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Review Article

Clinical Outcomes of cardiac rehabilitation programs in Patients with coronary artery disease

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Abstract

Cardiac rehabilitation is a structured, multidisciplinary secondary-prevention program combining supervised exercise training, risk-factor modification, psychosocial support, and patient education for patients with coronary artery disease. Despite strong guideline endorsement, referral, enrollment, and completion rates remain far below targets across most healthcare systems, leaving much of the intervention's demonstrated benefit unrealized at the population level.

This review synthesizes clinical outcomes evidence for cardiac rehabilitation in coronary artery disease, covering mortality reduction, functional capacity and quality-of-life outcomes, program delivery models, access barriers, and cost-effectiveness. Randomized meta-analyses and large cohorts consistently show reduced cardiovascular mortality and readmission, dose-dependent benefit with greater session attendance, and durable improvements in exercise capacity, angina burden, and quality of life alongside contemporary revascularization and medical therapy.

Home-based and hybrid delivery models now offer outcomes comparable to center-based programs for appropriately selected patients, and cost-effectiveness analyses place cardiac rehabilitation favorably against other established secondary-prevention therapies. The principal unresolved problem is implementation rather than efficacy: persistent underuse, geographic and demographic disparities in access, and markedly uneven global program availability. Automatic referral pathways, expanded home-based options, and sustained policy investment represent the most direct route to translating this evidence base into population-level reductions in coronary artery disease morbidity and mortality.

Keywords: Cardiac rehabilitation; Coronary artery disease; Secondary prevention; Exercise training; Cardiovascular outcomes

1. Introduction

Coronary artery disease remains the leading cause of death and disability worldwide, and the years following an acute coronary event or a revascularization procedure carry a disproportionate share of the recurrent events, rehospitalizations, and deaths that define the long-term burden of the disease. Cardiac rehabilitation, a structured, multidisciplinary program combining supervised exercise training, risk-factor modification, psychosocial support, and patient education, was developed specifically to interrupt this trajectory, and it has accumulated one of the deepest evidence bases of any secondary-prevention intervention in cardiovascular medicine [1,2]. Early randomized trials in the 1980s already suggested a mortality benefit from post-infarction exercise rehabilitation, and pooled analyses of those trials consistently favored rehabilitation over usual care despite the individual trials being underpowered on their own [3,4].

The evidence base has matured considerably since those early meta-analyses. Contemporary Cochrane reviews, drawing on dozens of randomized controlled trials conducted in the era of routine revascularization and guideline-directed medical therapy, continue to find that exercise-based cardiac rehabilitation reduces cardiovascular mortality and hospital readmissions, even though its effect on all-cause mortality has narrowed somewhat as background medical therapy has improved [5,6]. Professional society guidelines in Europe and North America now designate cardiac rehabilitation a Class I recommendation for patients following myocardial infarction, percutaneous coronary intervention, and coronary artery bypass grafting, reflecting the consistency of this evidence across trial populations and healthcare systems [7,8,9].

Despite this strong guideline endorsement, cardiac rehabilitation remains substantially underused. Referral rates, enrollment rates, and completion rates all fall well

short of guideline targets in most health systems, and the gap between what the evidence supports and what patients actually receive has itself become an active area of investigation [10,11,12]. This review synthesizes the evidence on clinical outcomes associated with cardiac rehabilitation participation in patients with coronary artery disease, covering mortality and cardiovascular event reduction, functional capacity and quality-of-life outcomes, program components and delivery models, barriers to participation, and the cost-effectiveness case for expanding access.

2. Mortality and cardiovascular event reduction

The mortality benefit of cardiac rehabilitation is the most extensively replicated finding in this literature. The 2016 Cochrane systematic review and meta-analysis by Anderson and colleagues, pooling 63 randomized controlled trials enrolling more than 14,000 patients with coronary heart disease, found that exercise-based cardiac rehabilitation reduced cardiovascular mortality and hospital admissions compared with no-exercise controls, with a more modest and statistically uncertain effect on all-cause mortality once trials that also modified risk factors and medical therapy were considered separately [5]. A subsequent update by Dibben and colleagues confirmed the reduction in cardiovascular mortality and cardiovascular-related hospital admission, reinforcing that the benefit persists in trials conducted alongside contemporary revascularization and pharmacotherapy [6].

Large observational cohorts corroborate the trial-based findings and extend them to real-world populations excluded from randomized trials, including older adults and those with greater comorbidity burden. Goel and colleagues, studying a community cohort of patients undergoing percutaneous coronary intervention, found that cardiac rehabilitation participation was associated with a significant reduction in long-term mortality, with the benefit apparent within the first year and persisting

over extended follow-up [13]. Witt and colleagues reported a similar mortality advantage in a population-based cohort following myocardial infarction, and Martin and colleagues found a graded, dose-dependent relationship in which patients who attended a greater number of rehabilitation sessions experienced progressively lower mortality and major adverse cardiovascular event rates than those who attended fewer sessions or none at all [14,15]. Pack and colleagues extended this dose-response observation to the surgical revascularization population, showing that participation in cardiac rehabilitation after coronary artery bypass grafting was independently associated with improved survival even after adjustment for baseline risk [16].

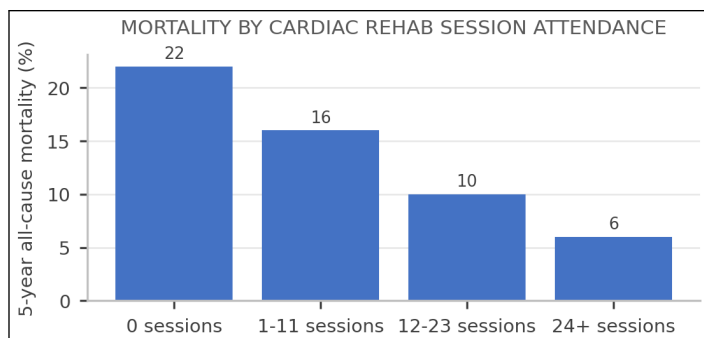


Figure 1: Long-term mortality by cardiac rehabilitation session attendance category in a community cohort following percutaneous coronary intervention, showing a graded, dose-dependent reduction in mortality with increasing number of sessions attended [15,13].

The Cardiac Rehabilitation Outcome Study meta-analysis by Rauch and colleagues specifically addressed whether the mortality benefit persists in the modern era of routine early revascularization and intensive statin therapy, pooling both randomized and non-randomized studies published after 1995, and found that cardiac rehabilitation continued to confer a significant reduction in total mortality even in this contemporary treatment landscape, allaying concerns that the benefit demonstrated in older trials had been superseded by advances in acute-phase care [17]. Lawler and colleagues, focusing specifically on post-myocardial-infarction populations, similarly found consistent reductions in cardiac mortality and recurrent

myocardial infarction across trials spanning several decades [18]. Taken together, this body of evidence supports a durable, dose-related mortality benefit from cardiac rehabilitation that has not been eroded by parallel advances in interventional and pharmacological therapy.

3. Functional capacity, symptom burden, and quality of life

Improvement in exercise capacity is among the most consistently observed outcomes of cardiac rehabilitation, and it carries prognostic significance independent of its role as a marker of program engagement. Keteyian and colleagues demonstrated that peak aerobic capacity measured on cardiopulmonary exercise testing independently predicts long-term prognosis in patients with coronary heart disease, with each incremental improvement in peak oxygen uptake associated with a measurable reduction in subsequent mortality risk, which provides a physiological rationale for why exercise-based rehabilitation improves hard clinical outcomes and not merely subjective wellbeing [19]. Beatty and colleagues showed that a simpler, more clinically accessible functional measure, the six-minute walk test, similarly predicted major adverse cardiovascular events and mortality in stable coronary disease, supporting its use as a practical serial outcome measure within rehabilitation programs that lack access to formal cardiopulmonary exercise testing [20].

Beyond functional capacity, cardiac rehabilitation produces measurable improvements in health-related quality of life and disease-specific symptom burden. Cannistra and colleagues, reviewing the accumulated literature on quality-of-life outcomes, concluded that structured rehabilitation consistently improves both generic and disease-specific quality-of-life measures across diverse coronary artery disease populations, with benefits extending to anxiety and depressive symptom burden, which are themselves independently associated with worse cardiovascular prognosis [21]. Long-term

ambulatory follow-up data reinforce that these functional and symptomatic gains translate into durable reductions in downstream cardiovascular events. Doimo and colleagues, following a cohort of patients enrolled in ambulatory cardiac rehabilitation over an extended observation period, found that program completion was associated with a lower incidence of subsequent cardiovascular events and hospitalizations years after the structured program itself had ended, suggesting that the behavioral and physiological adaptations achieved during rehabilitation persist well beyond the supervised training period [22].

4. Program components and delivery models

Contemporary cardiac rehabilitation is not a single intervention but a bundle of core components, and professional statements have worked to standardize what a program should include. The joint American Heart Association and American Association of Cardiovascular and Pulmonary Rehabilitation statement, updated by Balady and colleagues, defines core components spanning baseline patient assessment, nutritional counseling, weight and lipid management, blood pressure control, smoking cessation, psychosocial management, and physical activity counseling in addition to supervised exercise training, reflecting a shift away from viewing rehabilitation as exercise therapy alone toward a comprehensive secondary-prevention platform [9]. Nutritional counseling, historically the least standardized of these components, has itself become an active area of program development; Pryor and colleagues, surveying current practice, found substantial heterogeneity in how nutrition education is delivered across programs but consistent evidence that structured dietary counseling contributes incrementally to risk-factor improvement when integrated with exercise training [23].

Access barriers, particularly for patients in rural areas, those with mobility limitations, and those balancing rehabilitation attendance with work and caregiving

obligations, have driven the development of home-based and hybrid delivery models as alternatives to traditional center-based programs. The American Heart Association and American College of Cardiology scientific statement authored by Thomas and colleagues reviewed the accumulated trial evidence for home-based cardiac rehabilitation and concluded that, for appropriately selected lower-risk patients, home-based programs achieve outcomes in exercise capacity, risk-factor modification, and quality of life that are comparable to center-based programs, while substantially improving completion rates among patients who would otherwise not participate at all [24]. Global availability of cardiac rehabilitation programs remains markedly uneven, a disparity with direct implications for how broadly the evidence synthesized in this review can be translated into practice. Turk-Adawi and colleagues, surveying program density across more than one hundred countries, found that high-income countries offer dramatically greater per-capita access to cardiac rehabilitation than low- and middle-income countries, where the burden of coronary artery disease is rising fastest, a mismatch that represents one of the largest unaddressed gaps in global secondary-prevention infrastructure [25].

Table 1: Core components of contemporary cardiac rehabilitation programs and their primary clinical targets [9,24,23].			
Component	Primary target	Typical delivery	Evidence source
Supervised exercise training	Aerobic capacity, functional status	Center-based or home-based	[9]
Nutritional counseling	Dietary risk factors, weight	Individual or group sessions	[23]
Lipid and blood pressure management	Atherosclerotic risk factors	Integrated with medical follow-up	[9]
Psychosocial support	Anxiety, depression, adherence	Counseling, group support	[21]
Home-based / hybrid delivery	Access for lower-risk patients	Remote monitoring, telehealth	[24]

5. Barriers to participation and disparities in access

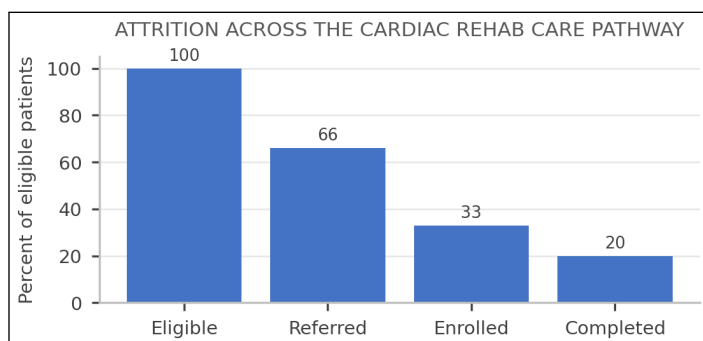


Figure 2: Attrition across the cardiac rehabilitation care pathway in a national Medicare cohort, from eligible patients to referral, enrollment, and completion of a full program course [10,12].

Even where cardiac rehabilitation programs exist and are accessible, referral, enrollment, and completion rates remain persistently low relative to guideline targets, and this attrition at each stage of the care pathway attenuates the population-level benefit that trial-level efficacy data would predict. Suaya and colleagues, analyzing a large Medicare cohort, found that fewer than one in five eligible beneficiaries enrolled in cardiac rehabilitation after myocardial infarction or coronary bypass surgery, with substantial variation by age, sex, geography, and the specifying index event [10]. Beatty and colleagues extended this observation by demonstrating marked geographic variation in participation across both Medicare and Veterans Affairs populations, indicating that local practice patterns and referral culture, rather than patient-level factors alone, materially shape who ultimately receives rehabilitation [11]. Ritchey and colleagues, using more recent national Medicare claims data, confirmed that participation and completion rates have improved only modestly over time despite two decades of guideline reinforcement, with completion of a full course of rehabilitation remaining the exception rather than the rule among enrolled patients [12].

Disparities in participation by demographic and socioeconomic characteristics compound the overall underuse problem. Prince and colleagues found that Black patients were substantially less likely to initiate cardiac rehabilitation than White patients after an eligible cardiac

event, and that this disparity in initiation was independently associated with worse survival, implicating unequal access to a proven therapy as a contributor to broader racial disparities in cardiovascular outcomes [26]. Resurreccion and colleagues, systematically reviewing barriers specific to women, identified transportation difficulties, competing caregiving responsibilities, lack of physician encouragement, and a program environment often perceived as male-oriented as recurring reasons for non-enrollment and early dropout among eligible women [27]. Physician referral strength is among the single strongest determinants of whether an eligible patient ultimately attends rehabilitation, a finding that has motivated interventions targeting the referral process itself, including automatic, opt-out referral procedures embedded in hospital discharge workflows, which substantially outperform passive, physician-discretion referral models in getting eligible patients enrolled.

6. Cost-effectiveness and health-system implications

The economic case for expanding cardiac rehabilitation access has strengthened as the evidence for its clinical benefit has matured, and cost-effectiveness analyses have become an important complement to the efficacy literature when health systems weigh investment in program capacity. Shields and colleagues, systematically reviewing published cost-effectiveness analyses of cardiac rehabilitation across multiple healthcare systems, found that the intervention consistently falls within commonly accepted cost-effectiveness thresholds, with incremental cost-effectiveness ratios generally comparing favorably to other established secondary-prevention interventions such as statin therapy [28]. Hinde and colleagues refined these estimates further by explicitly modeling the downstream cost offsets from prevented secondary cardiovascular events, concluding that earlier analyses had systematically understated the cost-effectiveness of cardiac rehabilitation by failing to capture the full economic value of events avoided years after program

completion [29].

Table 2: Summary of cost-effectiveness findings for cardiac rehabilitation across health-system analyses [28,29,30].		
Analysis	Comparator	Key finding
[28]	Usual care, other secondary prevention	Consistently within accepted cost-effectiveness thresholds
[29]	Standard cost-offset modeling	Earlier analyses understated value by omitting downstream event savings
[30]	Current reimbursement models	Argues for rebranding as core, reimbursable secondary prevention

Sandesara and colleagues, writing an influential commentary on the persistent underuse of cardiac rehabilitation despite this favorable cost-effectiveness profile, argued for a fundamental "rebranding" of the service, from a niche exercise program to a core, reimbursable component of guideline-directed secondary prevention on par with pharmacotherapy, coupled with policy changes to remove structural reimbursement and referral barriers that have persisted despite decades of supportive evidence [30]. Fernandez-Jimenez and colleagues, reviewing multidisciplinary rehabilitation models more broadly, similarly concluded that the greatest remaining opportunity to reduce recurrent cardiovascular events at the population level lies not in generating further efficacy evidence, which is already extensive and consistent, but in closing the implementation gap between what guidelines recommend and what health systems actually deliver [31]. This same tension between strong trial-level efficacy and disappointing real-world uptake was already apparent in early systematic reviews that helped establish the modern evidence base, and this review finds it has narrowed only incrementally in the two decades since.

7. Conclusion

The clinical outcomes literature on cardiac rehabilitation in patients with coronary artery disease is remarkably consistent across four decades of accumulating evidence: structured, multidisciplinary rehabilitation programs

reduce cardiovascular mortality and hospital readmission, improve functional capacity and quality of life, and confer these benefits in a dose-dependent fashion that persists into the era of routine revascularization and intensive guideline-directed medical therapy [5,17,15]. These benefits extend across delivery models, with home-based and hybrid programs now offering a validated alternative to center-based rehabilitation for appropriately selected patients, and the intervention compares favorably on cost-effectiveness grounds with other well-established components of secondary prevention [24,28]. The unresolved problem is not one of efficacy but of implementation: referral, enrollment, and completion rates remain far below guideline targets, disparities in access by race, sex, geography, and socioeconomic status persist, and global program availability remains highly uneven [10,26,25]. Closing this gap through automatic referral pathways, expanded home-based and hybrid delivery options, and sustained policy investment represents the most direct route to translating an already well-established evidence base into measurable population-level reductions in coronary artery disease morbidity and mortality.

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