JACC: ADVANCES VOL. 3, NO. 11, 2024

ORIGINAL RESEARCH

OUTCOMES AND QUALITY

Is 70% Achievable? Hospital-Level Variation in Rates of Cardiac Rehabilitation Use Among Medicare Beneficiaries

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ABSTRACT

BACKGROUND Despite national goals to enroll 70% of cardiac rehabilitation (CR)-eligible patients, enrollment remains low.

OBJECTIVES The purpose of this study was to evaluate how the treating hospital influences CR enrollment nationally.

METHODS We included Fee-for-Service Medicare beneficiaries aged ≥66 years who were hospitalized for acute myocardial infarction, coronary artery bypass grafting, percutaneous coronary intervention, or heart valve repair/replacement. We examined: 1) a risk-standardized model to assess comparative hospital rates; 2) a linear regression model to identify hospital factors associated with rates of risk-standardized CR; and 3) a hierarchical generalized linear model to calculate the hospital median OR.

RESULTS At 3,420 hospitals, we identified 264,970 eligible patients. A minority of hospitals (n = 1,446; 38%) performed cardiac surgery, but these hospitals cared for the majority (n = 242,875; 92%) of all eligible patients. Subsequent analyses were limited to these hospitals. The median risk-standardized CR enrollment rate was low (22%) and varied 10-fold across hospitals (10th, 90th percentile: 3%, 42%). Factors associated with higher hospital performance were Midwest location, higher number of hospital beds, directly affiliated CR program, and <1 mile distance between the hospital and closest CR facility. The national hospital median OR was 2.1.

CONCLUSIONS The treating hospital plays a key role in facilitating CR enrollment after discharge. Fewer than 1% of U.S. hospitals achieved a risk-standardized CR enrollment rate of >70%. Hospitals with cardiac surgery capability care for more than 90% of all CR-eligible patients and may be a logical place to focus improvement efforts. (JACC Adv. 2024;3:101275) © 2024 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

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Manuscript received May 30, 2024; revised manuscript received July 19, 2024, accepted August 6, 2024.

ISSN 2772-963X https://doi.org/10.1016/j.jacadv.2024.101275

ABBREVIATIONS AND ACRONYMS

ACC = American College of Cardiology

AHA = American Heart Association

AMI = acute myocardial infarction

CABG = coronary artery bypass graft surgery

CR = cardiac rehabilitation

MOR = median OR

PCI = percutaneous coronary intervention

RSCR = risk standardized cardiac rehabilitation rate

Cardiac rehabilitation (CR) is a multicomponent intervention that includes supervised exercise training and cardiac risk-modifying interventions.[1] It improves quality of life and reduces rehospitalization rates after cardiovascular events, procedures, and cardiac surgery.[1-5] CR may also reduce all-cause mortality for some conditions.[6] Despite the proven efficacy of CR, it is underutilized, with previous reports of national enrollment rates ranging from 19% to 34%, depending on the condition.[7-9] Recognizing the substantial benefits of CR, the American College of Cardiology (ACC) and American Heart Association (AHA) established referral and enrollment Performance Measures in 2018.[10] Simultaneously, the Center for Disease Control and Prevention instituted the Million Hearts Cardiac Rehabilitation Collaborative, a national initiative with the goal of attaining 70% enrollment among CR-eligible patients.[11] While this target is ambitious, Nebraska achieved an enrollment rate of 56% in 2017, and there are case reports of high-performing hospitals reaching 64%.[9,12]

Prior studies described variation in CR enrollment across condition, education, income, and region.[8,13-15] However, less attention has focused on hospital-level variation in CR enrollment. Arguably, hospital-level enrollment rates are more important than regional or national rates because hospitalization is when most patients are diagnosed or undergo a qualifying procedure; each hospital has clear responsibility and opportunity to improve care for its patients; the hospital is a major target of the ACC/AHA performance measures[10]; and value-based purchasing measure typically target hospitals.[16] Therefore, in a large national sample, we: 1) examined hospital-level variation in CR enrollment rates among patients hospitalized for acute myocardial infarction (AMI), coronary artery bypass graft surgery (CABG), percutaneous coronary intervention (PCI), or heart valve repair/replacement; 2) evaluated a possible method for using CR enrollment as a hospital quality metric by grouping hospitals as above, at, or below national rates of CR; 3) identified hospital factors associated with higher and lower CR enrollment rates; and 4) calculated the association between the hospital and CR participation using the median OR (MOR).

METHODS

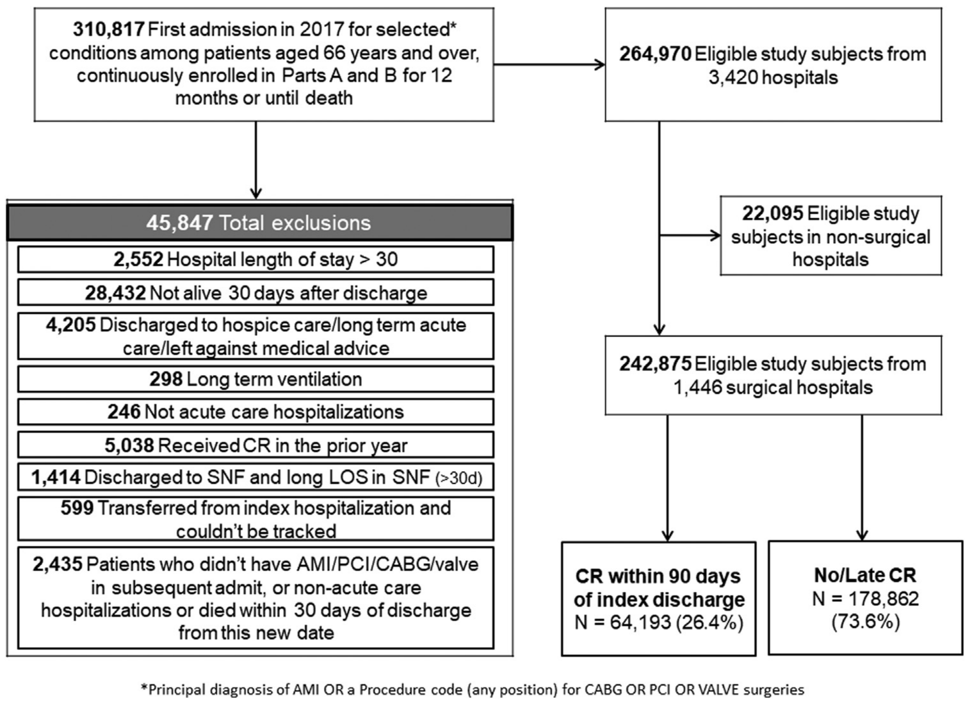
DESIGN, SETTING, AND STUDY POPULATION. The Baystate Health Institutional Review Board approved this study. We used the Centers for Medicare and Medicaid Services files to identify Fee-for-Service (FFS) beneficiaries who were aged ≥66 years and were hospitalized in 2017 with a principal diagnosis of AMI or with a procedure code for valve surgery, CABG, or PCI. The diagnostic and procedure codes used to identify our cohort are found in Supplemental Table 1. We used very similar inclusion and exclusion criteria to those used in the ACC/AHA performance measures.[10] We initially planned to include beneficiaries with heart failure but were unable to do so because too few patients with heart failure attended CR in 2018 to calculate hospital rates.

We considered patients' first admission in 2017 as the index admission. Because prolonged hospital admission is associated with loss of functional status that makes patients ineligible for CR, we excluded patients with long length of stay (>30 days). We excluded those who were not alive 30 days post discharge, those on long-term ventilation, those discharged or transferred to long-term acute care facilities, those who left the hospitalization against medical advice, and those discharged to skilled nursing facilities who then stayed in the facility longer than 30 days. We excluded patients whose discharge status could not be tracked post index hospitalization and those not continuously enrolled in the Medicare FFS program for >1 year following their index admission as we could not assess their receipt of CR. We required patients who transferred to have a discharge diagnosis code after transfer that qualified them for CR and considered the discharging hospital to be the primary hospital for analysis. We excluded patients who were transferred if: 1) we could not track the patient; 2) there was not a subsequent admission for AMI, CABG, PCI, or valve surgery; or 3) they died within 30 days of discharge. Finally, to create an inception cohort for our analysis, we excluded patients who received CR in the year prior to their index admission[17] (**Figure 1**).

COVARIATES. To assess comorbidities and prior healthcare utilization, we obtained claims data from 2016 to identify sociodemographic characteristics including age, sex, race/ethnicity, and Medicare/Medicaid dual eligibility from the Medicare Beneficiary Summary file. We computed a longitudinal Charlson Comorbidity Index score using prior year data from the inpatient, outpatient, and carrier files.[18] Using methods described by Gilbert et al,[19] we assigned all beneficiaries a frailty score and then categorized the risk of frailty as high, medium, or low.

We obtained hospital characteristics including size, region, teaching status, and rurality from publicly available Center for Medicare and Medicaid provider

FIGURE 1 Cohort Creation With Exclusion Details



AMI = acute myocardial infarction; CABG = coronary artery bypass grafting; CR = cardiac rehabilitation; LOS = length of stay; PCI = percutaneous coronary intervention; SNF = skilled nursing facility.

of service files. Hospitals were grouped as small (≤200 beds), medium (201-400 beds), or large (≥401 beds), and region was defined as Northeast, Midwest, West, and South. Using these data, we noted if a hospital had cardiac surgical capability, meaning that they had ≥1 CABG procedure code in the total cohort in the years of analysis. We also merged data from American Hospital Association survey to the analytic file to obtain CR service availability at hospitals, including the presence of outpatient CR.[20]

To assess the impact of distance on CR enrollment rates, we calculated the distance in miles between the hospital and the nearest CR program using known addresses of each. We categorized hospitals by distance using ≥1 mile as the cutoff, as this was near the median distance between hospitals and their closest CR program. We also calculated the distance in miles from the patient's home zip code to the nearest CR program. These distances were computed using the SAS ZIPCITYDISTANCE function, which uses centroid of the zip codes to compute the distance between any pair of zip codes.

MEASUREMENT OF CR ENROLLMENT. We defined CR enrollment in either institutional outpatient facilities or office-based programs; we identified CR claims using the Healthcare Common Procedure Coding System codes (G0422, G0433) and current procedural terminology codes (93,797, 93,798). To best evaluate the association between hospitalization and CR enrollment, we examined time from discharge to the initial CR session and then examined the cumulative enrollment percentage over the 12 months following discharge (Supplemental Figure 1). After examining this plot, we chose enrollment within 90 days as our cutoff because this captured >90% of patients and was close enough in time to the hospitalization that it was plausible the hospital could have impacted enrollment.

STATISTICAL ANALYSIS. In preliminary analyses, we found that the vast majority of all eligible cardiac patients (>90%) and almost all those who attended CR (also >90%) were seen at hospitals with surgical capability. Because we aimed to examine patient and hospital factors associated with CR enrollment, we knew that models that included nonsurgical hospitals would identify cardiac surgical capability as the overwhelming predictor of CR enrollment, which would limit our ability to understand and describe the impact of other hospital and patient characteristics. Thus, we limited additional analyses to patients seen at hospitals with surgical capability.[21]

We calculated patient- and hospital-level characteristics as frequencies and percentages for categorial variables and as mean ± SD or medians (IQR) for continuous variables. Due to the large sample size, we assessed associations between receipt of CR and patient and hospital characteristics using absolute standardized differences, where differences >10% were considered meaningful.[22]

To examine variation in hospital enrollment, we calculated hospitals' risk standardized rates of CR. To obtain stable estimates, we restricted our analyses to hospitals with 10 or more patients eligible for CR. We computed hospital-specific risk-standardized CR rates (RSCRs) using hierarchical generalized linear models with random intercepts for the hospital, with binomial distribution and logit link function. This model included limited patient-level factors from the list described above for the prediction model, consistent with prior published methodology.[23-26] We calculated an RSCR for each hospital as the ratio of predicted to expected CR rate multiplied by the crude CR rate from all patients in the cohort. (For full details, see Technical Appendix in the Supplemental Material).

Then, to understand factors associated with the RSCR rates, we fit a linear regression model to evaluate associations between RSCR rates and hospital characteristics. The variation between hospitals in patient subgroups (CABG, PCI, MI) was noted from crude hospital-level rates, but we did not create separate risk standardized models for each condition because we were concerned about model stability, especially for hospitals with smaller volume.

Using this RSCR model, we applied nonparametric bootstrap methods to identify better-, average-, or worse-performing hospitals relative to the national CR rate. We ran 500 bootstrap replications for the RSCR and estimated the percentile-based 95% CI.[25,27] This allowed us to classify a hospital as better performing (if their RSCR and the percentile-based 95% CI was completely above the crude CR rate), worse performing (if the corresponding RSCR and 95% CI was below the crude CR rate), or no different than the national average (if the 95% CI included the overall crude CR rate). See also Technical Appendix.

Finally, to assess patient and hospital factors predicting CR enrollment for individual patients, we built a hierarchical generalized linear model including a hospital random intercept. This model included patient demographics, an indicator of admission for surgery, PCI with or without MI, medical MI (yes/no), history of tobacco use, atrial fibrillation, Charlson comorbidities, number of hospitalizations in the year prior to the index admit, distance to closest CR facility, as well as hospital characteristics such as size, region, rurality, and teaching status. From this model, we computed the MOR, which measures the variation among hospitals after accounting for other factors in the model. The MOR is the median of a set of ORs between 2 patients with the same characteristics receiving CR at 2 randomly selected hospitals, one with a higher propensity to provide CR and the other with a lower propensity to provide CR.[28] All analyses were performed using SAS (version 9.4, SAS Institute) and STATA 17 (StataCorp) software.

RESULTS

We identified a total of 264,970 Medicare beneficiaries from 3,420 hospitals with a qualifying diagnosis in 2017 (Supplemental Table 1). In this full cohort, median of time to first CR session in days was 39 (IQR: 24-62), and median of number of sessions completed within the year of CR start was 30 (IQR: 16-36); thus, 67,006 (25.3%) patients attended CR within 90 days of discharge. At the 1,974 hospitals *without* surgical capability, there were 22,095 eligible patients of whom 2,813 (12.7%) attended CR, representing 4.2% of the 67,006 total who attended CR.

At the 1,446 hospitals *with* cardiac surgical capability, we identified 242,875 eligible beneficiaries after exclusions (**Figure 1**). This represented 91.7% of all eligible patients. As described in the Methods section, we then limited additional analyses to surgical hospitals.

Of 242,875 patients in surgical hospitals, 102,530 (42.2%) received cardiac surgery, 78,920 (32.5%) received PCI with or without AMI, and 61,425 (25.3%) had an AMI that was medically managed. The mean beneficiary age was 77.6 ± 7.3 years; fewer than half (41.3%) of the beneficiaries were female; the mean Charlson Comorbidity Index Score was 4.6 ± 3.0; and

TABLE 1 Characteristics of Patients With and Without Cardiac Rehabilitation Exposure Admitted to Hospitals With Cardiac Surgical Capability

	Patients in Surgical Hospitals			
	Total (N = 242,875, 100.0%)	No CR/Late CR (n = 178,862, 73.6%)	CR in 90 Days (n = 64,193, 26.4%)	ASD (%)
Age, y				41.7
Mean ± SD, y	77.6 ± 7.3	78.4 ± 7.6	75.5 ± 6.1	
Median (IQR), y	77 (71-83)	78 (72-84)	75 (70-80)	
Female	100,330 (41.3)	79,229 (44.3)	21,101 (32.9)	23.7
Race/ethnicity				25.4
White	207,575 (85.5)	149,264 (83.5)	58,311 (90.8)	
Black	14,753 (6.1)	12,727 (7.1)	2026 (3.2)	
Hispanic	10,601 (4.4)	9,148 (5.1)	1,453 (2.3)	
Other	9,946 (4.1)	7,543 (4.2)	2,403 (3.7)	
Group				63.2
Surgical	102,530 (42.2)	63,899 (35.8)	38,631 (60.2)	
Percutaneous coronary intervention ± MI	78,920 (32.5)	59,170 (33.1)	19,750 (30.8)	
MI only	61,425 (25.3)	55,613 (31.1)	5,812 (9.1)	
Medicaid dual eligibility	35,565 (14.2)	31,673 (17.7)	2,792 (4.4)	43.7
Weighted Longitudinal Charlson Score				46.2
Mean ± SD	4.6 (3.0)	5.0 (3.0)	3.7 (2.6)	
Median (IQR)	4 (2-7)	5 (3-7)	3 92-5)	
Charlson comorbidity groups				
MI	154,901 (63.8)	121,371 (67.9)	33,530 (52.2)	32.5
Heart failure	132,391 (54.5)	105,238 (58.9)	27,153 (42.3)	33.7
Peripheral vascular disease	90,764 (37.4)	71,478 (40.0)	19,288 (30.0)	21.0
Cerebrovascular disease	68,940 (28.4)	52,488 (29.4)	16,452 (25.6)	8.4
Dementia	21,310 (8.8)	19,544 (10.9)	1766 (2.8)	32.9
Chronic obstructive pulmonary disease	86,313 (35.5)	68,094 (38.1)	18,219 (28.4)	20.8
Connective tissue disease—rheumatic disease	13,590 (5.6)	10,493 (5.9)	3,097 (4.8)	4.7
Peptic ulcer disease	6,622 (2.7)	5,365 (3.0)	1,257 (2.0)	6.7
Mild liver disease	12,870 (5.3)	9,766 (5.5)	3,104 (4.8)	2.9
Diabetes without/with complications	112,628 (46.4)	86,635 (48.5)	25,993 (40.5)	16.1
Paraplegia and hemiplegia	4,955 (2.0)	4,303 (2.4)	652 (1.0)	10.8
Renal disease	87,853 (36.2)	70,933 (39.7)	16,920 (26.4)	28.7
Cancer	37,050 (15.3)	27,443 (15.4)	9,607 (15.0)	1.1
Moderate or severe liver disease	1,495 (0.6)	1,262 (0.7)	233 (0.4)	4.7
Metastatic carcinoma	4,300 (1.8)	3,617 (2.0)	683 (1.1)	7.8
Human immunodeficiency virus/AIDS	336 (0.1)	278 (0.2)	58 (0.1)	1.9
Frailty				39.9
Low risk (<5)	134,908 (55.6)	91,214 (51.1)	43,694 (68.1)	
Intermediate risk (5-15)	89,150 (36.7)	70,238 (39.3)	18,912 (29.5)	
High risk (>15)	18,817 (7.8)	17,230 (9.6)	1,587 (2.5)	
Cardiac catheterization	117,614 (48.4)	87,455 (48.9)	30,159 (47.0)	3.9
Any history of atrial fibrillation	90,743 (37.4)	67,040 (37.5)	23,703 (36.9)	1.2
Tobacco user	28,775 (11.9)	23,073 (12.9)	5,701 (8.9)	13.0
Prior year admissions categories				37.6
0 admissions	164,908 (67.9)	114,249 (63.9)	50,659 (78.9)	
1 admission	44,548 (18.3)	35,056 (19.6)	9,492 (14.8)	
2+ admissions	33,419 (13.80	29,377 (16.4)	4,042 (6.3)	
Distance to closest CR facility				22.6
Mean ± SD, miles (from patient zip code)	7.7 (11.1)	8.3 (12.0)	6.1 (7.4)	
Median (IQR), miles	4.8 (1.9-10.1)	5 (2.1-10.7)	4.3 (0-8.8)	
Distance to closest hospital (from patient zip code)				0.4
Mean ± SD, miles	6.0 (8.0)	6.0 (8.2)	6.0 (7.7)	
Median (IQR)	3.8 (0.1-8.4)	3.7 (1.9-9.3)	4 (0-8.5)	

Continued on the next page

TABLE 1 Continued

	Patients in Surgical Hospitals			
	Total (N = 242,875, 100.0%)	No CR/Late CR (n = 178,862, 73.6%)	CR in 90 Days (n = 64,193, 26.4%)	ASD (%)
Discharge disposition				24.9
Home or self-care	136,927 (56.4)	99,102 (55.5)	37,825 (58.9)	
Other short term or Critical Access Hospital	1068 (0.4)	764 (0.4)	304 (0.5)	
Skilled nursing facility/Intermediate care facility	32,663 (13.5)	27,312 (15.3)	5,351 (8.3)	
Home care	51,954 (21.4)	36,066 (20.2)	15,888 (24.8)	
Inpatient rehabilitation	11,703 (4.8)	8,850 (5.0)	2,853 (4.4)	
Other	8,560 (3.5)	6,588 (3.7)	1,972 (3.1)	

Values are mean ± SD, median (IQR), or n (%).
AIDS = Acquired Immune Deficiency Syndrome; ASD = absolute standardized difference; CR = cardiac rehabilitation; MI = myocardial infarction.

approximately 8% of the group was at high risk of frailty (Table 1).

In total, 64,193 (26.4%) beneficiaries participated in ≥1 CR session within 90 days of discharge. Most of the patients who attended CR received surgery (60.2%), approximately one-third of patients received PCI with or without AMI (30.8%), and <10% had a medically managed AMI (9.1%). Compared to the non-CR group, beneficiaries in the CR-enrolled group were less likely to be frail (2.5% vs 9.6% for low risk vs high risk of frailty), less likely to have been admitted to the hospital in the prior year, and more likely to have been discharged to home or self-care after hospitalization. Frequent comorbidities included diabetes (40.5%), renal disease (26.4%), and chronic obstructive pulmonary disease (28.4%) (Table 1).

Most hospitals were medium size (616, 42.6%) or large (514, 35.6%) by bed count. Most hospitals were in urban areas (1,339, 92.6%), nonteaching (742, 51.3%), and located in the South (588, 40.7%) (Table 2).

TABLE 2 Characteristics of Hospitals With Cardiac Surgery Capability (N = 1,446, 100%)

Size	
<201 beds	316 (21.9)
201-400 beds	616 (42.6)
>400 beds	514 (35.6)
Teaching status	
Nonteaching	742 (51.3)
Teaching	704 (48.7)
Rural/Urban status	
Urban	1,339 (92.6)
Rural	107 (7.4)
Region	
Northeast	201 (13.9)
Midwest	361 (25.0)
South	588 (40.7)
West	296 (20.5)
Distance between hospital and CR program, miles	1.4 ± 4.0
Cardiac rehabilitation owned or provided by the hospital or its subsidiary	1,053 (72.8)
Hospital provides CR/pulmonary rehabilitation services through satellite outpatient departments	604 (41.8)

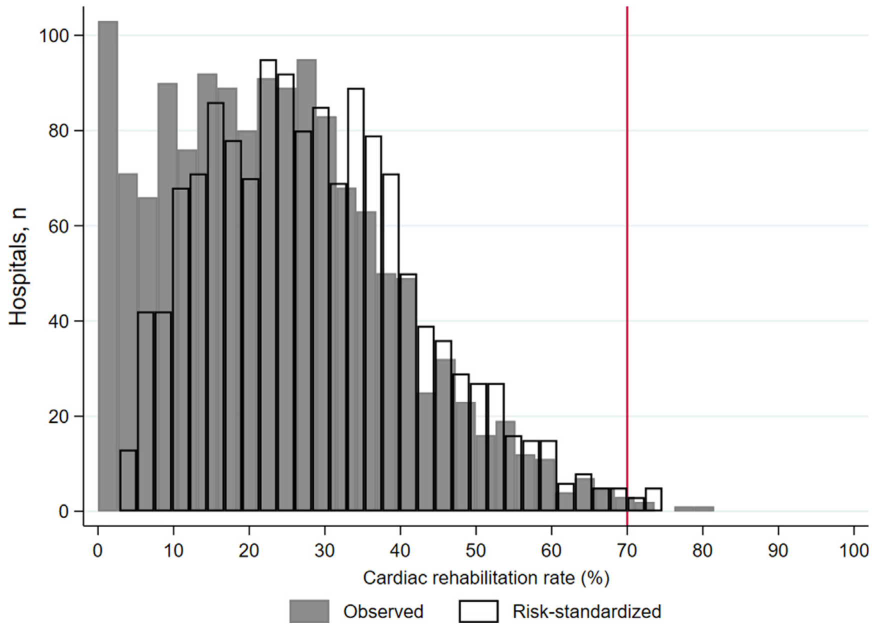
Values are n (%) or mean ± SD.

Observed (unadjusted) hospital rates showed an overall hospital median CR enrollment rate of 22.0% (IQR: 11.6%-32.6%) (Supplemental Table 2). Among hospitals with ≥10 patients with surgery, the median hospital enrollment rate was 38.9% (IQR: 24.0%-53.1%). Hospitals at the 90th percentile achieved at least 66% CR enrollment rate (N = 94); hospitals at the 95% percentile achieved a 72% enrollment rate (N = 58). In hospitals reporting ≥10 patients who received PCI, the median CR enrollment rate among patients who received a PCI was 23.3% (IQR: 12.5%-35.6%). Hospitals at the 90th percentile achieved a 47% CR enrollment rate (N = 128), and hospitals in the 95th percentile achieved a 56% CR enrollment rate (N = 62). In hospitals reporting ≥10 patients with medically managed MI, the median CR enrollment rate was 7.4% (IQR: 2.9%-13.3%); hospitals at the 90th percentile achieved an enrollment rate of 21.4% (N = 131).

After risk adjustment, in hospitals with at least 10 Medicare beneficiaries, the median hospital rate of risk-standardized CR enrollment was 27.6% (10th-90th percentile: 11.2%-48.3%) for all conditions combined. Hospitals at the 90th percentile had an enrollment rate of 48.3%, and hospitals at the 95th percentile had a rate of 54.9%. There were 37 hospitals that achieved an overall rate of 60% or higher. Less than 1% of hospitals achieved an overall risk-adjusted rate of 70% (Figure 2).

Independent factors associated with a higher hospital-based risk-standardized rate of CR

FIGURE 2 **Observed and Risk-Standardized Hospital-Specific Risk-Standardized Cardiac Rehabilitation Participation Rates**



Reference line on the x-axis at 70% shows the Million Hearts Campaign target for cardiac rehabilitation.

enrollment included Midwest location (+13.9% vs south, $P < 0.001$), <1 mile distance from the hospital to the closest CR program (+4.8%, $P < 0.001$), and presence of a hospital owned CR program (+6.7%, $P < 0.001$). Higher hospital bed count was associated with lower CR enrollment (−4.2%, $P < 0.001$, 400+ vs ≤200-bed hospital) (**Table 3**).

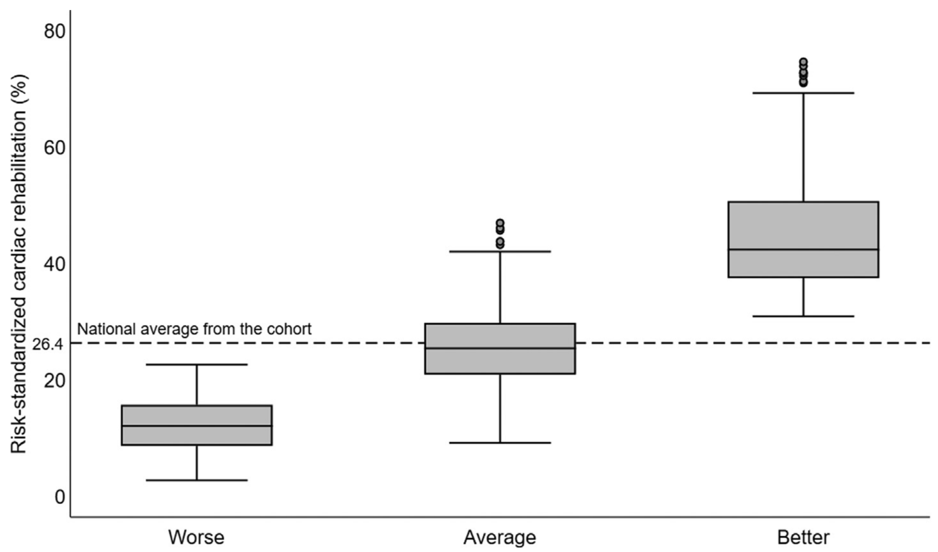
Using nonparametric bootstrap methods, we found that a large proportion of hospitals could be classified as better or worse than the national average. Specifically, 301 hospitals (21.2%) were worse than the national average, 662 (46.7%) were no different than the national average, and 453 (31.9%) were better than the national average (**Figure 3**). The median CR participation rate for each group were as follows: 12.2% (IQR: 8.7%-15.8%) for the worse than group, 25.5% (IQR: 21%-29.8%) for the no different group, and 42.4% (IQR: 37.5%-50.8%) for the better than group.

From the patient-level prediction model, factors associated with higher CR enrollment were having cardiac surgery (OR: 5.8 [95% CI: 5.6-6.0] vs MI); undergoing PCI (OR: 2.6 [95% CI: 2.5-2.7] vs MI); or living in the Midwest (OR: 2.4 [95% CI: 2.1-2.7] vs South) (**Table 4**). Factors associated with lower CR enrollment included older age (OR: 0.77 [95% CI: 0.76-0.774] per 5-year increase), lower socioeconomic status (OR: 0.33 [95% CI: 0.32-0.35]), and smoking (OR: 0.59 [95% CI: 0.57-0.61]). The hospital MOR was 2.1, similar in effect size to PCI or Midwest location.

TABLE 3 **Association Between Hospital Characteristics and Hospital Risk-Standardized Cardiac Rehabilitation Enrollment Rates**

	Estimate (SE)	*P* Value
Intercept	0.2329 (0.0101)	<0.0001
Region		
Northeast	0.0164 (0.0102)	0.109
Midwest	0.1390 (0.0082)	<0.0001
West	0.0150 (0.0087)	0.086
South (Referent)		
Rural hospital	−0.0073 (0.0123)	0.564
Teaching hospital	0.0003 (0.0070)	0.968
Size		
≤200 beds (Referent)		
201-400 beds	−0.0245 (0.0086)	0.005
>400 beds	−0.0421 (0.0097)	<0.0001
Distance between hospital and closest CR facility <1 mile	0.0481 (0.0080)	<0.0001
Cardiac rehabilitation owned or provided by the hospital or its subsidiary	0.0673 (0.0083)	<0.0001
Hospital provides CR/pulmonary rehabilitation services through satellite outpatient departments	0.0067 (0.0071)	0.350

FIGURE 3 Risk-Standardized CR Rates Among Worse, at Average, or Better Performing Hospitals



DISCUSSION

In a large national cohort of Medicare beneficiaries hospitalized for conditions for which CR is recommended, we observed wide variation (up to 10-fold differences) in rates of CR enrollment across hospitals. We identified patient and hospital predictors of CR enrollment: Patients were more likely to enroll in CR if they received CABG or valve surgery, were younger, nonsmokers, of higher socioeconomic status, and/or were residents of the Midwest. There was a significant association between discharging hospital and subsequent CR enrollment, with a MOR suggesting that a patient discharged from a high-performing hospital was twice as likely to enroll in CR compared to a similar patient from a low-performing hospital. About 30% of hospitals achieved CR participation rates that were better than the national average participation rate of 24%,[8] yet <1% of hospitals achieved the target of 70% participation across all conditions. If only considering enrollment rates of patients who received cardiac surgery, a small cohort of hospitals achieved or were close to this 70% mark, but these hospitals treat only a small proportion of patients who are eligible for CR in the United States. Notably, 92% of patients who were eligible for CR and 96% of patients who received CR after hospitalization were treated in hospitals that performed cardiac surgery, suggesting a logical place to focus improvement efforts (**Central Illustration**).

Our reported national enrollment rate of 24% is lower than that reported by Keteyian (28.9%) using data from 2018,[9] but this is likely because we only included CR enrollment up until 90 days after hospital discharge. Our reported rates are otherwise similar to data from 2014 to 2017,[8,29] although the COVID pandemic more recently worsened CR attendance.[29,30] Due to typical delays with Medicare data, more recent information is not available. However, measuring absolute rates was never our primary objective; rather our goal was to describe the relationship of the hospital to CR enrollment. We do not think a change in the absolute rate of CR enrollment would measurably impact our findings and hospital relationship to CR enrollment.

Our finding of higher enrollment rates for patients with CABG (54%) and PCI (29%) vs MI (13%) is a well-described pattern.[8] The reasons for this pattern are unknown but are likely due to: 1) the higher psychological impact of surgery and procedures for motivating post-hospital lifestyle change; and 2) these procedures are a distinct moment in hospital care where automatic orders set can be consistently implemented. For patients with MI, new strategies seem clearly needed to motivate them to attend CR. Innovative processes—like natural language processing of the electronic medical record to generate automatic orders—may help close some of the gaps for patients with medically managed MI.

To our knowledge, this article is the first to do a detailed analysis of the national variation in CR rates at the hospital level (rather than hospital referral region, state, or census division). We chose the hospital as our unit of analysis because current ACC/AHA performance measures are focused at the hospital level, and strategies for increasing CR rates (eg, a liaison or navigator; automatic referral; early appointments; physician endorsement; and others[31-33]) are also generally implemented at the hospital level. Our findings of wide between-hospital variation match those of Thompson et al. who found an overall CR enrollment rate of 28.8% among 33 hospitals in the state of Michigan, with hospital rates ranging from 9.8% to 51.6%.[16] Lastly, we are the first to show that only a small minority of hospitals (<1%) have achieved >70% enrollment.

Our calculation of a national-level MOR also adds to the literature. Prior studies of smaller samples of hospitals (within individual states or limited to the Department of Veterans Affairs) have reported MORs in the 1.6 to 3.8 range, but these were not limited to surgical hospitals.[34,35] Our MOR of 2.1 likely reflects a more realistic measurement of the hospital effect, in settings where services and procedures are uniformly available and not the only driving factor in enrollment.

Our study has important implications. We confirmed low CR utilization but also identified several opportunities for future research and implementation efforts, especially in surgical hospitals. For example, it is likely that high-performing hospitals in our study are employing strategies (eg, automatic referral, navigators) highlighted in the recent second edition of the Centers for Disease Control and Prevention's Cardiac Rehabilitation Change Package,[36] but few of these strategies have been tested in multisite implementation trials, highlighting a key area for future research. In the future, we plan to report how survey-determined hospital-based CR strategies affect risk-standardized enrollment rates.

Our findings also suggest an opportunity for using CR enrollment rates as a value-based purchasing measure focused on CR enrollment. The current Healthcare Effectiveness Data and Information Set measures focus only on the insurance industry, and the ACC/AHA performance measures did not establish upper or lower boundaries for incentive payments. The low rates of enrollment for medically managed MI also suggest that additional future research, policy, and quality-improvement efforts should be directed towards patients who do not undergo surgery or PCI but still qualify for CR.

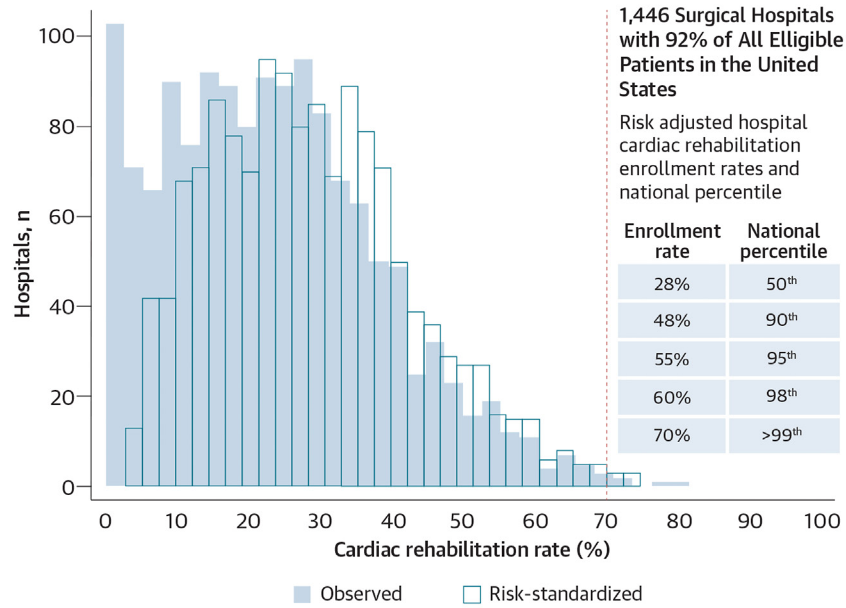
Finally, although we excluded patients at nonsurgical hospitals for statistical modeling purposes, we strongly believe that all patients, regardless of where they are cared for (rural, small, nonsurgical hospitals), should be referred and enrolled in CR. These patients will likely need alternate delivery models, such as home-based or technology-supported CR.[37]

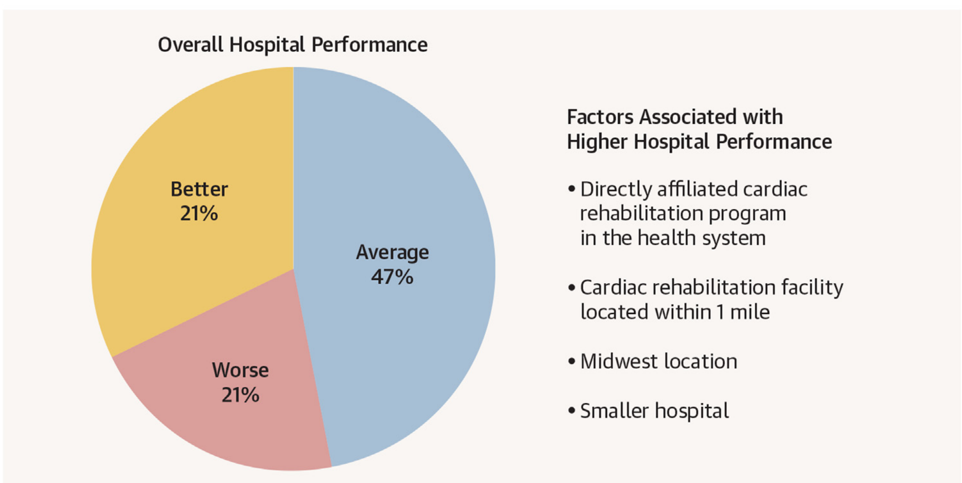
TABLE 4 Patient-Level Predictors of Cardiac Rehabilitation Enrollment From Hierarchal Generalized Linear Model Including Hospital Random Effect

	OR	LL	UL	*P* Value
Age, per 5 y	0.77	0.76	0.77	<0.0001
Gilbert frailty score, per 5 U	0.82	0.80	0.83	<0.0001
Distance to closest CR facility, per 5 miles	0.84	0.83	0.84	<0.0001
Group				
Surgical	5.76	5.56	5.97	<0.0001
Percutaneous coronary intervention ± MI	2.65	2.55	2.74	<0.0001
MI only (Referent)				
Female	0.79	0.78	0.81	<0.0001
Dual eligibility	0.33	0.32	0.35	<0.0001
Comorbidities				
Heart failure	0.66	0.64	0.67	<0.0001
Peripheral vascular disease	0.83	0.81	0.85	<0.0001
Cerebrovascular disease	1.04	1.01	1.07	0.0028
Dementia	0.59	0.55	0.62	<0.0001
Chronic obstructive pulmonary disease	0.89	0.86	0.91	<0.0001
Mild liver disease	1.05	1.00	1.11	0.0391
Moderate or Severe liver disease	0.63	0.54	0.74	<0.0001
Diabetes without/with complications	0.87	0.85	0.89	<0.0001
Paraplegia and hemiplegia	0.72	0.65	0.80	<0.0001
Renal disease	0.87	0.85	0.89	<0.0001
Cancer	1.10	1.07	1.14	<0.0001
Metastatic carcinoma	0.60	0.54	0.66	<0.0001
Active tobacco use	0.59	0.57	0.61	<0.0001
Atrial fibrillation	0.96	0.93	0.98	0.0002
Prior year admissions				
0 admission (Referent)				
1 admission	0.89	0.87	0.92	<0.0001
2+ admissions	0.74	0.70	0.77	<0.0001
Hospital characteristics				
Size				
≤200 beds (Referent)				
201-400 beds	0.93	0.81	1.06	0.2495
>400 beds	0.89	0.77	1.02	0.0945
Teaching status (Yes)	1.02	0.92	1.12	0.7317
Rural (Yes)	1.12	0.93	1.36	0.2359
Region				
Northeast	0.92	0.79	1.06	0.2385
Midwest	2.40	2.14	2.69	<0.0001
West	1.08	0.95	1.23	0.238
South (Referent)				

STUDY LIMITATIONS. Our study has some limitations. We restricted our analysis to beneficiaries aged ≥66 years with Medicare FFS coverage in 2018, so our study is not representative of younger patients, those with commercial insurance, changes in enrollment related to the coronavirus-19 pandemic, or the 30% to 40% of Medicare beneficiaries enrolled in a Medicare Advantage Plan. However, the sample was large and nationally representative of FFS Medicare beneficiaries. Because we were only able to determine eligibility based on claims, we were unable to assess patient-level exclusions that programs often apply. However, we did apply most of the exclusions

CENTRAL ILLUSTRATION The Key Role of Hospitals in Promoting Cardiac Rehabilitation Enrollment After Discharge





Pack QR, et al. JACC Adv. 2024;3(11):101275.

Hospitals differ by as much as 10× in their cardiac rehabilitation enrollment rates. The national median OR for hospital effect was 2.1—a substantial effect size similar to Midwest location. Less than 1% of hospitals achieved the 70% enrollment benchmark (red vertical line), set by the Million Hearts Cardiac Rehabilitation Collaborative.

and exceptions as suggested in the ACC/AHA performance measures, including death, transfer, leaving against medical advice, or discharge to a long-term care facility. We also excluded hospice patients and considered frailty as a marker of participation. However, even these exclusions may not adequately represent all the "softer" exclusions programs often apply,[12] where in 1 study, 15% (107 of 710) of patients were excluded because of center-level eligibility concerns. Thus, our denominator may be larger (and rates lower) than that many programs would consider when evaluating patients individually. Unlike the ACC/AHA performance measures, we chose not to exclude patients with >60-mile travel distance because this was a tiny portion of the population (0.5%), and we chose to err on the side of inclusiveness. Finally, as described earlier, we were unable to include patients with heart failure because of very small numbers of patients with heart failure who attended CR.

CONCLUSIONS

Despite the well-documented benefits of CR in enhancing the quality of life and reducing rehospitalization and mortality rates among patients with cardiac conditions, only a handful of hospitals in the United States have reached the Million Hearts Cardiac Rehab Collaborative goal of attaining a 70% CR participation rate. A few high performers may be using implementation strategies that should be tested in future studies. Hospital CR enrollment rate may have potential for eventual use as a hospital quality measurement tool.

FUNDING SUPPORT AND AUTHOR DISCLOSURES

This work was funded by the National Heart, Lung, and Blood Institute of the National Institutes of Health under Award 1R01HL146884. Dr Pack was supported by the National Heart, Lung, and Blood Institute under award K23 HL135440. All other authors have reported that they have no relationships relevant to the contents of this paper to disclose.

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PERSPECTIVES

COMPETENCY IN MEDICAL KNOWLEDGE AND PATIENT CARE: Guidelines strongly recommend that patients attend CR. Yet, most patients who are eligible for CR do not attend. Clinicians, especially cardiologists, should consistently persuade patients to attend CR after hospital discharge.

COMPETENCY IN SYSTEMS-BASED PRACTICE: The hospital where a patient is cared for is an important predictor of CR enrollment. Cardiologists should help build systems of care at their local hospital to assure consistent referral and enrollment.

TRANSLATIONAL OUTLOOK: New referral and recruitment strategies should be tested in randomized trials, and then implemented nationally, to help hospitals achieve 70% CR referral and enrollment.

REFERENCES

1. Thomas RJ. Cardiac rehabilitation - challenges, advances, and the road ahead. *N Engl J Med*. 2024;390(9):830–841. https://doi.org/10.1056/NEJMra2302291

2. Balady GJ, Williams MA, Ades PA, et al. Core components of cardiac rehabilitation/secondary prevention programs: 2007 update. *Circulation*. 2007;115(20):2675–2682. https://doi.org/10.1161/CIRCULATIONAHA.106.180945

3. Sibilitz KL, Berg SK, Tang LH, et al. Exercise-based cardiac rehabilitation for adults after heart valve surgery (Review). Cochrane heart group. *Cochrane Database Syst Rev*. 2016;3:CD010876. https://doi.org/10.1002/14651858.CD010876.pub2

4. Heran BS, Chen JM, Ebrahim S, et al. Exercise-based cardiac rehabilitation for coronary heart disease. The cochrane collaboration, ed. Cochrane database of systematic reviews. *Cochrane Database Syst Rev*. 2021:CD001800. https://doi.org/10.1002/14651858.CD001800.pub2

5. Bush M, Kucharska-Newton A, J Simpson R, Fang G, Stürmer T, Brookhart MA. Effect of initiating cardiac rehabilitation after myocardial infarction on subsequent hospitalization in older adults. *J Cardiopulm Rehabil Prev*. 2020;40(2):87–93. https://doi.org/10.1097/HCR.0000000000000452

6. Dibben GO, Faulkner J, Oldridge N, et al. Exercise-based cardiac rehabilitation for coronary heart disease: a meta-analysis. *Eur Heart J*. 2023;44(6):452–469. https://doi.org/10.1093/eurheartj/ehac747

7. Centers for Disease Control and Prevention (CDC). Receipt of cardiac rehabilitation services among heart attack survivors–19 states and the District of Columbia, 2001. *MMWR Morb Mortal Wkly Rep*. 2003;52(44):1072–1075.

8. Ritchey MD, Maresh S, McNeely J, et al. Tracking cardiac rehabilitation participation and completion among Medicare beneficiaries to inform the efforts of a national initiative. *Circ: Cardiovascular Quality and Outcomes*. 2020;13(1). https://doi.org/10.1161/CIRCOUTCOMES.119.005902

9. Keteyian SJ, Jackson SL, Chang A, et al. Tracking cardiac rehabilitation utilization in Medicare beneficiaries: 2017 update. *J Cardiopulm Rehabil Prev*. 2022;42(4):235–245. https://doi.org/10.1097/HCR.0000000000000675

10. Thomas RJ, Balady G, Banka G, et al. 2018 ACC/AHA clinical performance and quality measures for cardiac rehabilitation. *J Am Coll Cardiol*. 2018;71(16):1814–1837. https://doi.org/10.1016/j.jacc.2018.01.004

11. Ades PA, Keteyian SJ, Wright JS, et al. Increasing cardiac rehabilitation participation from 20% to 70%: a road map from the million hearts cardiac rehabilitation collaborative. *Mayo Clin Proc*. 2017;92(2):234–242. https://doi.org/10.1016/j.mayocp.2016.10.014

12. Frechette KM, Conley SM, Tang A, Welch TD. Cardiac rehabilitation in a rural setting: optimization of referral and participation rates. *J Cardiopulm Rehabil Prev*. 2019;39(1):E4–E7. https://doi.org/10.1097/HCR.0000000000000386

13. Ritchey MD, Wall HK, Owens PL, Wright JS. Vital signs: state-level variation in nonfatal and fatal cardiovascular events targeted for prevention by million hearts 2022. *MMWR (Morb Mortal Wkly Rep): Morb Mortal Wkly Rep*. 2018;67(35):974–982. https://doi.org/10.15585/mmwr.mm6735a3

14. Aragam KG, Dai D, Neely ML, et al. Gaps in referral to cardiac rehabilitation of patients undergoing percutaneous coronary intervention in the United States. *J Am Coll Cardiol*. 2015;65(19):2079–2088. https://doi.org/10.1016/j.jacc.2015.02.063

15. Gaalema DE, Higgins ST, Shepard DS, Suaya JA, Savage PD, Ades PA. State-by-State variations in cardiac rehabilitation participation are associated with educational attainment, income, and program availability. *J Cardiopulm Rehabil Prev*. 2014;34(4):248–254. https://doi.org/10.1097/HCR.0000000000000059

16. Thompson MP, Yaser JM, Hou H, et al. Determinants of hospital variation in cardiac rehabilitation enrollment during coronary artery disease episodes of care. *Circ: Cardiovascular*

Quality and Outcomes. 2021;14(2). https://doi.org/10.1161/CIRCOUTCOMES.120.007144

17. Lindenauer PK, Stefan MS, Pekow PS, et al. Association between initiation of pulmonary rehabilitation after hospitalization for COPD and 1-year survival among Medicare beneficiaries. *JAMA*. 2020;323(18):1813–1823. https://doi.org/10.1001/jama.2020.4437

18. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chron Dis*. 1987;40(5):373–383.

19. Gilbert T, Neuburger J, Kraindler J, et al. Development and validation of a Hospital Frailty Risk Score focusing on older people in acute care settings using electronic hospital records: an observational study. *Lancet*. 2018;391(10132):1775–1782. https://doi.org/10.1016/S0140-6736(18)30668-8

20. AHA annual survey Database™ | AHA data. Accessed December 22, 2023. https://www.ahadata.com/aha-annual-survey-database

21. Beatty Alexis L, Doll Jacob A, Schopfer David W, et al. Cardiac rehabilitation participation and mortality after percutaneous coronary intervention: insights from the Veterans Affairs clinical assessment, reporting, and tracking program. *J Am Heart Assoc*. 2018;7(19):e010010. https://doi.org/10.1161/JAHA.118.010010

22. Austin PC. Using the standardized difference to compare the prevalence of a binary variable between two groups in observational research. *Commun Stat Simulat Comput*. 2009;38(6):1228–1234. https://doi.org/10.1080/03610910902859574

23. Lindenauer PK, Grosso LM, Wang C, et al. Development, validation, and results of a risk-standardized measure of hospital 30-day mortality for patients with exacerbation of chronic obstructive pulmonary disease. *J Hosp Med*. 2013;8(8):428–435. https://doi.org/10.1002/jhm.2066

24. Lindenauer PK, Normand SLT, Drye EE, et al. Development, validation, and results of a measure of 30-day readmission following hospitalization for pneumonia. *J Hosp Med*. 2011;6(3):142–150. https://doi.org/10.1002/jhm.890

25. Krumholz HM, Wang Y, Mattera JA, et al. An administrative claims model suitable for profiling hospital performance based on 30-day mortality rates among patients with heart failure. *Circulation*. 2006;113(13):1693–1701. https://doi.org/10.1161/CIRCULATIONAHA.105.611194

26. Krumholz H, Normand SL, Galusha D, et al. *Risk-Adjustment Models for AMI and HF 30-Day Mortality: Methodology. Prepared for the Centers for Medicare & Medicaid Services under Subcontract #8908-03-02*. Yale University; 2005. Accessed February 10, 2010. http://www.qualitynet.org/dcs/ContentServer?c=Page&pagename=QnetPublic%2FPage%2FQnetTier3&cid=1163010421830

27. Lindenauer PK, Bernheim SM, Grady JN, et al. The performance of US hospitals as reflected in risk-standardized 30-day mortality and readmission rates for Medicare beneficiaries with pneumonia. *J Hosp Med*. 2010;5(6):E12–E18. https://doi.org/10.1002/jhm.822

28. Merlo J, Chaix B, Ohlsson H, et al. A brief conceptual tutorial of multilevel analysis in social epidemiology: using measures of clustering in multilevel logistic regression to investigate contextual phenomena. *J Epidemiol Community Health*. 2006;60(4):290–297. https://doi.org/10.1136/jech.2004.029454

29. Pandey A, Keshvani N, Zhong L, et al. Temporal trends and factors associated with cardiac rehabilitation participation among Medicare beneficiaries with heart failure. *JACC Heart Fail*. 2021;9(7):471–481. https://doi.org/10.1016/j.jchf.2021.02.006

30. Varghese MS, Beatty AL, Song Y, et al. Cardiac rehabilitation and the COVID-19 pandemic: persistent declines in cardiac rehabilitation participation and access among US Medicare beneficiaries. *Circ Cardiovasc Qual Outcomes*. 2022;15(12):e009618. https://doi.org/10.1161/CIRCOUTCOMES.122.009618

31. Grace SL, Angevaare KL, Reid RD, et al. Effectiveness of inpatient and outpatient strategies in increasing referral and utilization of cardiac rehabilitation: a prospective, multi-site study. *Implement Sci*. 2012;7:120. https://doi.org/10.1186/1748-5908-7-120

32. Pack QR, Mansour M, Barboza JS, et al. An early appointment to outpatient cardiac rehabilitation at hospital discharge improves attendance at orientation: a randomized, single-blind, controlled trial. *Circulation*. 2013;127(3):349–355. https://doi.org/10.1161/CIRCULATIONAHA.112.121996

33. Pio CS de A, Chaves G, Davies P, Taylor R, Grace S. Interventions to promote patient utilization of cardiac rehabilitation: cochrane systematic Review and meta-analysis. *J Clin Med*. 2019;8(2):189. https://doi.org/10.3390/jcm8020189

34. Beatty AL, Truong M, Schopfer DW, Shen H, Bachmann JM, Whooley MA. Geographic variation in cardiac rehabilitation participation in Medicare and Veterans Affairs populations: opportunity for improvement. *Circulation*. 2018;137(18):1899–1908. https://doi.org/10.1161/CIRCULATIONAHA.117.029471

35. Sukul D, Seth M, Thompson MP, et al. Hospital and operator variation in cardiac rehabilitation referral and participation after percutaneous coronary intervention: insights from blue cross blue shield of Michigan cardiovascular consortium. *Circ Cardiovasc Qual Outcomes*. 2021;14(11):e008242. https://doi.org/10.1161/CIRCOUTCOMES.121.008242

36. Centers for Disease Control and Prevention. *Cardiac Rehabilitation Change Package*. Second Edition. Centers for Disease Control and Prevention, US Department of Health and Human Services; 2023.

37. Beatty AL, Beckie TM, Dodson J, et al. A new era in cardiac rehabilitation delivery: research gaps, questions, strategies, and priorities. *Circulation*. 2023;147(3):254–266. https://doi.org/10.1161/CIRCULATIONAHA.122.061046

KEY WORDS cardiac rehabilitation, Medicare, quality of care

APPENDIX For the Statistical Technical Appendix and a supplemental figure and tables, please see the online version of this paper.