation	Exercise related events
Naser 2008	Not Reported	Not Reported	Not Reported	Not Reported
Salveti 2008	Not Reported	Not Reported	Not Reported	Not Reported
Babu 2010	Not Reported	Not Reported	Not Reported	Not Reported
Babu 2011	Not Reported	Not Reported	Not Reported	Not Reported
Mehani 2013	Not Reported	Not Reported	Not Reported	Not Reported
Ajiboye 2015	Not Reported	Not Reported	Not Reported	Not Reported
Yadav 2015	Not Reported	Not Reported	Not Reported	Not Reported
Hassan 2016	Not Reported	Not Reported	Not Reported	Not Reported
Zhang 2017	Not Reported	Not Reported	Not Reported	Not Reported
Jafari 2018	Not Reported	Not Reported	Not Reported	Not Reported
Mehani 2018	Not Reported	Not Reported	Not Reported	Not Reported
Soleimani 2018	Not Reported	Not Reported	Not Reported	Not Reported
Zolfaghari 2018	Not Reported	Not Reported	Not Reported	Not Reported
Dorje 2019	Not Reported	Not Reported	Not Reported	Not Reported
Chaves 2019	CR: 1/76 Control: 4/39	Not Reported	CR: 0/76 Control: 3/39	No severe adverse events reported during CR.
UI-Haq 2019	Not Reported	Not Reported	Not Reported	Not Reported
Khalid 2019	Not Reported	Not Reported	Not Reported	Not Reported
Prabhakaran 2020	CR: 13/1,953 Control: 15/1,968	CR: 4/1,953 Control: 3/1,968	Not Reported	Not reported
Song 2020	Not Reported	Not Reported	Not Reported	Not Reported
Hasanpour 2020	Not Reported	Not Reported	Not Reported	Not Reported
Jena 2020	Not Reported	Not Reported	Not Reported	Not Reported
Mendes 2020	Not Reported	Not Reported	Not Reported	CR 1/15 (Atrial fibrillation during a session) Control 0/15
Uddin 2020				
Ma 2021	CR 6/70 Control 5/70	CR 3/70 Control 3/70	CR 2/70 Control 3/70	Not Reported
Hisam 2022	Not Reported	Not Reported	Not Reported	Not Reported

Simões 2022	Not Reported	Not Reported	Not Reported	Not Reported
Heidari 2023	Not Reported	Not Reported	Not Reported	Not Reported
Kayhan 2024	Not Reported	Not Reported	Not Reported	Not Reported
Zhang 2024	Not Reported	Not Reported	Not Reported	Not Reported
Totals	CR: 20 Control: 24	CR: 7 Control: 6	CR: 2 Control: 6	CR: 1 Control: 0

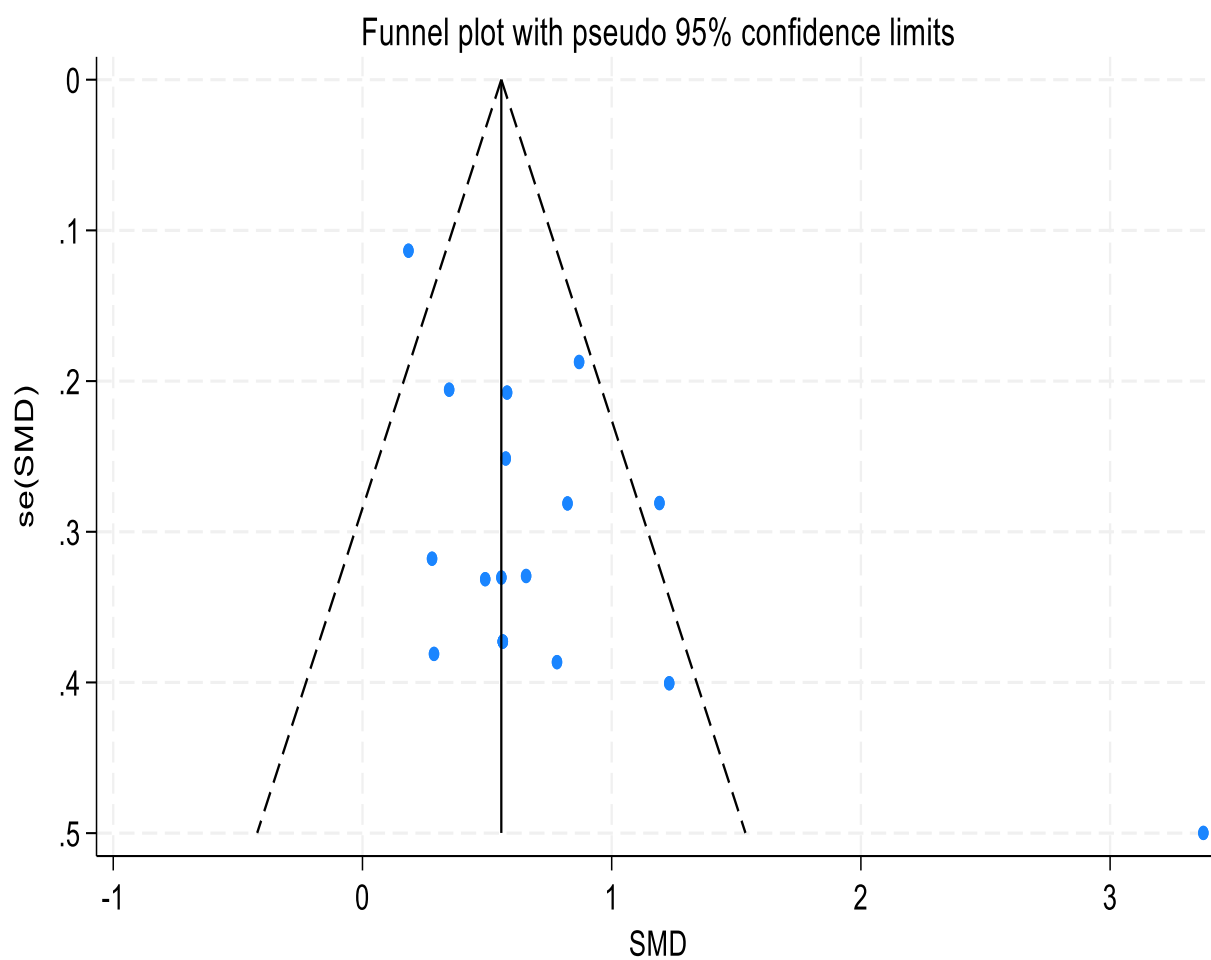
eTable 5: Cost and cost effectiveness data

Author/year	Simões et al. 2022 (Valeria)
Follow-up (months)	6
Year of costs (currency)	\$PPP
Cost of rehabilitation	
Mean cost/patient	Total healthcare costs (for 6 months) Intervention = 11628.6 (\$PPP)
Costs considered	Exams, healthcare visits, medication, hospitalisation
Total healthcare costs	
Rehabilitation mean cost/patient	\$11,628.6 SPPP
Usual care mean cost/patient	\$3,031.3 SPPP
Absolute difference in mean cost/patient*	+\$8,597.3 SPPP
P value for cost difference	p < 0.001
Additional healthcare costs considered	Exams, medication, hospitalisation
Cost-effectiveness	
Rehabilitation mean health care benefits	+1.8 ml kg ⁻¹ min ⁻¹
Usual care mean health care benefit	-2.8 ml kg ⁻¹ min ⁻¹
Incremental mean health care benefit	+4.6 ml kg ⁻¹ min ⁻¹
Incremental cost effectiveness ratio/patient	1874.3 \$PPP per 1.0 ml kg ⁻¹ min ⁻¹ increase

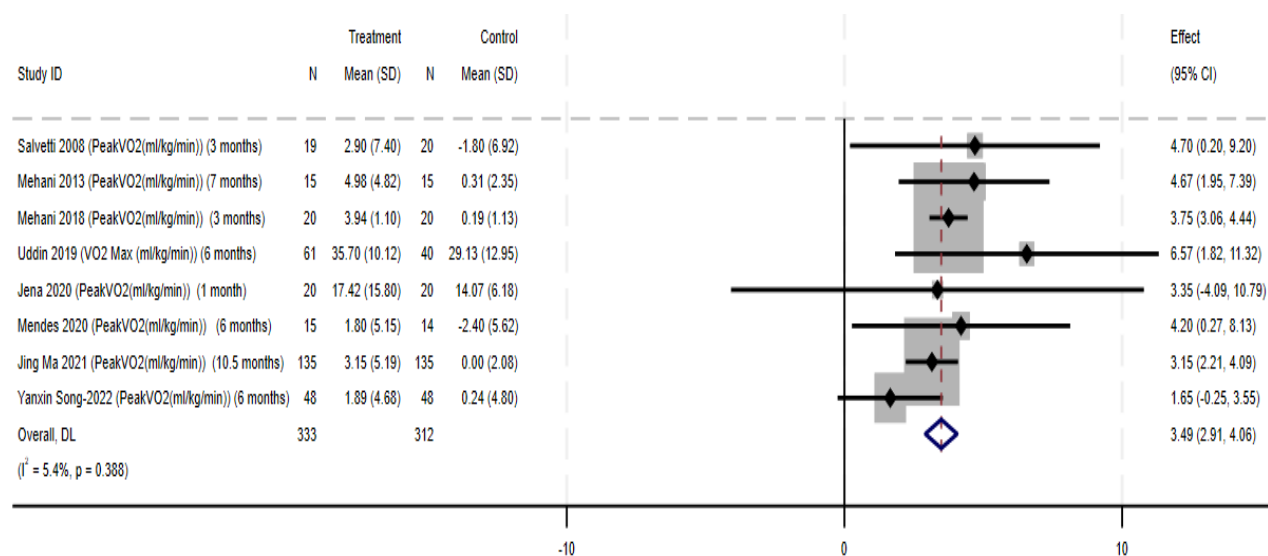
eTable 6: Meta-regression analysis for all exercise outcomes

Study level variable	Coefficient (95% CI)	p-value	Residual I²
Year of publication	-0.15 (-0.09 to 0.6)	0.677	72%
Type of CR (comprehensive vs exercise only)	0.001 (-0.33 to 0.34)	0.995	73%
Centre (single vs multicentre)	-0.17 (-1.14 to 1.09)	0.782	72%
LMIC category (lower-middle vs. and upper-middle income)	-0.07 (-0.19 to 0.05)	0.242	69%
Exercise dose (programme duration [weeks] × frequency [sessions per week] × length of session [in minutes])	0.005 (-0.002 to 0.006)	0.638	69%
Follow up	-0.01 (-0.12 to 0.09)	0.782	73%
Risk of bias (low risk for both random sequence generation and allocation concealment vs. not)	0.04 (-0.29 to 0.37)	0.789	72%
Mode of delivery (centre vs. home vs. hybrid)	-0.33 (-0.70 to 0.05)	0.083	65%
Exercise modality (aerobic only vs aerobic + resistance)	0.22 (-0.12 to 0.56)	0.191	70%

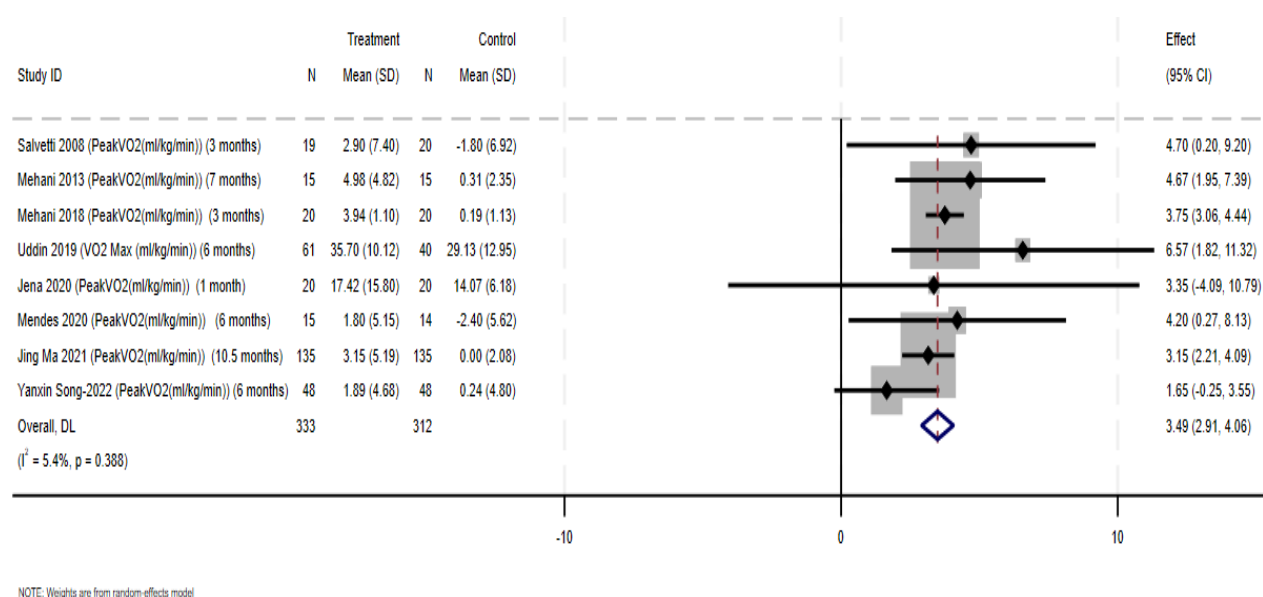
eFigure 1: Funnel Plot for exercise capacity all measures (SMD)



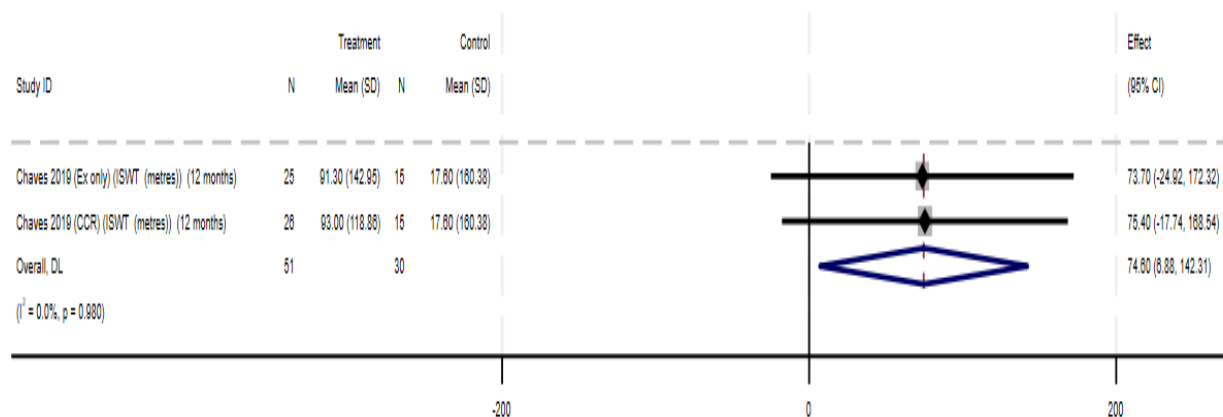
eFigure 2: Forest plot PeakVO2



eFigure 3: Forest plot 6MWT

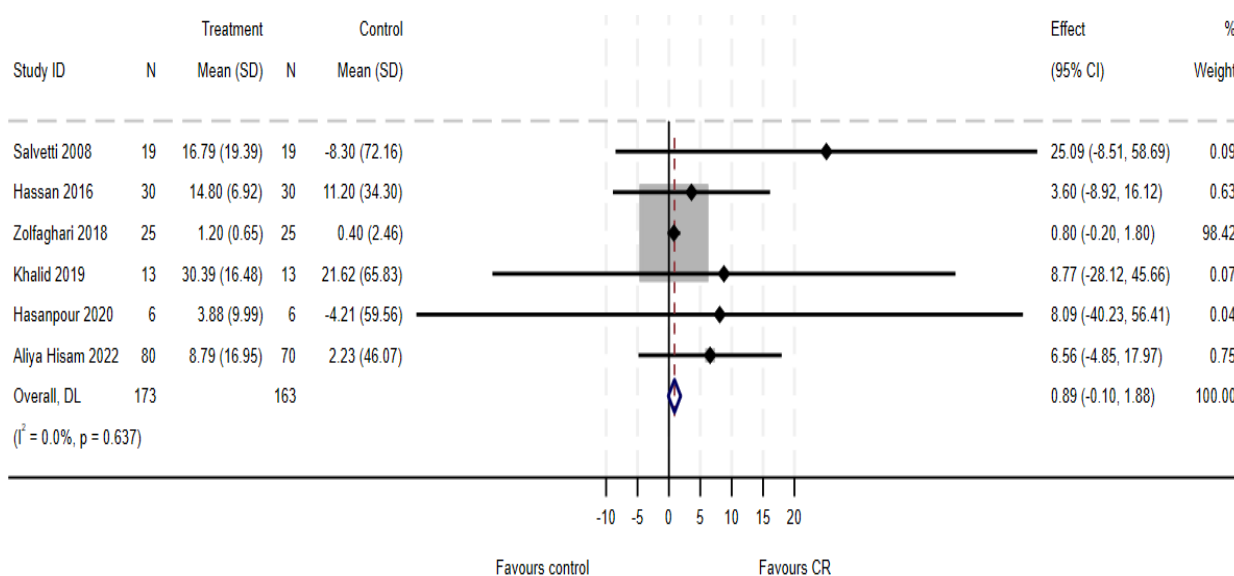


eFigure 4: Forest plot ISWT



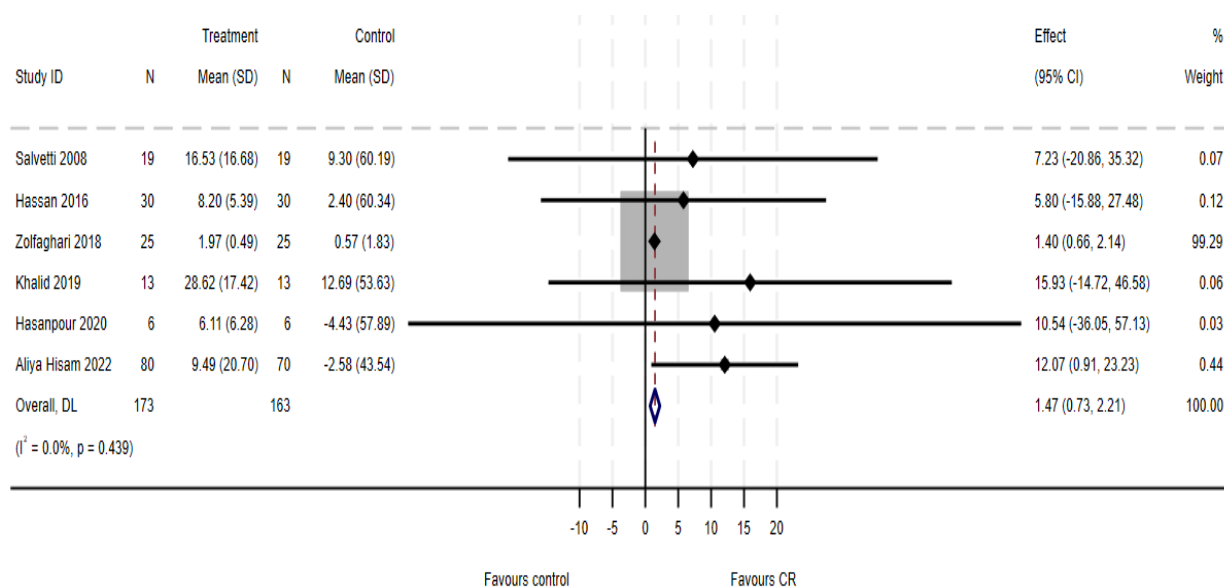
NOTE: Weights are from random-effects model

eFigure 5a: General health



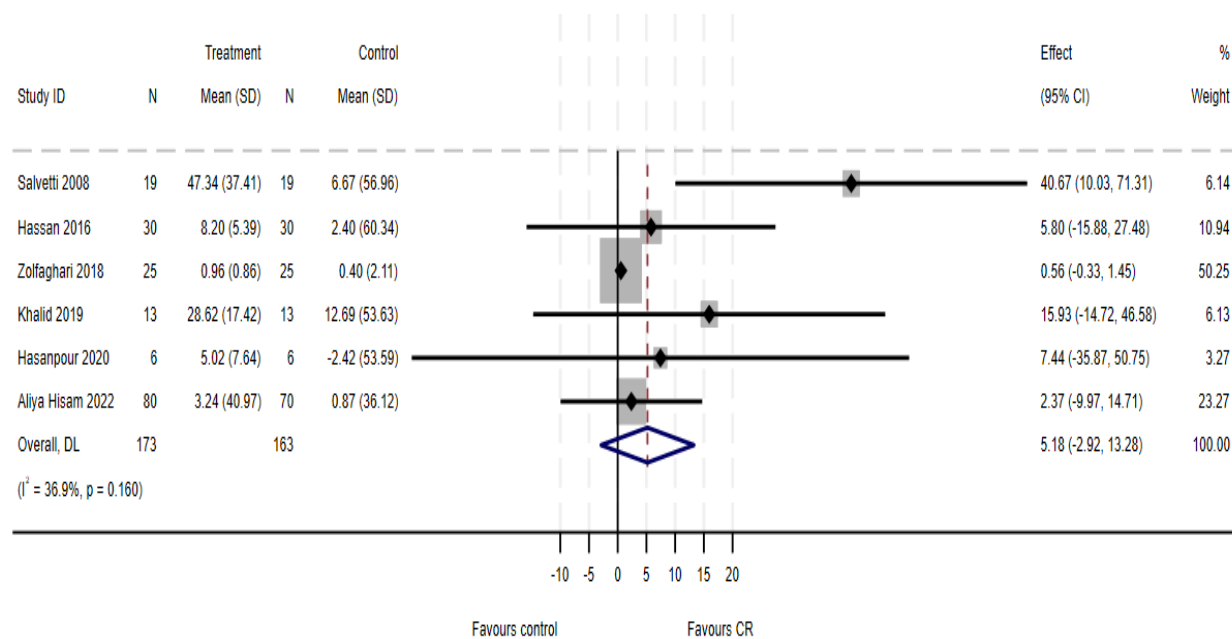
NOTE: Weights are from random-effects model

eFigure 5b: Mental health



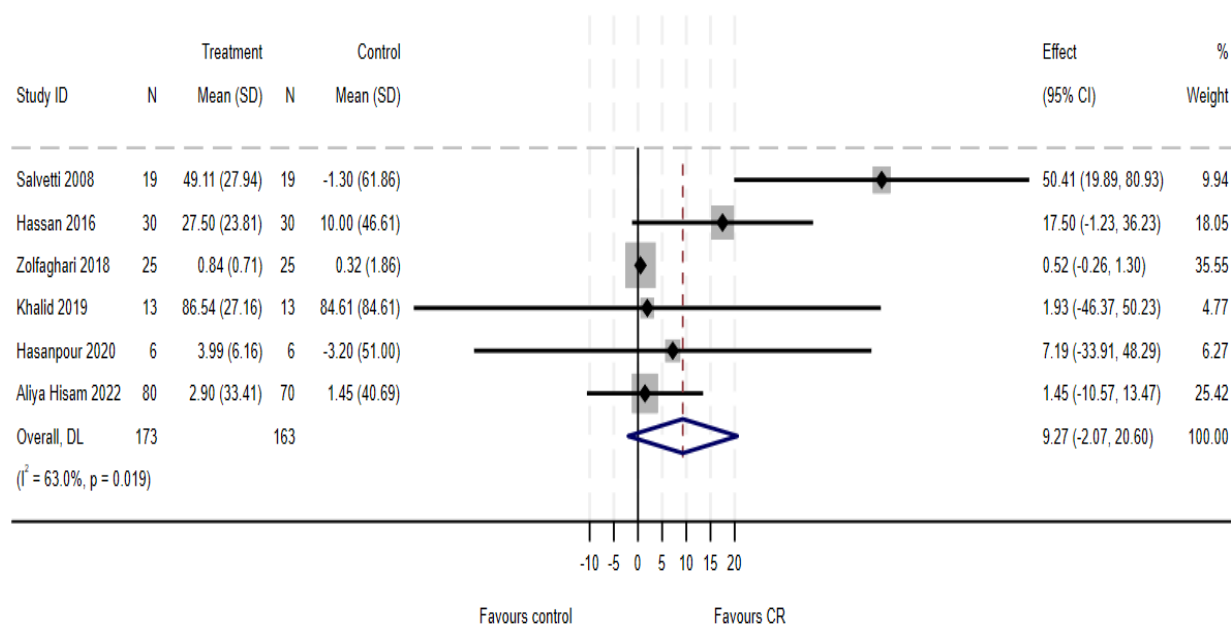
NOTE: Weights are from random-effects model

eFigure 5c: Role-emotional



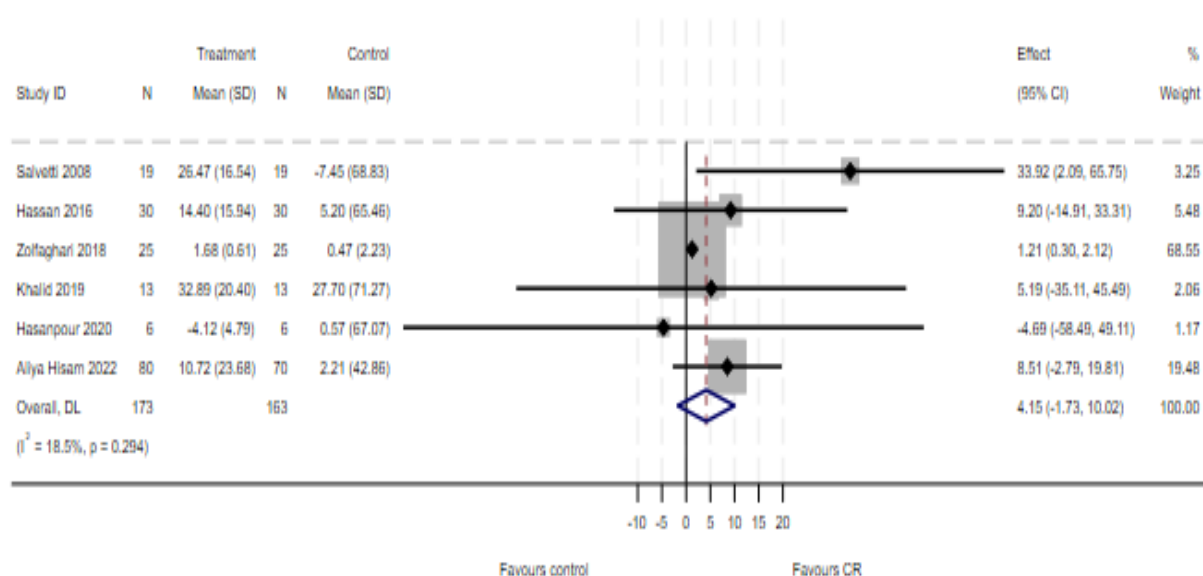
NOTE: Weights are from random-effects model

eFigure 5d: Role-physical



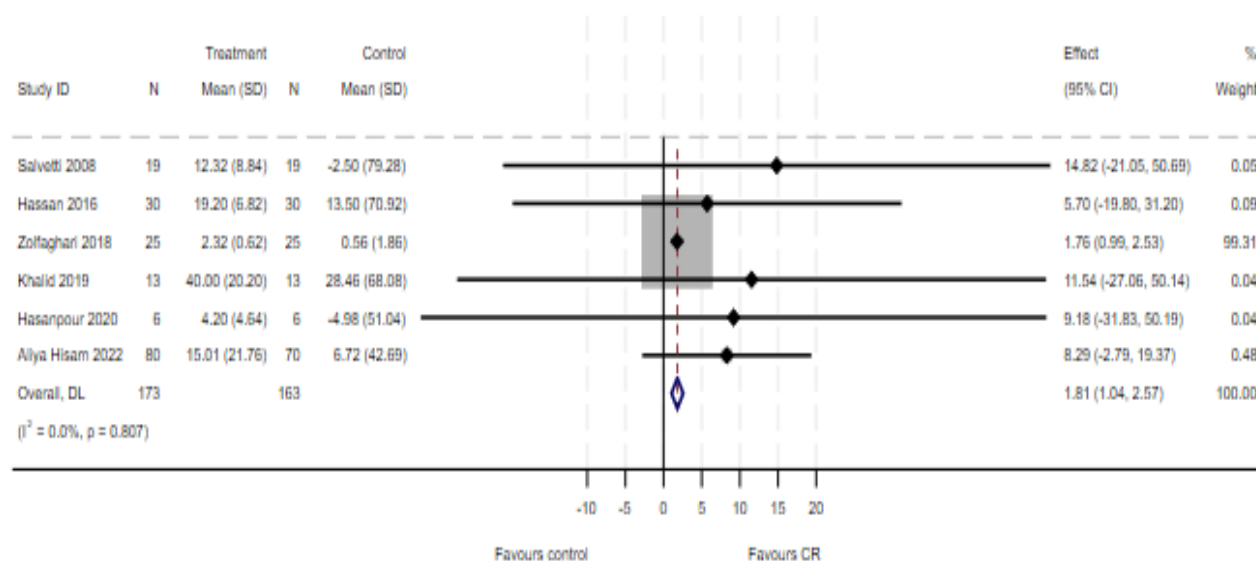
NOTE: Weights are from random-effects model

eFigure 5e : Bodily pain



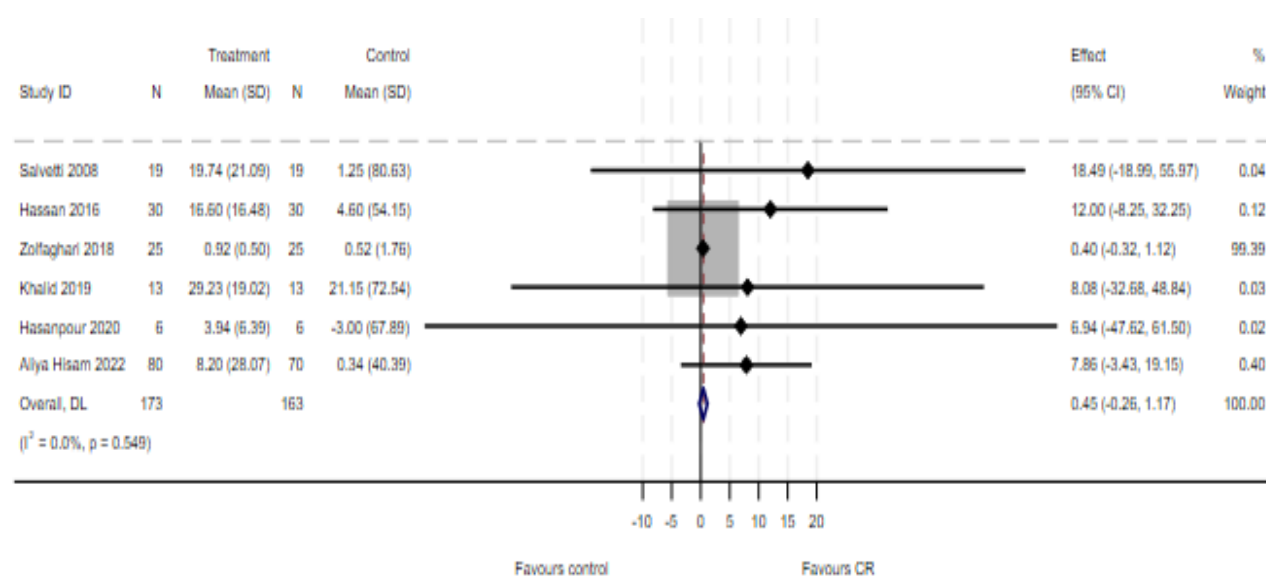
NOTE: Weights are from random-effects model

eFigure 5f: Physical functioning



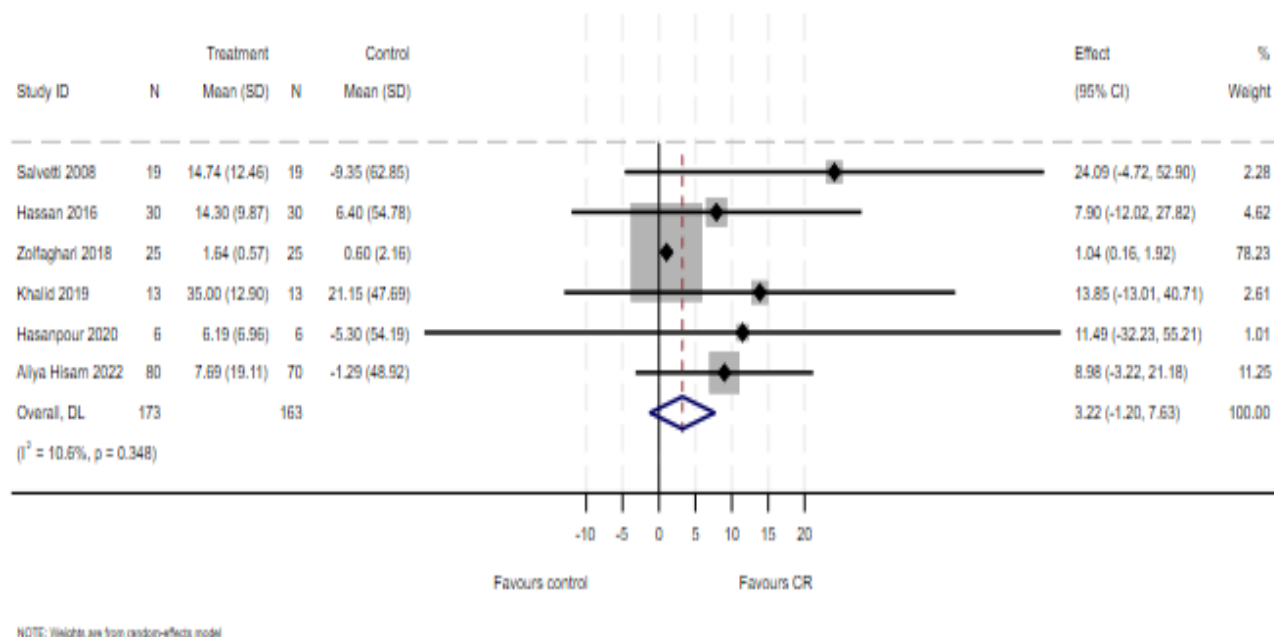
NOTE: Weights are from random-effects model

eFigure 5g: Social functioning

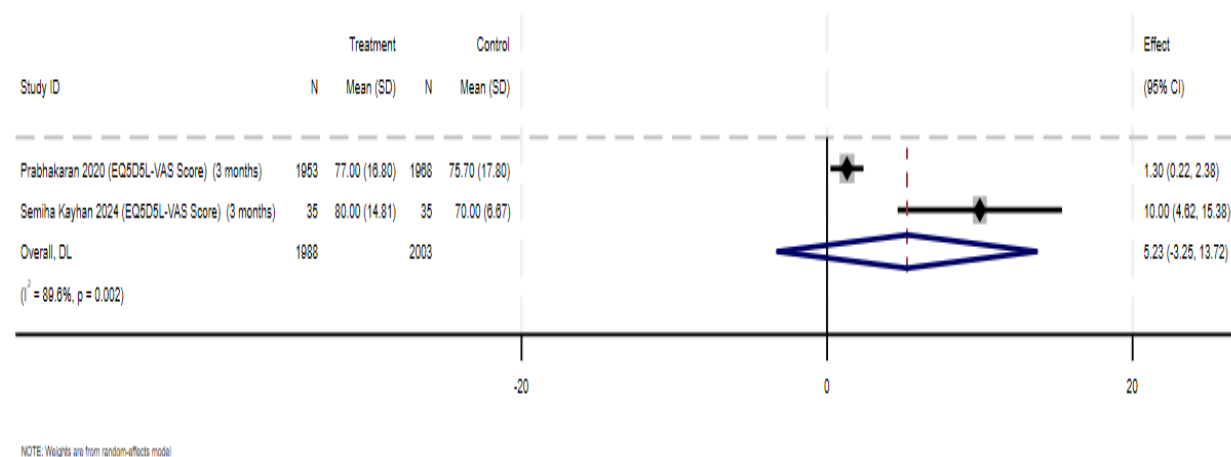


NOTE: Weights are from random-effects model

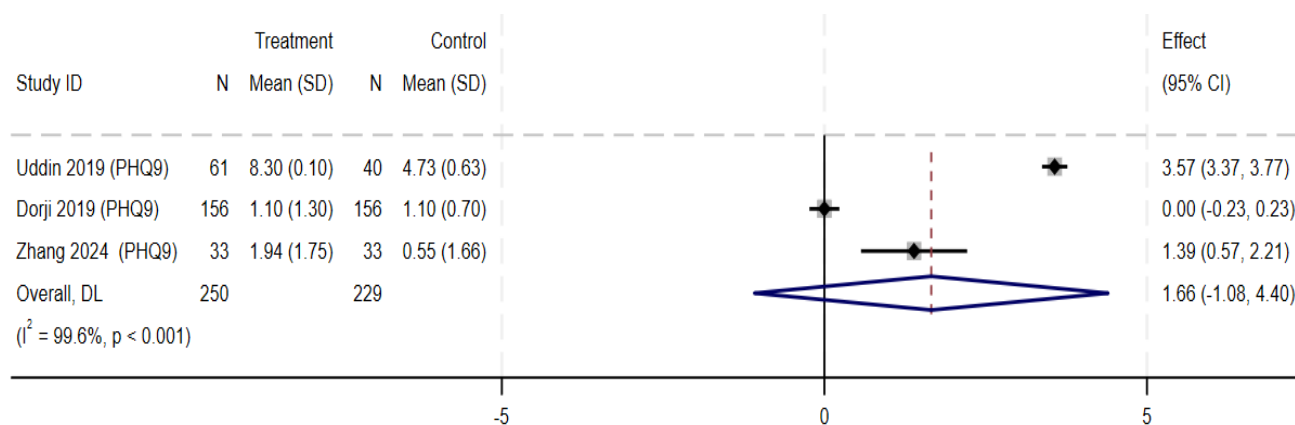
eFigure 5h: Vitality



eFigure 6: Forest plot (EQ5D5L_VAS)

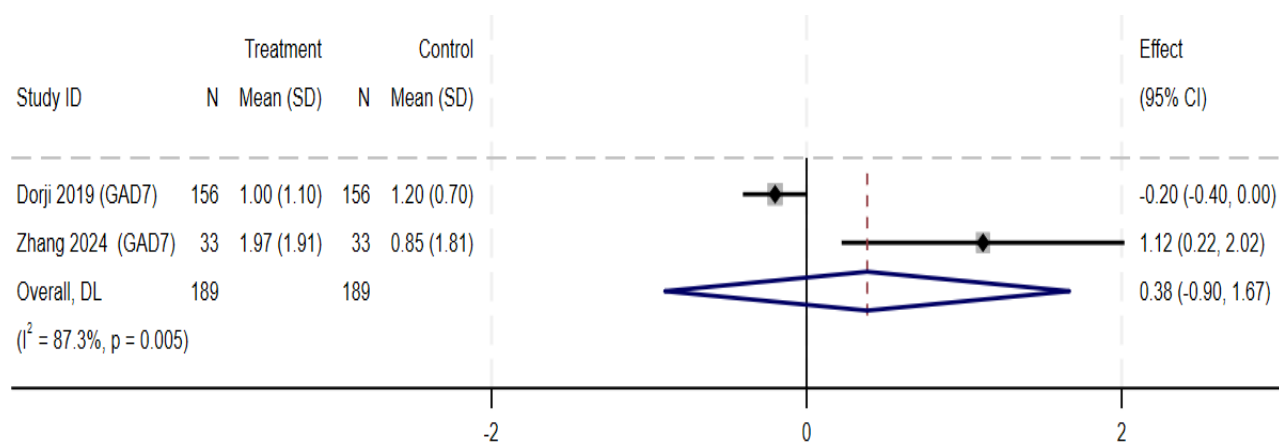


e-Figure 7a: Forest plot (PHQ 9)



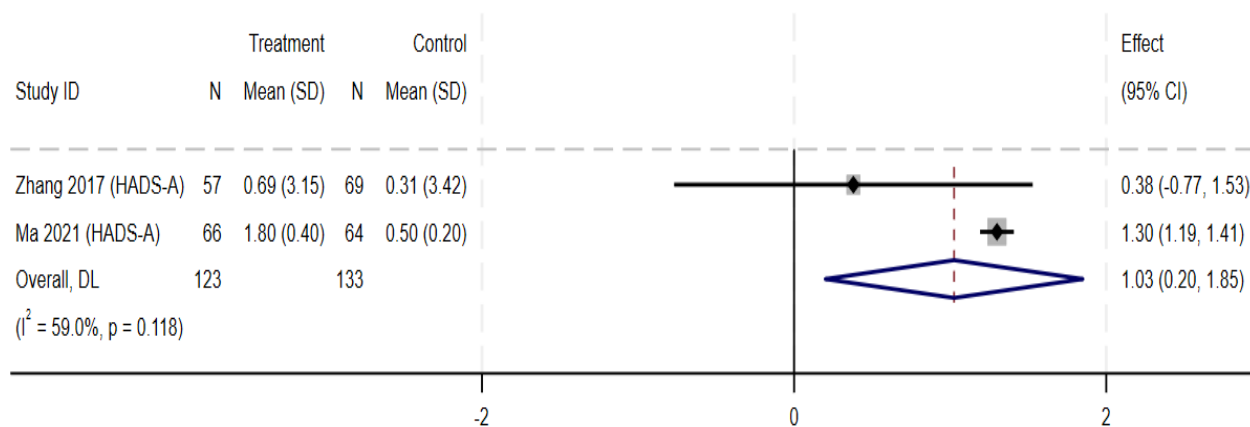
NOTE: Weights are from random-effects model

e-Figure 7b: Forest plot GAD7



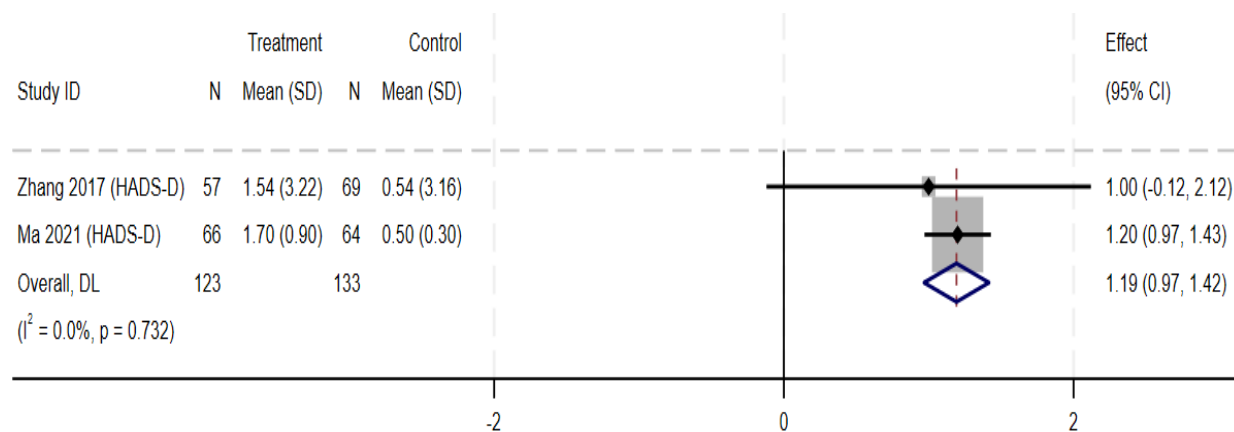
NOTE: Weights are from random-effects model

e-Figure 7c: Forest plot HADS-A



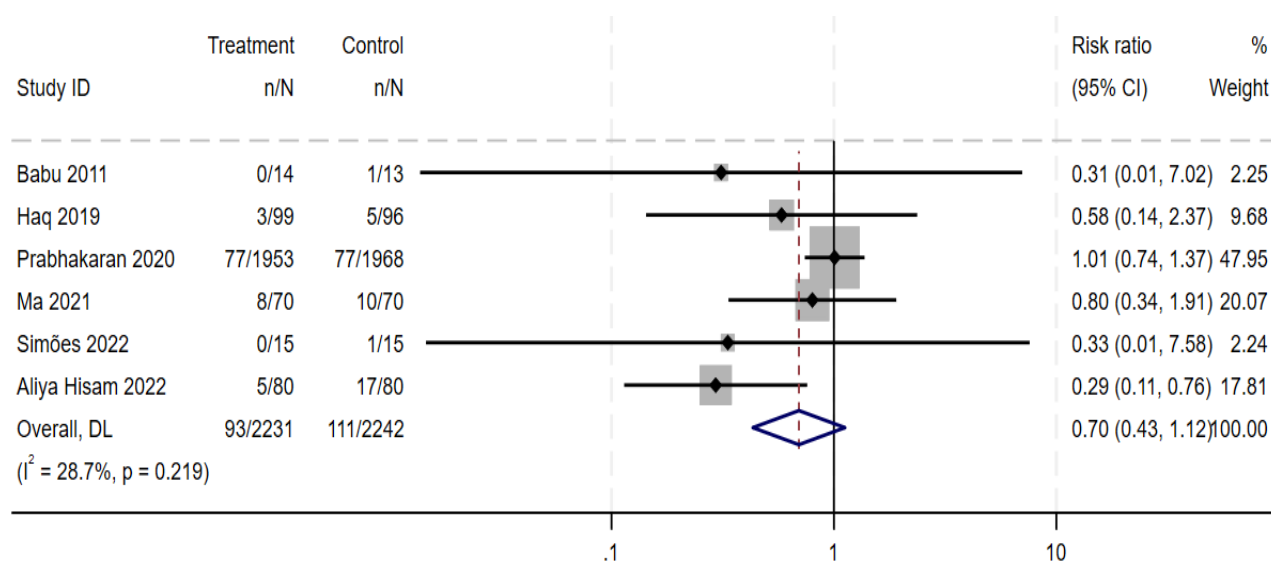
NOTE: Weights are from random-effects model

e-Figure 7d: Forest plot HADS-D



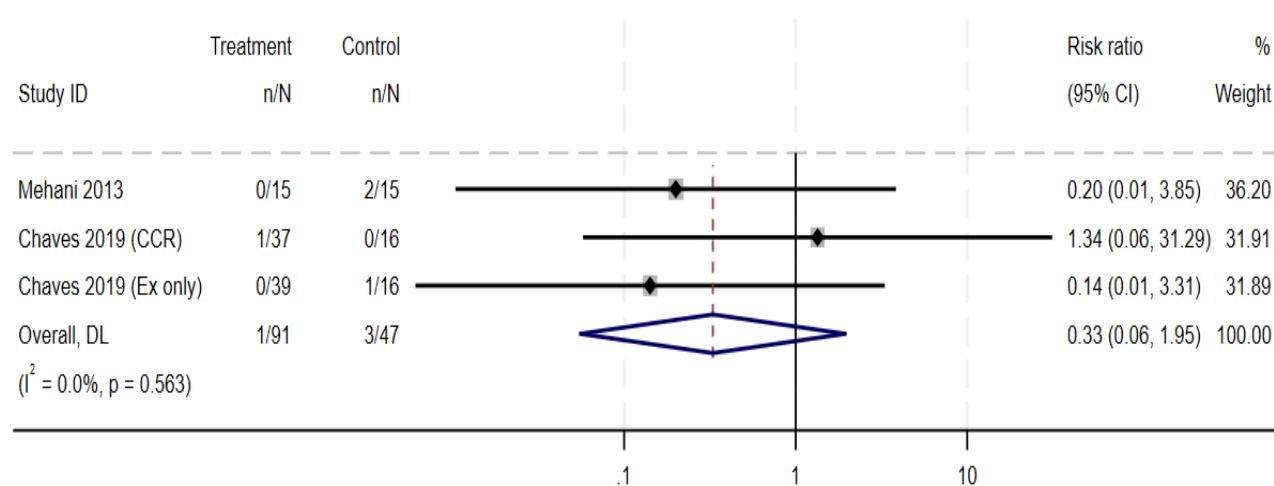
NOTE: Weights are from random-effects model

e-Figure 8a: Forest plot all cause mortality



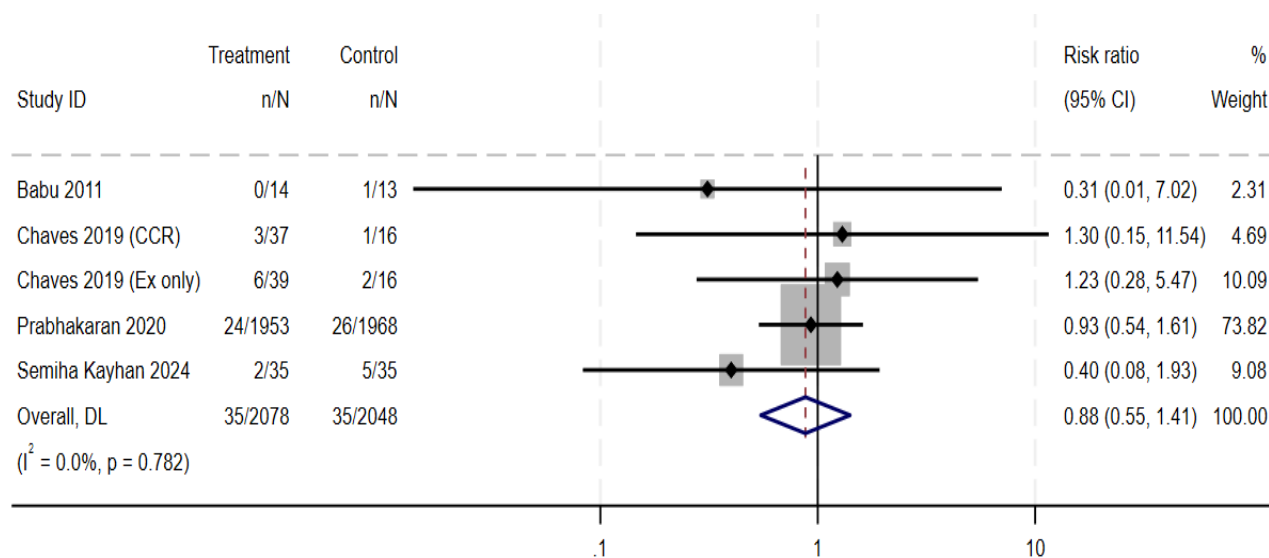
NOTE: Weights are from random-effects model; continuity correction applied to studies with zero cells

e-Figure 8b: Forest plot CVD mortality



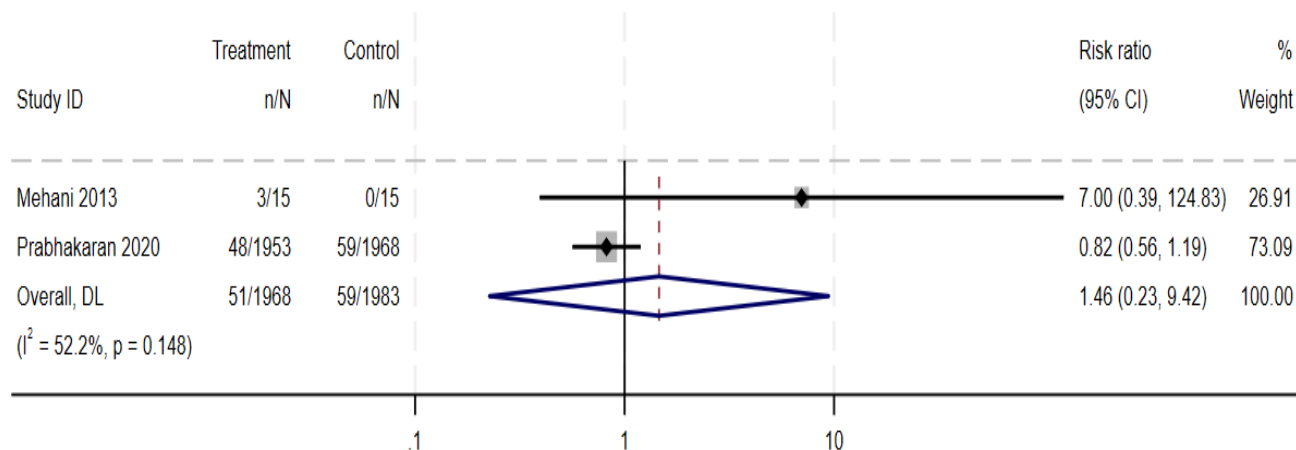
NOTE: Weights are from random-effects model; continuity correction applied to studies with zero cells

e-Figure 8c: Forest plot all cause hospitalisation



NOTE: Weights are from random-effects model; continuity correction applied to studies with zero cells

e-Figure 8d: Forest plot CVD Hospitalisation



NOTE: Weights are from random-effects model; continuity correction applied to studies with zero cells