

## **Appendix B.1**

**Of the**

### **Evaluation of Lifestyle Modification and Cardiac Rehabilitation in Medicare Beneficiaries\***

#### **Use of Cardiac Rehabilitation by Medicare Beneficiaries after Myocardial Infarction or Coronary Bypass Surgery<sup>+</sup>**

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## **ABSTRACT**

### **Background:**

Cardiac rehabilitation (CR) is effective in prolonging survival and reducing disability in patients with coronary heart disease. However, national utilization patterns and predictors of CR use have not been thoroughly evaluated.

### **Methods:**

Using Medicare claims, we analyzed outpatient (Phase II) CR use following hospitalizations for acute myocardial infarctions (AMI) or coronary artery bypass graft (CABG) surgery in 267,427 fee-for-service beneficiaries aged 65 and older who survived for at least 30 days after hospital discharge. We used multivariable analyses to identify predictors of CR use and to quantify geographic variations in its use. We obtained unadjusted, adjusted-smoothed, and standardized rates of CR use by state.

### **Results:**

Overall, CR was used in 13.9% of patients hospitalized for AMI and 31.0% of patients who underwent CABG surgery. Older individuals, women, non-whites, and patients with comorbidities (including congestive heart failure, previous stroke, diabetes, or cancer) were significantly less likely to receive CR. CABG surgery during the index hospitalization, higher median household income, higher level of education, and shorter distance to the nearest CR facility were important predictors of higher CR use. Adjusted CR use varied 9-fold among states ranging from 6.6% in Idaho to 53.5% in Nebraska. The highest CR use rates were clustered in North Central states of the U.S.

### **Conclusions:**

CR use is relatively low among Medicare beneficiaries despite convincing evidence of its benefits and recommendations for its use by professional organizations. Use is higher following CABG surgery than AMIs not treated with revascularization procedures and varies dramatically by state and region of the U.S.

Key words: Coronary disease, myocardial infarction, bypass, exercise, prevention

## **INTRODUCTION**

Patients with coronary heart disease (CHD) who have experienced an acute myocardial infarction (AMI), or have undergone coronary artery bypass graft (CABG) surgery are prime candidates for cardiac rehabilitation (CR) services. Meta-analyses of randomized-controlled trials have consistently shown that participation in CR programs improves mortality and morbidity outcomes, and may favorably influence cardiac risk factors.<sup>1-5</sup> In these studies, reductions in all-cause mortality ranged from 15% to 28% and reductions in cardiac mortality from 26% to 31%. While some of these trials preceded concomitant intensive approaches to reduce coronary risk reduction, such as the widespread use of anti-lipemic medications, survival benefits were of similar magnitude to those observed in more recent studies.<sup>5</sup> Exercise training in CR programs has been shown to be safe, with very low rates of nonfatal myocardial infarctions or cardiac mortality among patients of all ages.<sup>6,7</sup>

A clinical practice guideline for CR was published in 1995 and subsequently endorsed by a number of professional associations<sup>6,8,9</sup> and the Centers for Medicare & Medicaid Services (CMS).<sup>10</sup> Core components of CR include an exercise plan; nutritional counseling; management of blood lipid levels, diabetes, high blood pressure, and weight; smoking cessation; and psychosocial interventions.<sup>11</sup>

Hospitalizations for coronary diagnoses frequently provide patients with inpatient or Phase I CR, including supervised early mobilization and education on controlling risk factors and physical activities following discharge. However, as the duration of hospitalization for AMI has shortened<sup>12</sup>, outpatient CR has become increasingly important. Outpatient (Phase II) CR can be initiated as soon as three weeks following hospital discharge, generally in a supervised hospital- or community-based ambulatory setting, and includes supervised exercise, nutrition counseling, and other lifestyle modification interventions aimed at reducing cardiac risk factors. After supervised CR, patients are encouraged to maintain healthy lifestyles and unsupervised exercise with periodic monitoring of symptoms, risk factors, and medications by medical providers (Phase III CR).

The high prevalence of CHD and its important contribution to disability<sup>13</sup> underscores the importance of efforts to improve clinical outcomes and prevent recurrent CHD events. In 2003, more than 13 million people in the U.S. had CHD, over 860,000 people suffered AMIs, and 480,000 people died of CHD.<sup>14</sup> Disease burdens are especially high in people 65 years of age or older, who account for more than 55 percent of AMIs and 86 percent of CHD deaths.<sup>15</sup> The economic burden of CHD—both medical and social costs—falls disproportionately on the elderly.

Since 1982, Medicare, the primary health insurer for people in the US who are 65 years of age and older, has provided coverage for up to three weekly outpatient CR sessions for three months following AMI, CABG surgery, or stable angina pectoris, if these sessions are prescribed and supervised by a

physician.<sup>10</sup> In March 2006, CMS expanded coverage to include percutaneous revascularization procedures, heart valve surgery, and heart or heart-lung transplant.<sup>16</sup>

Using Medicare claims data, we identified patient and hospital predictors of outpatient CR use. This is the largest (267,427 patients) and most comprehensive analysis to date of the use of outpatient CR.

## **METHODS**

### **Cohort**

The cohort consisted of Medicare beneficiaries who had an index hospitalization in 1997 in a U.S. non-federal, acute care hospital with “a qualifying coronary diagnosis or procedure.” Inclusion was based on a principal discharge diagnosis code (using the International Classification of Diseases, Version 9, ICD9) for AMI (410.xx) or a procedure code for CABG (36.1x). For patients with more than one qualifying admission during 1997, the earliest admission was considered the “index” admission.

Additional inclusion criteria were age 65 or above at the time of admission, an index hospitalization stay of 31 days or less and alive at 30 days after discharge (used to identify reasonable CR candidates) and uninterrupted enrollment in fee-for-service (FFS) payment (not in capitated health plan) and entitlement under Medicare Part A and Part B during the 12 months after the index hospitalization discharge date. Patients with index hospitalizations in Puerto Rico or U.S. territories were excluded due to small numbers of patients.

### **Data Sources**

The primary data source was Medicare’s National Claims History File. For qualifying patients, we linked inpatient claims with Medicare’s master enrollment database to obtain information on date of birth, sex, race, date of death (where applicable), residence zip code, enrollment status over time, entitlements (Part A and Part B), and group health plan membership. Census 2000 data were linked to the patient’s residence zip code statistics as proxies for socio-economic, educational, and disability statuses. We used American Hospital Association and Medicare data to determine hospital characteristics for index admissions.

### **Cardiac Rehabilitation Services Use**

The use of CR services was defined as any Medicare payment in hospital outpatient claims for at least one CR session (Current Procedure Terminology codes 93797 and 93798) within one year following discharge from the index hospitalization. We also evaluated how soon after discharge from the index hospitalization CR was initiated. We characterized CR intensity by the number of sessions received within one year and the number of days they spanned.

## **Predictors of CR Use**

Predictors of CR use were identified using Andersen and Aday's classical behavioral model of health services utilization that focuses on predisposing, enabling and illness characteristics of patients.<sup>17, 18</sup> CR candidates were classified into two main groups: AMI or CABG surgery without AMI. Patients with AMI were further classified into three subgroups: medical treatment only, percutaneous coronary intervention (PCI) without CABG, or CABG. Patients who received both CABG and PCI were classified as CABG.

Patient demographic and comorbidity characteristics were examined using information from the claims data. We identified 25 comorbidity groups considered related to CR use that resembled Charlson's groupings using diagnostic and procedure codes from the index hospitalization (or any hospitalization within one year before) and DxCG software (DxCG, Inc., Boston, MA, 2001<sup>19</sup>). For patients aged 65, the qualifying age for Medicare benefits for the elderly, on average the claims file contained only half a year of pre-hospitalization data to identify comorbid conditions. These participants represented only about 6% of the entire study cohort.

We also examined distance from patient's residence to the nearest CR facility. Distance to CR was defined as the shortest distance (in miles) from the patient's zip code centroid to the nearest available CR facility within the state (located by its exact latitude and longitude). We assumed that patients did not cross state borders to receive CR.

Patient socioeconomic characteristics were inferred by Medicaid dual eligibility and Census data. Enrollment in Medicaid was the only patient-level indicator of low income available in the claims file. We also assigned variables to each patient reflecting the proportions of people within the patient's zip code: residing in urban areas; living under poverty line according to race and age groups (65-74 and 75+); having some college education according to gender and race; having any disability (according to race, gender and age group); and household median income by age group of the head of household. We created overall quintiles for each of these indicators. We used five hospital characteristics: availability of cardiac catheterization, angioplasty, and open heart surgery, number of beds, and medical school affiliation.

## **Statistical Analyses**

We first performed univariate and bivariate analyses. We used univariate analyses to determine the proportion of patients receiving CR. We employed bivariate analyses to describe differences in CR use by patient demographics, comorbidities, characteristics of the index hospitalization and hospital in which it

occurred, and by patient zip code, census region, and state (50 states and the District of Columbia). T-tests were computed for continuous variables and chi squared tests for categorical variables.

We next estimated a multiple logistic regression model to identify patient and hospital predictors of CR use. Covariates in the model were: patient demographics and comorbid conditions, characteristics of the index hospitalization and inpatient facility, socioeconomic and disability characteristics of the patient's zip code, distance to nearest CR facility, and state indicators. We adjusted for clustering of patients within their index hospital through generalized estimating equations (GEE) using the GENMOD procedure in SAS software, version 9.1 (SAS Institute Inc., Cary, North Carolina). A single correlation (exchangeable option) affecting any pair of patients within each cluster (hospital) was used, and adjusted odds ratios (ORs) of CR use were obtained for each variable included in the model.

### **Geographic Variation**

In order to quantify geographic variation in CR use, we estimated a random intercept hierarchical logistic regression model. The random intercepts represented the underlying log-odds of CR use for each state and were assumed to vary across states. We adjusted for patient demographic and socioeconomic characteristics using the same predictors as in the GEE model. The model was fitted using the SAS GLIMMIX procedure. We then calculated both state-adjusted estimates of CR use and standardized state-specific rates of CR use using the methodology developed by one of the authors (SLN).<sup>20</sup> The adjusted state-specific CR use rate was estimated as the average of the predicted individual probabilities of all the CR candidates living in each state. The expected state rate was calculated as the average of the predicted individual probabilities as if those individuals were living in an average state (through the exclusion of the effect of the state-specific random effect). The standardized state-specific rates of CR use was then estimated as the adjusted, state-specific CR rate divided by the expected CR rate for that state, multiplied by the national unadjusted CR rate.

Each state's 95% confidence interval on its adjusted rate was examined to determine if it excluded the national CR rate. If it did, then we concluded that the state had higher or lower rates than expected

## **RESULTS**

### **Use of Cardiac Rehabilitation**

Our study cohort consisted of 267,427 patients, of whom 18.7% (49,877) received at least one session of outpatient CR following hospital discharge (**Table 1**). Recipients of CR received an average of 24 sessions (SD 12). Men were more likely to receive CR than women (22.1% vs. 14.3%); use was inversely related to age; and whites were more than twice as likely as non-whites to receive CR. Only 5.2% of people dually eligible for Medicaid and Medicare received CR compared to 20.3% of those who were not.

Overall, CR was used in 13.9% of patients hospitalized for AMI and in 31.0% of those who underwent CABG surgery. Only 11.1% of patients with an AMI and no subsequent revascularization procedure during the index hospitalization received CR. Patients were more likely to receive CR if they had been admitted from home (19.3%) than if they had been transferred from another acute care hospital (13.2%) or nursing home (5.6%). Index admissions to hospitals with cardiac catheterization, angioplasty, and open heart surgery capabilities increased CR use to 22.4% from 13.8 % in hospitals with none of these capabilities. Slightly higher CR rates were observed in hospitals affiliated with medical schools (20.5%) vs. not affiliated (17.1%).

Women, older people, non-whites, and patients receiving Medicaid received somewhat fewer sessions on average. Patients initiated CR an average of 55 days after discharge from the index hospitalization, with 25 percent initiating therapy within 21 days, and more than 25 percent initiating more two months after discharge. Women, non-whites, and Medicaid recipients began about one week later than their complementary groups ( $p < 0.0001$ ), but there was no association of age with the timing of CR initiation.

### **Comorbidities**

Commonly reported comorbidities among patients with a coronary diagnosis or procedure (**Table 2**) were hypertension (57%), congestive heart failure (37%), diabetes (26%), arrhythmias (33%), chronic pulmonary disease (21%), and musculoskeletal conditions (mainly arthritis) (18%). Overall, CR users had fewer comorbidities than non-users (2.1 versus 2.7,  $p < 0.0001$ ) among the 25 comorbidity groups considered. In a bivariate analysis, patients with congestive heart failure, diabetes with complications, cerebrovascular disease, chronic pulmonary disease, or renal disease had moderate reductions in any CR use (0.69 to 0.77), while patients with dementia or metastatic malignancies were very unlikely to receive CR.

### **Other Patient-Related Predictors of CR Use**

Older individuals, women, and non-whites were less likely to receive CR than their comparison groups (**Table 3**). For example, men and women aged 75-84 years were only 87% and 69%, respectively, as likely to receive CR as men, aged 65-74 years. Gender differences increased with age. Whites were 33% more likely to receive CR than non-whites after adjustment for age and gender (ORs 1.33 vs. 1.00).

CABG surgery during the index hospitalization was a strong predictor of CR use whether or not it was performed following an AMI (OR 3.5). Patients who received PCI following an AMI were nearly two times more likely to receive CR than those with no revascularization procedure (OR 1.8).

Distance to the nearest CR facility was an important predictor of CR use in a multivariable analysis with use declining monotonically as distance increased (**Table 3**). For example, patients living in the furthest

quintile were 71% less likely to participate in CR than those living in the quintile closest to a CR facility (adjusted OR 0.29).

CR use was also associated with the zip code characteristics of the patient's residence including degree of urbanization, income, proportion of the population at or below the poverty level, and the proportion with college education (not shown). Patients living in zip codes with the highest levels of urbanization and poverty were 36% and 17% less likely to use CR than those living in the most rural or least impoverished areas, respectively ( $p < 0.001$ ). Conversely, patients living in zip codes with the highest levels of median household income and education were 23% and 33% more likely to use CR than those living in zip codes with the lowest income and education ( $p < 0.001$ ).

### **Hospital Predictors**

Patients transferred from a skilled nursing facility (SNF) or long-term care facility (LTC) for their index hospitalizations were less likely to receive CR (OR 0.72) than those admitted from home. Patients from smaller hospitals were more likely to participate in CR (OR 1.27) as were those hospitalized in facilities not affiliated to medical schools (OR 1.33) compared to patients in hospitals with the opposite characteristics.

### **Geographic Variations**

More than a 9-fold geographic variation in CR use was found among states in all unadjusted, adjusted-smoothed (shrinkage) and standardized rates, with rates ranging from 6.6% in Idaho to 53.5% in Nebraska after multivariable adjustment (**Table 4**). Large regional variations are evident in **Figure 1**, with the highest use states clustered in the North Central region. The rate of CR use by state was strongly positively correlated with the number of CR facilities per 10,000 people aged 65 and above ( $r = 0.82$ ,  $p < 0.001$ ).

## **DISCUSSION**

### **Importance**

This is the largest and most comprehensive study of which we are aware to examine the use of CR in older patients with coronary heart disease. We found that only 13.9% of Medicare beneficiaries with AMIs and 31.0% of those who had undergone CABG surgery received CR services after index hospitalizations in 1997. For AMI, this rate is higher than the 7% found in elderly patients in 1990<sup>21</sup> but lower than the 29% rate found in a 2001 survey of patients aged 65-79 in 19 states and the District of Columbia.<sup>22</sup> Our study found lower use rates in females, non-whites, older patients, and "dual eligibles" who were also receiving Medicaid. Our study also documents the deterrent effects on CR use of lower mean income, less education, and higher prevalence of disability. Patients with more concomitant illnesses were less likely to receive CR.

Geographic variations in CR use are especially striking. Use rates were more than four-fold higher in North Central states (Nebraska, Iowa, North and South Dakota, Minnesota, and Wisconsin) than in Southern states. In seeking explanations, we found no correlations between these state variations in CR use with indicators of health consciousness (e.g. smoking rates) or quality of care (e.g. use of pneumococcal vaccine or use beta-blockers after an AMI) among elders in 1997.<sup>23</sup> Instead, interviews with CR staff suggest the role of factors such as the training and attitudes of physicians and CR staff, abundance of training programs for CR staff, the application of standing orders for CR, and procedures and data systems for initiating and tracking referral and entry into CR<sup>24</sup>

Higher rates of CR use in patients undergoing CABG surgery than in those with AMIs probably reflect the high salience of the surgical procedure to the patient and systematic referral by cardiac surgeons. Our finding of a strong deterrent effect on CR use of a greater distance from the patient's residence to a CR facility, even after correcting for patient and hospital characteristics in multivariable analyses, is consistent with other studies.<sup>25, 26</sup>

As distance to the nearest CR facility was an important predictor of CR use, payers may wish to explore the feasibility of reimbursing community- or home-based CR programs as supplements or alternatives to facility-based programs, particularly in rural and sparsely populated areas. Available evidence indicates that such programs are safe and equally effective, at least for patients who are at low or moderate risk of complications patients following AMIs or revascularization procedures.<sup>6, 27</sup>

## **Study Limitations**

Our study's main limitations relate to its heavy reliance on Medicare claims data and its focus on 1997 hospitalizations. Medicare claims have strengths and limitations. They provide excellent information on the principal diagnoses for hospital admissions, major diagnostic and treatment procedures received, and some information on comorbid conditions. However, claims lack important clinical data such as left ventricular ejection fraction, body weight, smoking habits, and lipid levels, and they do not accurately distinguish treatment complications, such as cardiac arrhythmias or cardiac arrests, from preexisting conditions

Medication use is not generally available to researchers from Medicare claims. The fact that our study focused on index hospitalizations for AMI or CABG surgery during 1997 means that it does not reflect subsequent changes in the standards for care for AMIs, newer medications for CHD, advances in cardiac surgery or the increased use and sophistication of PCI. While changes in medical practice may have affected the use of CR, Medicare's eligibility criteria for AMI and CABG remained unchanged until 2006. On balance, we believe our findings closely mirror recent CR use patterns in Medicare beneficiaries. Other, less important, study limitations are its restriction to Medicare beneficiaries with both Part A and

Part B coverage who were continuously enrolled in fee-for-service Medicare. Hence, we cannot generalize our findings to individuals who did not have Part B or who were enrolled in HMOs, but they constitute small shares of Medicare beneficiaries. In 1997, 97% of 32.2 million beneficiaries enrolled in Part A has also Part B<sup>28</sup> and approximately 85% of Medicare beneficiaries were under FFS.<sup>29</sup>

### **Effects of the Underuse of Cardiac Rehabilitation**

The low CR utilization rates we have documented are discouraging in light of the considerable evidence that supports the effectiveness of CR. Meta-analyses of controlled studies have found 15% to 28% reductions in all-cause mortality and 26% to 31% reductions in cardiac mortality. In addition, studies have documented substantial reductions in morbidity and decreases in cardiac risk factors.<sup>1-5</sup> Assuming that the CR use rate in Nebraska (53.5%) were achieved in all other states, 93,000 additional Medicare beneficiaries would have received CR and cardiac mortality would have decreased 26% to 31% in these individuals. Cost-effectiveness analyses suggest that achieving these gains would be highly cost-effective.<sup>30, 31</sup>

### **Opportunities to Increase the Use of Cardiac Rehabilitation**

Increased use of CR might be achieved by improving methods of referring patients to CR facilities after their hospitalizations, implementing quality indicators, and by increasing reimbursement rates for these services. Opportunities to increase referrals include using automatic referrals after qualifying hospital admissions<sup>32</sup>, creating web-based referral opportunities, and learning lessons from states that currently demonstrate high utilization rates. For example, striking increases in referrals, from 27% to 62%, were achieved by one web-based referral opportunity<sup>33</sup>. A high overall referral rate, however, may not eliminate disparities based reflecting lower use, for example, among women,<sup>34, 35</sup> non-whites<sup>36</sup>, or the very old.

Referral to, enrollment in, and completion of CR programs have been proposed as quality indicators in cardiovascular care.<sup>37</sup> Such measures might be considered by organizations such as the American College of Cardiology, American Heart Association, Agency for Health Care Research and Quality, the National Committee for Quality Assurance, and the Joint Commission on Accreditation of Health Care Organizations as means to increase appropriate CR use. They might also be adopted by Medicare in its pay-for-reporting program and the pay-for-performance (P4P) initiative for hospitals that it is currently developing. Rewards could be given both to the hospital from which the patient was discharged and the responsible physician.<sup>38, 39</sup> Quality indicators might reflect both referral rates to CR and the completion of a specified number (e.g. 24) of CR sessions within 90 days after a hospital discharge. Lessons from recent P4P demonstrations suggest the importance of aligning incentives between physicians and

hospitals, incorporating case-mix adjustment, and rewarding improvement as well as excellent performance.<sup>40</sup>

Finally, increased reimbursement rates for CR could serve as positive incentives. Medicare expanded eligibility for CR services in 2006 to include PCI and other indications but did not change levels of reimbursement for the service.<sup>16</sup> The midpoint reimbursement rate by Medicare for a Phase II CR session was \$15.50 in 2001<sup>41</sup> and was \$34 in 2006 (unpublished data from CMS, 2006). Some CR providers argue that the current rate does not fully cover costs and is a deterrent to CR use. CMS could reassess reimbursement levels against their resource costs and compare the merits of reimbursement per session versus packaged reimbursement per program completed. Separate payments for key components, such as nutritional counseling and stress management might also be considered.

In conclusion, this study has found low national utilization rates of CR following AMI and CABG surgery and remarkable cross-state variations in use. Lower use rates were found in women, non-whites, dual eligibles, the very old, and in persons with more comorbidities, lower socio-economic status, or who live farther from a CR facility.

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## TABLES

**Table 1. Cohort Characteristics and Crude Rates of Cardiac Rehabilitation (CR) Use**

<b>Characteristic</b>	<b>Number of patients</b>	<b>% of cohort</b>	<b>Crude rate of any CR use (%)</b>
<b>Entire cohort</b>	267,427	100%	18.7%
<b>Sociodemographic characteristics of patients</b>			
Gender and age group			
Males (overall)	149,383	55.9%	22.1%
65-74 years	84,089	31.4%	26.6%
75-84 years	54,012	20.2%	18.6%
85 plus	11,282	4.2%	4.6%
Females (overall)	118,044	44.1%	14.3%
65-74 years	47,908	17.9%	21.7%
75-84 years	49,122	18.4%	12.4%
85 plus	21,014	7.9%	2.1%
Race			
Whites	245,504	91.8%	19.6%
Non-Whites	21,923	8.2%	7.8%
Medicaid at discharge			
No	238,315	89.1%	20.3%
Yes	29,112	10.9%	5.2%
<b>Index Hospitalization</b>			
AMI in principal diagnosis	192,926	72.1%	13.9%
No coronary revascularization	151,187	56.5%	11.1%
AMI + PCI	27,431	10.3%	20.9%
AMI + CABG	13,372	5.0%	29.8%
AMI+ PCI + CABG	936	0.4%	35.7%
CABG, no AMI in principal diagnosis	74,501	27.9%	31.0%
CABG alone	73,239	27.4%	31.0%
CABG + PCI	1,262	0.5%	30.4%
Origin of hospitalization			
Home	252,953	94.6%	19.3%
Transferred from acute hospital	4,609	1.7%	13.2%
Transferred from SNF or LCF	9,865	3.7%	5.6%
Patient destination after discharge			
Home	194,451	72.7%	19.5%
Transferred to Acute Hospital	45,146	16.9%	20.2%
Transferred to SNF or LCF	27,830	10.4%	10.2%
Hospitalizations within prior 12 months			
None	190,554	71.3%	21.0%
For AMI	6,130	2.3%	11.6%
For other condition	70,743	26.5%	12.8%
<b>Availability of coronary procedures at index hospital</b>			
Open heart surgery, angioplasty, and catheterization	135,268	50.6%	22.4%
Angioplasty and cardiac catheterization only	9,244	3.5%	13.2%
Cardiac catheterization only	30,965	11.6%	12.8%
None of the above	44,636	16.7%	13.8%
Unknown	47,314	17.7%	17.6%
Medical school affiliation			
No	138,444	51.8%	17.1%
Yes	118,607	44.4%	20.5%
Unknown	10,376	3.9%	17.6%

Abbreviations: AMI, acute myocardial infarction; CABG, coronary artery bypass graft; PCI, percutaneous coronary intervention; SNF, skilled nursing facility; LCF, long-term care facility.

Beginning of CR: number of days from index hospital discharge to first CR session.

The average number of comorbid conditions were 2.06 (SD 1.70) for CR users and 2.71 (SD 2.22 ) for non-CR users.

**Table 2. Crude Rates and Adjusted Odds Ratios (OR) of Any Cardiac Rehabilitation (CR) Use by Patient Comorbid Conditions**

Comorbid Condition	Number of patients	% of cohort *	Crude rate of any CR use (%)	Adjusted Odds Ratios		
				Estimate	Lower and upper 95% CI	
Cardiovascular disease						
Hypertensive heart disease	152,433	57.0%	11.0%	0.88	0.74	1.04
Congestive heart failure	97,605	36.5%	11.0%	0.77	0.75	0.80
Arrhythmias	88,216	33.0%	17.8%	0.96	0.93	0.98
Peripheral vascular disease	51,011	19.1%	15.3%	0.92	0.90	0.95
Valvular heart disease	47,993	17.9%	14.2%	0.95	0.92	0.98
Heart conduction disorders	44,304	16.6%	16.3%	1.04	1.00	1.07
Cerebrovascular disease	27,459	10.3%	13.3%	0.77	0.74	0.80
Cardiac arrest	23,708	8.9%	14.8%	0.99	0.95	1.03
Diabetes without complications	70,775	26.5%	15.9%	0.90	0.87	0.92
Chronic liver disease	779	0.3%	8.5%	0.63	0.48	0.83
Metastatic malignancies	1,989	0.7%	6.3%	0.43	0.36	0.52
Malnutrition	3,954	1.5%	6.4%	0.63	0.54	0.73
Other liver disease	3,654	1.4%	13.1%	0.98	0.88	1.09
Bone fractures	4,814	1.8%	4.2%	0.51	0.44	0.59
Central neurological condition	5,618	2.1%	10.0%	0.71	0.65	0.78
Dementia	12,126	4.5%	2.4%	0.34	0.30	0.38
Malignancies	11,205	4.2%	12.9%	0.86	0.81	0.91
Chronic pulmonary disease	57,256	21.4%	13.5%	0.77	0.75	0.79
Musculoskeletal condition	47,588	17.8%	15.9%	1.03	1.00	1.06
Hematological (non malignant) disease	64,045	23.9%	19.6%	1.02	0.99	1.04
Urinary tract disease	47,107	17.6%	11.7%	0.89	0.86	0.92
Infectious diseases	20,241	7.6%	9.5%	0.89	0.85	0.94
Gastric ulcer	18,172	6.8%	11.1%	0.85	0.81	0.89
Renal disease	18,712	7.0%	8.5%	0.69	0.65	0.73
Diabetes with complications	13,490	5.0%	10.2%	0.77	0.72	0.82

\* Cohort: n=267,427.

**Table 3. Adjusted Odds Ratios (OR) for Any Cardiac Rehabilitation (CR) Use by Patient and Hospitalization Characteristics**

Characteristics	Adjusted Odds Ratio	Lower 95% CI	Upper 95% CI
<b>Patient characteristics</b>			
Gender by age group			
Male, aged 65-74	1.00	Reference group	
Male, aged 75-84	0.87	0.84	0.91
Male, aged 85+	0.29	0.27	0.32
Female, aged 65-74	0.98	0.95	1.01
Female, aged 75-84	0.69	0.66	0.72
Female, aged 85+	0.17	0.15	0.19
Race			
No White	1.00	Reference group	
White	1.33	1.26	1.41
Medicaid at discharge			
No	1.00	Reference group	
Yes	0.44	0.42	0.47
<b>Index hospitalization characteristics</b>			
Type of coronary diagnosis and revascularization			
AMI in principal diagnosis			
No coronary revascularization	1.00	Reference group	
AMI + PCI	1.84	1.75	1.94
AMI +CABG*	3.54	3.30	3.78
CABG, no AMI in principal diagnosis**		3.35	3.76
Origin of hospitalization			
Home	1.00	Reference group	
Transferred from acute hospital	0.89	0.81	0.98
Transferred from SNF or LCF	0.72	0.65	0.79
Patient destination after discharge			
Home	1.00	Reference group	
Transferred to Acute Hospital	1.71	1.64	1.79
Transferred to SNF or LCF	0.64	0.61	0.68
<b>Hospitalizations within 1 year prior index hospitalization</b>			
For any cause			
No	1.00	Reference group	
Yes	0.95	0.92	0.98
For AMI			
No	1.00	Reference group	
Yes	0.92	0.84	1.01
<b>Facility characteristics for index hospitalization</b>			
Availability of cardiac catheterization			
Unknown	0.80	0.28	2.32
No	0.89	0.82	0.97
Yes	1.00	Reference group	
Hospital size			
Unknown	1.60	0.55	4.61
1- 160 beds (quintiles 1-4)	1.27	1.11	1.46
161 plus beds (quintile 5)	1.00	Reference group	
Medical school affiliation			
Unknown	1.05	0.86	1.28
No	1.33	1.21	1.46
Yes	1.00	Reference group	

Abbreviations: AMI, acute myocardial infarction; CABG, coronary artery bypass graft; PCI, percutaneous coronary intervention; SNF, skilled nursing facility; LCF, long-term care facility.

Includes 334 patients with both CABG and PCI

\*\* Includes 384 patients receiving CABG and PCI

**FIGURES**

**Figure 1: Standardized rates of CR by state**

