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Participation in Cardiac Rehabilitation, Readmissions and Death After Acute Myocardial Infarction

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Abstract

Background—Participation in cardiac rehabilitation has been shown to decrease mortality following acute myocardial infarction, but its impact on readmissions requires examination.

Methods—We conducted a population-based surveillance study of residents discharged from the hospital following their first-ever myocardial infarction in Olmsted County, Minnesota from January 1, 1987 to September 30, 2010. Patients were followed up through December 31, 2010. Participation in cardiac rehabilitation following myocardial infarction was determined using billing data. We used a landmark analysis approach (cardiac rehabilitation participant vs. not determined by attendance in at least one session of cardiac rehabilitation at 90 days post-myocardial infarction discharge) to compare readmission and mortality risk between cardiac rehabilitation participants and non-participants accounting for propensity to participate using inverse probability treatment weighting.

Results—Of 2991 patients with incident MI, 1569 (52.5%) participated in cardiac rehabilitation following hospital discharge. The cardiac rehabilitation participation rate did not change during the study period, but increased in the elderly, and decreased in men and younger patients. After adjustment, Cardiac rehabilitation participants had lower all-cause readmission (HR 0.75, 95% CI 0.65-0.87, $p<0.001$), cardiovascular readmission (HR 0.80, 95% CI 0.65-0.99, $p=0.037$), non-cardiovascular readmission (HR 0.72, 95% CI 0.61-0.85, $p<0.001$), and mortality (HR 0.58, 95% CI 0.49-0.68, $p<0.001$) risk.

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Conclusions—Cardiac rehabilitation participation is associated with a markedly reduced risk of readmission and death after incident myocardial infarction. Improving cardiac rehabilitation participation rates may have a large impact on post-myocardial infarction healthcare resource use and outcomes.

Keywords

myocardial infarction; epidemiology; survival; cardiac rehabilitation; readmission

INTRODUCTION

Each year, an estimated 635,000 Americans will have a first acute myocardial infarction ((1). With advancement in therapies, in-hospital survival after MI has dramatically improved(2, 3). Thus, a large number of incident myocardial infarction survivors are being dismissed from the hospital into the community and are at risk for readmission. In fact, effective October 1, 2012, readmissions occurring early after MI hospital discharge are being used as a publicly-reported measure of quality of healthcare delivery, and as a determinant of reimbursement by the Center for Medicare and Medicaid Services (CMS)(4).

Participation in a cardiac rehabilitation program after MI has been shown to improve survival, decrease the risk of recurrent MI, and improve exercise capacity(5-8). However, its impact on readmissions requires further investigation. Reports from the early 1990s suggested that cardiac rehabilitation participation may reduce costs in part through a reduction in readmissions(9, 10), but more focused contemporary data are needed. Despite its known benefits, cardiac rehabilitation remains underutilized by myocardial infarction survivors, with participation rates as low as 14% in some series(11). As referral to cardiac rehabilitation remains a large barrier to participation(12), evidence that cardiac rehabilitation reduces readmission would provide an additional incentive for hospitals and providers to refer their patients to cardiac rehabilitation following myocardial infarction.

We aimed to examine the association between cardiac rehabilitation participation and outcomes including readmissions and death following incident myocardial infarction in our ongoing myocardial infarction surveillance study in Olmsted County, Minnesota. We are uniquely positioned to examine this issue since we identify all incident myocardial infarctions, and the entire health care experience from diagnosis to death is captured for these patients in a community setting.

METHODS

Study Design and Setting

This study was conducted in Olmsted County, Minnesota. Population-based research is possible because there are few hospitals, namely Olmsted Medical Center and Mayo Clinic. Medical records from all sources of care for residents are extensively indexed and linked via the Rochester Epidemiology Project(13). Therefore, patient-level information can be obtained via the medical and administrative records. This study was approved by the Mayo Clinic and Olmsted Medical Center Institutional Review Boards.

Incident Myocardial Infarction Patient Identification and Validation

Olmsted County residents admitted with possible myocardial infarction to Olmsted County Hospitals from January 1, 1987-September 30, 2010 were identified using ICD-9 codes 410 and 411, as previously described(3). Patients were excluded if they declined to provide Minnesota Research Authorization. Myocardial infarctions were validated using standard epidemiologic criteria (3). Patients diagnosed with myocardial infarction prior to 1987 were excluded. The diagnosis of myocardial infarction was verified based on the presence of cardiac pain, elevated biomarkers, and ECG changes(3). The biomarkers creatine kinase (CK) and CKMB were used in clinical practice until 2000 and troponin thereafter. A review was done to ensure that alternative causes for elevations in biomarkers were considered. Troponin T, CK, and CKMB were measured with a sandwich electrochemiluminescence immunoassay on the Elecsys 2010 (Roche Diagnostics Corp, Indianapolis, IN). The presence of ST elevation on the ECG was identified using the Minnesota code(14). Reperfusion or revascularization during hospitalization was defined as having thrombolytic therapy or receiving coronary artery bypass grafting or percutaneous coronary intervention.

Participation in Cardiac Rehabilitation

Participation in cardiac rehabilitation was ascertained using administrative billing data. We relied on CPT codes (93797, 93798, or 93799) with an associated numeric key specific for cardiac rehabilitation participation. Manual chart review was used to supplement billing data to ensure accuracy. The time to first cardiac rehabilitation participation was defined as the number of days after hospital discharge.

Additional Patient-Level Data

Baseline characteristics present at the time of myocardial infarction were obtained from the medical record. Clinical diagnosis was used to define hyperlipidemia, chronic obstructive pulmonary disease (COPD), cerebrovascular disease, and peripheral vascular disease. Smoking status was classified as 'current' (if the patient smoked or quit within the last 6 months) or 'prior/never'. Hypertension was defined by physician diagnosis, systolic blood pressure >140mm Hg, or diastolic blood pressure >90mm Hg. Diabetes mellitus was defined by blood glucose levels or use of diabetic medications. Anemia was defined as hemoglobin<13mg/dL in men or <12mg/dL in women. The Modification of Diet in Renal Disease equation(15) was used to estimate glomerular filtration rate (GFR). Zip code of residence was used as a marker of socioeconomic status.

Study Outcomes

Data on all-cause hospitalizations after myocardial infarction from 1987-2010 were obtained through the Olmsted County Healthcare Expenditure and Utilization Database(16-18). In-hospital transfers or between the Olmsted Medical Center and Mayo Clinic hospitals were considered a single hospitalization. Patients who died during their initial hospitalization were excluded. The principal diagnosis for each hospitalization was assessed using the primary ICD-9 code, which reflects the main reason for admission. The primary reason for hospitalization was divided into cardiovascular (ICD-9 390-459) or non-cardiovascular (all other codes).

Death was ascertained from the medical record and through the follow-up infrastructure within the Rochester Epidemiology Project. In addition to deaths noted in clinical care, the Mayo Clinic registration office records obituaries and local death notices, and death data are obtained from the State of Minnesota Department of Vital and Health Statistics quarterly.

Statistical Analysis

Differences in baseline characteristics by cardiac rehabilitation participants and non-participants were tested using t-tests for normally-distributed continuous variables, the Wilcoxon rank sum test for non-normally distributed variables, and χ^2 for binary variables. As cardiac rehabilitation is a non-randomized intervention, we fitted a logistic regression model predicting cardiac rehabilitation participation. The model contained 20 variables (sex, age, hypertension, hyperlipidemia, smoking, diabetes, COPD, cerebrovascular disease, BMI, ST-elevation myocardial infarction, Killip class, GFR, anemia, reperfusion/revascularization, cardiologist care, receipt of beta blocker and aspirin, length of stay, discharge to skilled nursing facility, zip code). To examine the association between cardiac rehabilitation participation and readmission, we used Andersen Gill models which account for the repeated nature of hospitalizations (19). Cox proportional hazard regression models were used to examine the association between cardiac rehabilitation participation and mortality.

The association of cardiac rehabilitation with outcomes was assessed using a landmark analysis in which all patients who died within 90 days of discharge after their myocardial infarction were excluded. The 90-day mark was considered day 0 for analysis, and patients were categorized as having attended cardiac rehabilitation (participants) or not (non-participants) by day 90 post-discharge. Three methods were used to account for differences in propensity to participate by cardiac rehabilitation participation status. First, propensity score was adjusted for in the models. Second, we used the inverse probability of treatment weighting (IPTW) which uses weights based on the propensity score to create a synthetic sample in which the distribution of measured baseline covariates is independent of treatment assignment(20). A subject's weight is equal to the inverse of the probability of receiving the treatment that the subject received. Finally, we matched patients based on propensity to participate. A sensitivity analysis specifying 60 days post-discharge as day 0 for analysis yielded similar results (data not shown). Analyses were performed using STATA Version 13.0 and SAS Version 9.3. A p value of <0.05 was used as the level of significance.

RESULTS

Patient Characteristics

A total of 2991 patients were diagnosed with incident myocardial infarction from January 1, 1987 to September 30, 2010 and survived to hospital discharge. The characteristics of the study population are shown in Table 1. Cardiac rehabilitation participants were more likely to be obese, smoke, have hyperlipidemia, be cared for by a cardiologist in the hospital, receive reperfusion/revascularization, be treated with beta blockers and aspirin, and have ST-elevation myocardial infarction. Non-participants had longer hospital length of stay, were more likely to be discharged to assisted and skilled care facilities, and had more

comorbidity. Baseline characteristics of cardiac rehabilitation participants and non-participants stratified by propensity to participate quartiles are shown (Table 2). Patients were followed for an average of 7.6 years after myocardial infarction, and 1424 (47.6%) died.

Cardiac Rehabilitation Participation

Overall, 1569 (52.5%) patients participated in cardiac rehabilitation within 90 days of hospital discharge. While there was no change in the overall cardiac rehabilitation participation over time ($p=0.34$), there were changes by age and sex (Figure 1). Men ($p=0.001$) and younger patients ($p<.001$) were less likely to participate in cardiac rehabilitation, while participation was stable among women ($p=0.13$) and increased in the elderly ($p=0.045$, age*year of diagnosis $p<.001$, sex*year of diagnosis $p=0.001$). Most participants attended their first session early after discharge (median [25th, 75th percentile] 7 [5, 13] days (Figure 2). Time to first participation was longer in elderly patients (median 9 vs. 7 days for those ≥ 65 vs. <65 years, $p<.001$) and those who had coronary artery bypass grafting (median 10 vs. 7 days, $p<.001$). The number of sessions attended within 6 months after myocardial infarction varied widely. While the median was 14 (8, 21) sessions, 204 (13.2%) patients participated in <5 sessions. Current smokers attended fewer sessions than non-smokers (13 vs. 17, $p<0.001$).

Cardiac Rehabilitation Participation and Readmission

Most patients ($n=2265$, 76%) were rehospitalized at least once. The primary reason for readmission was cardiovascular in 39.2% of cases and non-cardiovascular in 60.8%. The most common cardiovascular reasons were ischemic heart disease (ICD-9 428, 10.0%) and heart failure (ICD-9 428, 7.1%). The most common non-cardiovascular reasons were respiratory/ chest symptoms (ICD-9 786, 6.2%) and pneumonia (ICD-9, 3.4%). Cardiac rehabilitation participation was associated with markedly reduced all-cause readmission (Table 3, Figure 3A). All three methods of adjustment for propensity to participate utilized demonstrated a reduction in the risk of all-cause, cardiovascular, and non-cardiovascular readmission in patients who attended cardiac rehabilitation compared with non-participants. The most conservative estimates were provided using the inverse probability treatment weighting approach, and these are highlighted in the abstract. The reduction in risk of readmission associated with cardiac rehabilitation participation was similar across all quartiles of propensity to participate. The impact of cardiac rehabilitation participation on readmission risk differed by type of myocardial infarction (p value for interaction= 0.022 , Figure 4A). Participation in cardiac rehabilitation after non ST-elevation myocardial infarction was associated with a marked reduction in the risk of readmission (HR 0.69, $p<0.001$), but had no association with readmission after ST-elevation myocardial infarction (HR 0.94, $p=0.60$). Cardiac rehabilitation participation also had a trend toward less impact on smokers readmission risk (p value for interaction with non-smokers= 0.060).

Cardiac Rehabilitation Participation and Mortality

Cardiac rehabilitation participation was associated with markedly reduced mortality (Table 3). The one-year Kaplan-Meier predicted mortality was 1.8% and 20.5% for participants and non-participants, respectively (Figure 3B). All three methods of adjustment for propensity to

participate demonstrated a reduction in the risk of readmission in patients who attended cardiac rehabilitation compared with non-participants. The impact of cardiac rehabilitation participation on risk of death differed by smoking status (p value for interaction =0.015, Figure 4B). Participation in cardiac rehabilitation in non-smokers was associated with a more marked reduction in the risk of death (HR 0.53, $p<0.001$) compared with smokers (HR 0.82, $p=0.23$).

DISCUSSION

Among this community cohort, only half of patients participated in cardiac rehabilitation after myocardial infarction. While age and gender disparities existed in likelihood of participation, they narrowed over time. Participation in cardiac rehabilitation was associated with lower post-myocardial infarction mortality and a reduced risk of cardiovascular and non-cardiovascular readmissions.

Cardiac Rehabilitation Participation

Similar to others(21), we found that women and the elderly receive equal benefit from cardiac rehabilitation participation compared with their younger male counterparts. However, they are less likely to be referred and attend cardiac rehabilitation after myocardial infarction(5, 11, 22). While the average participation rate remained at approximately 52% over the last three decades, the age/ gender gap narrowed over time, as cardiac rehabilitation participation increased among the elderly and declined among men and younger individuals. This decline in participation among men and younger people is concerning, and improved participation among all ages and genders is needed. It is notable that most patients began participating in cardiac rehabilitation very early after hospital discharge with a median discharge-to-participation time of only 7 days. Early cardiac rehabilitation participation has been the standard of care at our institution for several decades, and patients are enrolled in cardiac rehabilitation while still hospitalized and their first appointment is usually setup very early post-discharge. The early enrollment in cardiac rehabilitation in our program is unique and in alignment with the guidelines, though nationally, time to enrollment averages 4-6 weeks(23). Early cardiac rehabilitation participation has been shown to be safe(24), effective(25), and increase participation rates(26).

Cardiac Rehabilitation and Mortality After Myocardial Infarction

Meta-analyses of randomized controlled trials and observational studies(5, 7, 27-30) have demonstrated a reduction in mortality after myocardial infarction associated with cardiac rehabilitation participation. Crude differences in mortality in observational studies are of greater magnitude than those observed in randomized controlled trials(5, 31). In part, this can be attributed to the non-randomized nature of the intervention, whereby older, sicker patients are less likely to be referred and participate in cardiac rehabilitation, but more likely to experience adverse outcomes. However, examination of mortality differences in real-world populations is of great importance, as trial populations are highly selected(32). The elderly patient with comorbidities that is commonly encountered in clinical practice would generally be excluded from trial enrollment, and their response to interventions such as

cardiac rehabilitation may differ. We found that participation in cardiac rehabilitation post-myocardial infarction was associated with a 42% reduction in mortality over an average of 7.6 years. Furthermore, the mortality reduction persisted across the range of propensities to participate in cardiac rehabilitation, indicating that even the highest-risk incident myocardial infarction survivors participating in cardiac rehabilitation have lower mortality compared to those who do not participate. Current smokers were the sole subgroup who did not experience reduced mortality, though they attended fewer cardiac rehabilitation sessions which could have impacted their benefit.

Cardiac Rehabilitation and Readmission After Myocardial Infarction

Very little is known about the association between cardiac rehabilitation participation and readmissions. In the early 1990s, patients participating in cardiac rehabilitation had lower readmission charges post-myocardial infarction compared with non-participants, both due to lower incidence of hospitalizations and lower charges per hospitalization(9). While a randomized controlled trial would be the most definitive way to examine the impact of cardiac rehabilitation participation on readmissions, no such trial exists. In our well-defined community cohort of patients with incident myocardial infarction we found that cardiac rehabilitation participation was associated with a 25% reduction in long-term readmission risk. These findings were robust to multiple statistical techniques used to account for differences in propensity to participate in cardiac rehabilitation. There are several potential reasons that cardiac rehabilitation participation may reduce the risk of both cardiovascular and non-cardiovascular readmissions. First, cardiac rehabilitation participation is known to reduce the risk of reinfarction, improve functional status, and has favorable effects on cardiovascular risk factors such as smoking and blood pressure(8). Furthermore, cardiac rehabilitation programs not only offer secondary prevention therapies and regular repeated interactions and assessments by a multidisciplinary team, but also an avenue for continued education and counseling of patients during the vulnerable period after acute myocardial infarction.

Public Health Implications

The association between cardiac rehabilitation participation, readmissions and mortality are important in targeting public health efforts. Despite the fact that participation in cardiac rehabilitation has received a class I recommendation in the American College of Cardiology Foundation/ American Heart Association (ACCF/AHA) guidelines after acute myocardial infarction, both referral and participation rates remain low(11, 12). As there is a tremendous impetus to implement strategies to reduce readmissions, improving cardiac rehabilitation participation rates may represent a high-yield area to focus improvement efforts. Several key recommendations toward improving cardiac rehabilitation participation rates include educating patients and providers about the benefits of cardiac rehabilitation, implementing system-based approaches such as automating cardiac rehabilitation referrals, and improving accessibility and insurance coverage of cardiac rehabilitation programs(33, 34). The ACC, AHA, and American Association of Cardiovascular and Pulmonary Rehabilitation have developed, tested, and implemented cardiac rehabilitation performance measures(35), which are included in the Physician Quality Reporting System, and will be audited by CMS starting this year.

Limitations and Strengths

Some limitations should be acknowledged when interpreting these results. We captured readmissions occurring at Olmsted County facilities. However, among CMS-eligible Olmsted County residents, only 1% of 30-day readmissions and 5% of all hospitalizations in 2005 were to facilities outside of Olmsted County. Therefore, the impact of hospitalizations at outside facilities on results is likely negligible. We rigorously accounted for differences in propensity to participate in cardiac rehabilitation, but cannot eliminate the possibility that residual confounding may exist. At our institution, we are not allowed to include insurance status in any modeling. However, the proportion of uninsured patients was very low (1.7%), and lack of insurance coverage for cardiac rehabilitation attendance after myocardial infarction is likely rare. We were limited in our ability to assess the impact that cardiac rehabilitation participation has on readmissions early after hospital discharge, as patients were just beginning to participate in cardiac rehabilitation during that time. Finally, this reflects the experience of a single community, and results may differ in other settings. Despite these potential limitations, our study has several unique strengths, including the rigorous myocardial infarction definition applied to an entire community population, and the extensive longitudinal follow-up with detailed information about patient characteristics and clinical outcomes.

Conclusion

Despite the clear benefits of participation in cardiac rehabilitation, it remains underutilized following acute myocardial infarction. In this community cohort, while only half of patients attended cardiac rehabilitation, participation was associated with marked reductions in hospital readmissions and mortality. Increasing participation in cardiac rehabilitation after myocardial infarction should be considered as part of a strategy to reduce readmissions.

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Clinical Significance

- Only half of community patients participate in cardiac rehabilitation following acute myocardial infarction
- Participation in a cardiac rehabilitation program after myocardial infarction reduces the risk of long-term hospital readmission by 25% and death by 42%
- Patients should be educated about the positive impact of cardiac rehabilitation participation on long-term outcomes after myocardial infarction

Figure 1. Cardiac Rehabilitation Participation According to Age and Sex

The proportion of patients participating in cardiac rehabilitation by year of myocardial infarction diagnosis according to age (panel A, elderly if age ≥ 65 years) and sex (panel B) are shown.

Figure 2. Timing of Participation in Cardiac Rehabilitation

The number of days after incident myocardial infarction hospital discharge that patients attended their first session of cardiac rehabilitation is shown.

Figure 3. Readmission and Mortality After Myocardial Infarction for Cardiac Rehabilitation Participants and Non-Participants

The estimated mean number of readmissions over time (A) and Kaplan Meier curves demonstrating time to death (B) after myocardial infarction are shown for cardiac rehabilitation participants and non-participants. The number of patients at risk is shown below the figures.

Figure 4. Risk of Readmission and Death According to Baseline Characteristics

The HR (95% CI) for readmission (A) and death (B) according to patient baseline characteristics are shown.

Patient Baseline Characteristics

Table 1

Characteristic	Missing, <i>n</i>	Overall (<i>n</i> = 2991)	Cardiac Rehabilitation Status Non-Participant (<i>n</i> =1422)	Participant (<i>n</i> =1569)	<i>P</i> Value
Mean age at myocardial infarction (SD), <i>y</i>	0	67.3 (14.6)	73.2 (14.2)	62.0 (12.8)	<.001
Women, <i>n</i> (%)	0	1215 (40.6)	754 (53.0)	461 (29.4)	<.001
Risk factors and comorbid conditions, <i>n</i> (%)					
Hypertension	1	1827 (61.1)	993 (69.8)	834 (53.2)	<.001
Current smoker	5	738 (24.7)	302(21.3)	436 (27.8)	<.001
Hyperlipidemia	2	1488 (49.8)	667 (46.9)	821 (52.4)	0.003
Diabetes mellitus	1	654 (21.9)	392 (27.6)	262 (16.7)	<.001
Obese (BMI ≥ 30 kg/m ²)	4	989 (33.1)	431 (30.4)	558 (35.6)	0.002
COPD	2	389 (13.0)	261 (18.4)	128 (8.2)	<.001
Cerebrovascular disease	3	424 (14.2)	306 (21.5)	118 (7.5)	<.001
Anemia (<i>n</i> , %)	32	804 (27.2)	533 (37.8)	271 (17.5)	<.001
Estimated GFR<60mL/min, <i>n</i> , %	17	1478 (49.7)	870 (61.5)	608 (39.0)	<.001
Incident Myocardial Infarction characteristics					
Cardiology provider, <i>n</i> (%)	12	2638 (88.6)	1118 (79.0)	1520 (97.2)	<.001
ST-segment elevation, <i>n</i> (%)	38	922 (31.2)	346 (24.7)	576 (37.1)	<.001
Killip class 2–4, <i>n</i> (%)	16	827 (27.8)	498 (35.2)	329 (21.1)	<.001
Q waves, <i>n</i> (%)	203	1493 (53.5)	693 (52.9)	800 (54.1)	0.53
Reperfusion/revascularization during hospitalization, <i>n</i> (%)	5	1911 (64.0)	610 (43.0)	1301 (83.0)	<.001
Fibrinolysis, <i>n</i> (%)*		261 (8.7)	71 (5.0)	190 (12.1)	-
Coronary artery bypass grafting, <i>n</i> (%)		280 (9.4)	85 (6.0)	195 (12.4)	-
PCI, <i>n</i> (%)		1526 (51.2)	480 (33.8)	1046 (66.7)	-
Medications during hospitalization					
Beta-blocker, <i>n</i> (%)	9	2595 (87.0)	1159 (81.8)	1436 (91.8)	<.001
ACE-I/ARB, <i>n</i> (%)		1559 (52.3)	755 (53.3)	804 (51.4)	0.34
Aspirin, <i>n</i> (%)		2791 (93.6)	1278 (90.2)	1513 (96.7)	<.001
Hospital length of stay, <i>days</i> , <i>median</i> (25 th , 75 th percentile)	0	5 (3.8)	6 (3, 10)	5 (3, 7)	<.001
Discharge to assisted or skilled care facility, <i>n</i> (%)	3	386 (12.9)	359 (25.3)	27 (1.7)	<.001

Table 2
Selected Baseline Characteristics of Cardiac Rehabilitation Participants and Non-Participants by Propensity to Participate Quartiles

Characteristic	Propensity to Participate in Cardiac Rehabilitation (Quartiles)							
	Lowest Quartile (n=725)		Low Quartile (n=724)		High Quartile (n=724)		Highest Quartile (n=725)	
	Participants	Non-Participants	Participants	Non-Participants	Participants	Non-Participants	Participants	Non-Participants
Mean age, years	78	81	69	71	65	64	54	54
Women	65%	67%	48%	48%	37%	39%	8%	8%
Current smoker	18%	14%	30%	23%	30%	34%	25%	32%
Hyperlipidemia	58%	42%	44%	50%	49%	51%	59%	54%
Diabetes mellitus	42%	32%	25%	28%	19%	22%	7%	9%
Obese (BMI ≥30)	36%	23%	33%	36%	38%	38%	35%	39%
CVD	28%	33%	16%	19%	7%	5%	<1%	<1%
STEMI	17%	19%	23%	25%	37%	31%	48%	43%
Killip class 2-4	40%	49%	24%	29%	22%	22%	13%	8%
Anemia	46%	54%	31%	33%	18%	18%	5%	4%
Estimated GFR<60	78%	78%	50%	59%	42%	38%	26%	23%
Aspirin use	92%	85%	92%	92%	98%	98%	99%	100%
Median length of stay	8	7	5	5	5	5	4	3

All values shown are % unless otherwise noted

BMI= body mass index, COPD= chronic obstructive pulmonary disease, CVD= cerebrovascular disease, GFR= glomerular filtration rate, STEMI= ST-segment elevation myocardial infarction

Table 3
Participation in Cardiac Rehabilitation, Readmissions, and Mortality

All-Cause Readmission	Risk of Participants vs. Non-Participants Hazard Ratio (95% CI), P value			
	Unadjusted	* Adjusted (Method 1)	* Adjusted (Method 2)	* Adjusted (Method 3)
Long-term				
All-cause	0.52 (0.47-0.57), <0.001	0.72 (0.64-0.81), <0.001	0.75 (0.65-0.87), <0.001	0.61 (0.55-0.67), <0.001
Cardiovascular	0.59 (0.52-0.67), <0.001	0.77 (0.66-0.89), <0.001	0.80 (0.65-0.99), 0.037	0.64 (0.56-0.74), <0.001
Non-Cardiovascular	0.48 (0.43-0.53), <0.001	0.69 (0.60-0.79), <0.001	0.72 (0.61-0.85), <0.001	0.59 (0.52-0.66), <0.001
Death				
All-cause	0.24 (0.22-0.27), <0.001	0.55 (0.48-0.64), <0.001	0.58 (0.49-0.68), <0.001	0.46 (0.39-0.54), <0.001

Method 3 matches based on propensity score (maximum matched pair difference in propensity=0.10). This resulted in 804 matched pairs. CI= confidence interval

* Method 1 is adjusted for propensity to participate.

* Method 2 used inverse probability treatment weighting which generates weights based on the propensity score.