



# Geographic Variation in Cardiac Rehabilitation Participation in Medicare and Veterans Affairs Populations

## Opportunity for Improvement

Editorial, see p 1909

**BACKGROUND:** Cardiac rehabilitation is strongly recommended after myocardial infarction, percutaneous coronary intervention, or coronary artery bypass surgery, but it is historically underused. We sought to evaluate variation in cardiac rehabilitation participation across the United States.

**METHODS:** From administrative data from the Veterans Affairs (VA) healthcare system and a 5% Medicare sample, we used International Classification of Diseases, 9th Revision codes to identify patients hospitalized for myocardial infarction, percutaneous coronary intervention, or coronary artery bypass surgery from 2007 to 2011. After excluding patients who died in  $\leq 30$  days of hospitalization, we calculated the percentage of patients who participated in  $\geq 1$  outpatient visits for cardiac rehabilitation during the 12 months after hospitalization. We estimated adjusted and standardized rates of participation in cardiac rehabilitation by state using hierarchical logistic regression models.

**RESULTS:** Overall, participation in cardiac rehabilitation was 16.3% (23403/143756) in Medicare and 10.3% (9123/88826) in VA. However, participation rates varied widely across states, ranging from 3.2% to 41.8% in Medicare and 1.2% to 47.6% in VA. Similar regional variation was observed in both populations. Patients in the West North Central region (Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota) had the highest participation, whereas those in the Pacific region (Alaska, California, Hawaii, Oregon, and Washington) had the lowest participation in both Medicare (33.7% versus 10.6%) and VA (16.6% versus 5.1%) populations. Significant hospital-level variation was also present, with participation ranging from 3% to 75% in Medicare and 1% to 43% in VA.

**CONCLUSIONS:** Cardiac rehabilitation participation remains low overall in both Medicare and VA populations. However, remarkably similar regional variation exists, with some regions and hospitals achieving high rates of participation in both populations. This provides an opportunity to identify best practices from higher performing hospitals and regions that could be used to improve cardiac rehabilitation participation in lower performing hospitals and regions.

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**Key Words:** cardiac rehabilitation  
■ cardiovascular surgery ■ coronary artery disease ■ percutaneous coronary intervention ■ quality of health care

Sources of Funding, see page 1907

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## Clinical Perspective

### What Is New?

- Despite substantial efforts to promote cardiac rehabilitation by including it in guidelines and performance measures, only 16% of Medicare patients and 10% of veterans attended cardiac rehabilitation after a myocardial infarction, percutaneous coronary intervention, or coronary artery bypass surgery from 2007 to 2011.
- Patients in the West North Central region (Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota) had the highest participation, whereas those in the Pacific region (Alaska, California, Hawaii, Oregon, and Washington) had the lowest participation in both Medicare (33.7 versus 10.6%) and Veterans Affairs (16.6% versus 5.1%) populations.

### What Are the Clinical Implications?

- New approaches are needed to improve participation in cardiac rehabilitation.
- Hospitals and health systems in low-participation regions should examine the practices of high-participation hospitals and regions to improve participation.
- Innovative policies and programs could be catalysts for hospitals, health systems, and regions to implement strategies for improving the delivery of cardiac rehabilitation.

Cardiac rehabilitation is an evidence-based program of exercise training, risk factor modification, and psychosocial counseling.<sup>1,2</sup> Participation in cardiac rehabilitation is associated with lower cardiovascular mortality, fewer hospitalizations, and improved quality of life.<sup>3–7</sup> Most health insurance providers, including Medicare Part B and the Veterans Affairs (VA) healthcare system, cover cardiac rehabilitation after myocardial infarction (MI), percutaneous coronary intervention (PCI), or coronary artery bypass surgery (CABG).

Cardiac rehabilitation participation has historically been poor. An analysis of participation in Medicare patients hospitalized for MI or CABG in 1997 revealed 19% participation in cardiac rehabilitation,<sup>8</sup> and a recent analysis demonstrated 8.1% to 13.2% participation in VA patients with ischemic heart disease.<sup>9</sup> In an effort to improve participation in cardiac rehabilitation, professional societies have published guidelines and performance measures that strongly recommend cardiac rehabilitation after MI, PCI, and CABG.<sup>10–15</sup> Although referral to cardiac rehabilitation has increased since these publications,<sup>16</sup> it is unclear whether this increase has translated into greater participation among eligible patients.

In this study, we aimed to describe national rates of cardiac rehabilitation participation among patients with ischemic heart disease and evaluate variation in participation rates across the Medicare and VA populations. The extent to which cardiac rehabilitation participation varies is not well understood. Quality improvement efforts involve examining variation in care, identifying best practices at high-performing sites, and using those practices to improve care at low-performing sites. Thus, identifying sites or regions with high participation in cardiac rehabilitation may offer an opportunity for improving participation at low-performing sites.

## METHODS

For the purposes of reproducing the results or replicating the procedure, the data cannot be made available to other researchers, but analytic methods will be made available to other researchers on request.

### Population

We used VA administrative data and a standard analytic dataset of a 5% random sample of Medicare beneficiaries<sup>17</sup> to identify unique patients discharged or undergoing procedures from January 1, 2007, to December 31, 2011, with a diagnosis of MI (primary diagnosis only), PCI, or CABG using International Classification of Diseases, 9th Revision, Clinical Modification and Current Procedural Terminology codes (MI 410.xx; PCI 0.66, 17.55, 36.0x, 92973, 92974, 92980–92982, 92984, 92995, 92996, G0290, G0291, 92920, 92921, 92924, 92925, 92928, 92929, 92933, 92934, 92937, 92938, 92941, 92943, 92944; CABG 36.10–36.16, 36.19, 36.2, 33510–33514, 33516–33519, 33521–33523, 33530, 33533–33536, 33572, 35600, S2205, S2206, S2207, S2208, S2209). We excluded beneficiaries who died in  $\leq 30$  days of the index event. The University of California, San Francisco, and VA Puget Sound Health Care System Institutional Review Boards approved the study and waived the requirement for informed consent.

### Outcomes

Cardiac rehabilitation participation was identified as  $\geq 1$  procedure codes for cardiac rehabilitation (Current Procedural Terminology codes 93797, 93798, S9472, S9473, G0422, and G0423) in  $\leq 1$  year after discharge. During the period of analysis, onsite cardiac rehabilitation programs were available at 35 VA facilities (including a program in Puerto Rico). When a VA cardiac rehabilitation program was not available or when it was not feasible for a veteran to attend that program, veterans could be referred to a non-VA cardiac rehabilitation facility, where they would receive care that was paid for by the VA (purchased care). Our VA analysis includes data on cardiac rehabilitation participation from both VA and non-VA cardiac rehabilitation programs.

### Patient Characteristics

Patient characteristics were obtained from inpatient data (1 claim in the year before and including the index event) and

from outpatient data (2 claims in the year before the index event). State was determined by patient zip code.

## Hospital Characteristics

Hospital characteristics were obtained from the American Hospital Association database. VA hospital cardiac rehabilitation site status was determined from VA records.

## Statistical Analysis

We analyzed data from Medicare and VA populations separately. Differences in patient characteristics by cardiac rehabilitation participation were compared using the  $\chi^2$  test. Hospitals with  $\geq 10$  patients were divided into quartiles of cardiac rehabilitation participation, and hospital characteristics were compared using the  $\chi^2$  test. We described crude rates of participation in cardiac rehabilitation by state. We created a hierarchical logistic regression model, clustered by hospital with a random intercept for state, using the adaptive quadrature likelihood approximation method (SAS PROC GLIMMIX). To ensure that our methods were similar to a previous analysis, we based our approach on described methods.<sup>8</sup> The model included patient characteristics of age, sex, race/ethnicity, Medicaid status, hospitalization diagnoses, and all comorbidities listed in Tables 1 and 2. We estimated state-adjusted rates of cardiac rehabilitation participation as the average of the predicted individual probabilities of all patients living in the state by using the solutions for state-specific random effects (SAS BLUP option).<sup>18</sup> We estimated standardized rates of cardiac rehabilitation participation as the adjusted state rate divided by the expected state rate, multiplied by the national unadjusted cardiac rehabilitation participation rate. Expected state rates of cardiac rehabilitation were calculated as the average of the predicted individual probabilities as if those individuals were living in an average state using only fixed effects without the state-specific random effect (SAS NOBLUP option). To estimate the magnitude of regional variation, we calculated odds ratios (ORs) adjusted for patient characteristics (age, sex, race/ethnicity, Medicaid status, hospitalization diagnoses, and all comorbidities listed in Tables 1 and 2), hospital characteristics (hospital size, medical school affiliation, urban/rural, and presence of an onsite cardiac rehabilitation center), and state-level socioeconomic status indicators (median income and high school graduation rate from the 2010 American Community Survey) with US Census divisions grouped by ranking of participation and the lowest-ranking Pacific region (Alaska, California, Hawaii, Oregon, and Washington) serving as the reference group. To estimate the magnitude of hospital- and state-level variation, we calculated the median OR from the multilevel mixed-effects model variances. The median OR is a measure of between-group (hospital or state) variation that expresses the relative odds of cardiac rehabilitation participation for 2 identical patients living in 1 randomly selected group compared with a second randomly selected group. A median OR is always  $\geq 1$  and can be interpreted on the same scale as fixed-effects ORs.<sup>19,20</sup> We conducted a sensitivity analysis of adjusting for state-level cardiac rehabilitation program density (obtained from the number of programs with cardiac rehabilitation claims in the 5% Medicare sample for each state per 100 eligible patients in

the 5% sample in that state). We also conducted a sensitivity analysis including only VA patients  $>65$  years of age in the analysis. All analyses were performed with SAS Enterprise Guide (version 7.1) or Stata (version 14).

## RESULTS

Participation in cardiac rehabilitation after MI, PCI, or CABG in Medicare patients was 16.3% (23 403/143 756) and in VA patients was 10.3% (9123/88 826). Medicare patients (Table 1) were older and more were female compared with VA patients (Table 2). A greater proportion of the VA cohort received PCI and CABG. Women were less likely to participate in cardiac rehabilitation in the Medicare population but not in VA. Variation in participation by race and ethnicity was seen in both populations, but low participation among minorities was more prominent in the Medicare population. In Medicare, participation rates were 17.6% for whites, 7.3% for blacks, and 3.8% for Hispanics, whereas in VA, participation rates were 10.4% for whites, 8.9% for blacks, and 12.0% for Hispanics.

Hospitals in the higher quartiles of patient participation in cardiac rehabilitation were more likely to be larger, academically affiliated, and have onsite cardiac rehabilitation (Table 3).

Standardized participation rates varied widely across states, ranging from 3.2% to 41.8% in Medicare and 1.2% to 47.6% in VA (Figure 1, [Table I in the online-only Data Supplement](#)). State-level variation in cardiac rehabilitation participation was present in both populations (Figure 2). The region with the highest rates of participation in cardiac rehabilitation was the West North Central United States (Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota) for both Medicare (33.7%) and VA (16.6%) populations (Table 4).

After adjusting for patient characteristics, hospital characteristics, and state-level socioeconomic status ([Tables II and III in the online-only Data Supplement](#)), significant variation remained at the state level for both Medicare (median OR, 1.81; 95% confidence interval, 1.63–1.99) and VA patients (median OR, 2.05; 95% confidence interval, 1.54–2.56) and at the hospital level for both Medicare (median OR, 1.78; 95% confidence interval, 1.74–1.82) and VA patients (median OR, 2.57; 95% confidence interval, 2.17–2.96).

A sensitivity analysis adjusting for cardiac rehabilitation program density using estimates from the 5% Medicare sample ([Tables II and III in the online-only Data Supplement](#)) did not meaningfully alter estimates of regional and state variation ([Tables IV and V in the online-only Data Supplement](#)). A sensitivity analysis including only VA patients  $>65$  years of age demonstrated an overall participation rate of 8.5% (3163/37 245) ([Table VI in the online-only Data Supplement](#)). Signifi-

**Table 1. Characteristics of Medicare Patients Eligible for Cardiac Rehabilitation**

Patient Characteristics	Total	Participant	Nonparticipant	P Value†
	n=143 756	n=23 403	n=120 353	
Age, y				<0.001
66–75	59 584 (41.4)	12 357 (52.8)	47 227 (39.2)	
76–85	58 810 (40.9)	9 672 (41.3)	49 138 (40.8)	
>85	25 362 (17.6)	1 374 (5.9)	23 988 (19.9)	
Race/ethnicity				<0.001
White	126 249 (87.8)	22 160 (94.7)	104 089 (86.5)	
Black	10 476 (7.3)	760 (3.2)	9 716 (8.1)	
Hispanic	2 649 (1.8)	101 (0.4)	2 548 (2.1)	
Asian, Pacific Islander, or American Indian	4 215 (2.9)	367 (1.6)	3 848 (3.2)	
Unknown or missing	167 (0.1)	15 (0.1)	152 (0.1)	
Female	70 256 (48.9)	9 071 (38.8)	61 185 (50.8)	<0.001
Medicaid	24 256 (16.9)	1 741 (7.4)	22 515 (18.7)	<0.001
Hospitalization				<0.001
MI only	44 626 (31.0)	1 002 (4.3)	43 624 (36.2)	
PCI only	41 601 (28.9)	6 748 (28.8)	34 853 (29.0)	
CABG only	18 618 (13.0)	6 615 (28.3)	12 003 (10.0)	
MI and PCI	28 035 (19.5)	5 337 (22.8)	22 698 (18.9)	
MI and CABG	7 050 (4.9)	2 071 (8.8)	4 979 (4.1)	
PCI and CABG	1 796 (1.2)	835 (3.6)	961 (0.8)	
MI, PCI, and CABG	2 030 (1.4)	795 (3.4)	1 235 (1.0)	
Comorbid condition				
Hypertension	118 497 (82.4)	19 270 (82.3)	99 227 (82.4)	0.69
Heart failure	53 694 (37.4)	6 097 (26.1)	47 597 (39.5)	<0.001
Arrhythmias	61 726 (42.9)	10 104 (43.2)	51 622 (42.9)	0.43
Peripheral vascular disease	32 350 (22.5)	5 339 (22.8)	27 011 (22.4)	0.21
Valvular heart disease	51 741 (36.0)	8 722 (37.3)	43 019 (35.7)	<0.001
Cerebrovascular disease	16 613 (11.6)	1 611 (6.9)	15 002 (12.5)	<0.001
Diabetes mellitus	54 323 (37.8)	8 244 (35.2)	46 079 (38.3)	<0.001
Dementia	12 366 (8.6)	903 (3.9)	11 463 (9.5)	<0.001
Cancer	33 315 (23.2)	7 075 (30.2)	26 240 (21.8)	<0.001
Chronic obstructive pulmonary disease	33 777 (23.5)	4 143 (17.7)	29 634 (24.6)	<0.001
Chronic kidney disease	31 797 (22.1)	3 576 (15.3)	28 221 (23.4)	<0.001
Region*				<0.001
New England	6 991 (4.9)	1 281 (5.5)	5 710 (4.8)	
Mid-Atlantic	21 527 (15.1)	2 382 (10.2)	19 145 (16.0)	
South Atlantic	29 261 (20.5)	4 528 (19.4)	24 733 (20.7)	
East North Central	25 636 (17.9)	5 470 (23.4)	20 166 (16.9)	
East South Central	10 640 (7.4)	1 386 (5.9)	9 254 (7.7)	
West North Central	10 658 (7.5)	3 596 (15.4)	7 062 (5.9)	
West South Central	15 923 (11.1)	1 923 (8.2)	14 000 (11.7)	
Mountain	7 473 (5.2)	1 241 (5.3)	6 232 (5.2)	
Pacific	14 918 (10.4)	1 588 (6.8)	13 330 (11.1)	

Values are n (%).

CABG indicates coronary artery bypass grafting; MI, myocardial infarction; and PCI, percutaneous coronary intervention.

\*New England: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont; Mid-Atlantic: New Jersey, New York, and Pennsylvania; South Atlantic: Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, and West Virginia; East North Central: Indiana, Illinois, Michigan, Ohio, and Wisconsin; East South Central: Alabama, Kentucky, Mississippi, and Tennessee; West North Central: Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota; West South Central: Arkansas, Louisiana, Oklahoma, Texas; Mountain: Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming; Pacific: Alaska, California, Hawaii, Oregon, and Washington.

†P values for comparison between participants and nonparticipants by  $\chi^2$  test.

**Table 2. Characteristics of Veterans Affairs Patients Eligible for Cardiac Rehabilitation**

Patient Characteristics	Total	Participant	Nonparticipant	P Value†
	n=88826	n=9123	n=79703	
Age, y				<0.001
≤65	51 579 (58.1)	5960 (65.3)	45 619 (57.2)	
66–75	18860 (21.2)	1949 (21.4)	16911 (21.2)	
76–85	14494 (16.3)	1070 (11.7)	13424 (16.8)	
>85	3891 (4.4)	144 (1.6)	3747 (4.7)	
Race/ethnicity				<0.001
White	69 716 (78.5)	7219 (79.1)	62 497 (78.5)	
Black	10457 (11.8)	926 (10.2)	9531 (12.0)	
Hispanic	4904 (5.5)	587 (6.4)	4317 (5.4)	
Asian, Pacific Islander, or American Indian	1190 (1.3)	118 (1.3)	1072 (1.3)	
Unknown or missing	2559 (2.9)	273 (3.0)	2286 (2.9)	
Female	1426 (1.6)	143 (1.6)	1283 (1.6)	0.76
Medicaid	5571 (6.3)	579 (6.3)	4992 (6.3)	0.76
Hospitalization				<0.001
MI only	17 271 (19.4)	849 (9.3)	16 422 (20.6)	
PCI only	34 083 (38.4)	2010 (22.0)	32 073 (40.2)	
CABG only	19 097 (21.5)	3998 (43.8)	15 099 (18.9)	
MI and PCI	13 103 (14.8)	1162 (12.7)	11 941 (15.0)	
MI and CABG	2867 (3.2)	537 (5.9)	2330 (2.9)	
PCI and CABG	1628 (1.8)	396 (4.3)	1232 (1.5)	
MI, PCI, and CABG	777 (0.9)	171 (1.9)	606 (0.8)	
Comorbid condition				
Hypertension	69 561 (78.3)	7066 (77.5)	62 495 (78.4)	0.04
Heart failure	16 574 (18.7)	1163 (12.7)	15 411 (19.3)	<0.001
Arrhythmias	14 731 (16.6)	1181 (12.9)	13 550 (17.0)	<0.001
Peripheral vascular disease	13 069 (14.7)	1079 (11.8)	11 990 (15.0)	<0.001
Valvular heart disease	10 438 (11.8)	1152 (12.6)	9286 (11.7)	0.006
Cerebrovascular disease	6012 (6.8)	432 (4.7)	5580 (7.0)	<0.001
Diabetes mellitus	39 007 (43.9)	4031 (44.2)	34 976 (43.9)	0.58
Dementia	984 (1.1)	24 (0.3)	960 (1.2)	<0.001
Cancer	11 707 (13.2)	975 (10.7)	10 732 (13.5)	<0.001
Chronic obstructive pulmonary disease	15 877 (17.9)	1259 (13.8)	14 618 (18.3)	<0.001
Chronic kidney disease	12 510 (14.1)	902 (9.9)	11 608 (14.6)	<0.001
Region*				<0.001
New England	2922 (3.4)	267 (3.0)	2655 (3.4)	
Mid-Atlantic	5694 (6.5)	432 (4.9)	5262 (6.7)	
South Atlantic	19 637 (22.5)	2105 (23.8)	17 532 (22.4)	
East North Central	10 574 (12.1)	1360 (15.4)	9214 (11.8)	
East South Central	8105 (9.3)	632 (7.2)	7473 (9.5)	
West North Central	7643 (8.8)	1271 (14.4)	6372 (8.1)	
West South Central	13 495 (15.5)	814 (9.2)	12 681 (16.2)	
Mountain	10 074 (11.6)	1486 (16.8)	8588 (11.0)	
Pacific	9046 (10.4)	464 (5.3)	8582 (11.0)	

Values are n (%).

CABG indicates coronary artery bypass grafting; MI, myocardial infarction; and PCI, percutaneous coronary intervention.

\*New England: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont; Mid-Atlantic: New Jersey, New York, and Pennsylvania; South Atlantic: Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, and West Virginia; East North Central: Indiana, Illinois, Michigan, Ohio, and Wisconsin; East South Central: Alabama, Kentucky, Mississippi, and Tennessee; West North Central: Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota; West South Central: Arkansas, Louisiana, Oklahoma, and Texas; Mountain: Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming; Pacific: Alaska, California, Hawaii, Oregon, and Washington.

†P values for comparison between participants and nonparticipants by  $\chi^2$  test.

**Table 3. Hospital Characteristics, by Quartile of Participation in Cardiac Rehabilitation for Medicare and Veterans Affairs Patients**

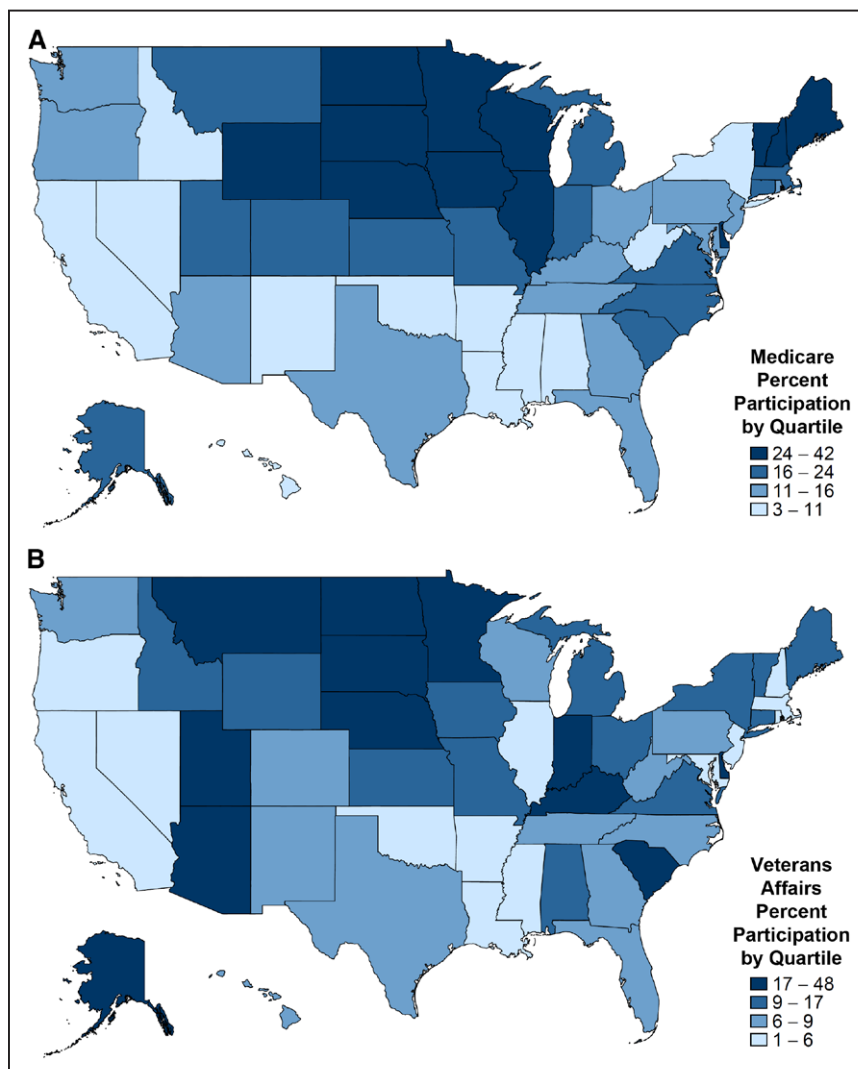
	Medicare				Veterans Affairs			
	Quartile 1	Quartile 2	Quartile 3	Quartile 4	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Participation range, %	3.3–16.6	16.7–22.6	22.7–32.4	32.4–75.4	1.1–6.0	6.1–10.1	10.2–18.1	18.2–43.2
Hospitals, n	178	176	181	178	17	17	17	16
Patients, n	27 073	20 128	18 572	14 987	24 308	20 138	15 679	16 437
Hospital characteristic, patients, n (%)								
Hospital bed size <200	622 (2.4)	1410 (7.0)	1679 (9.1)	1817 (12.2)	2160 (10.9)	5669 (31.9)	3510 (22.4)	3096 (20.5)
Academic affiliation	7847 (29.8)	5209 (25.9)	4540 (24.6)	4610 (31.0)	9745 (49.1)	7393 (41.6)	6072 (38.7)	6190 (41.0)
Nonmetropolitan	443 (1.7)	408 (2.0)	1065 (5.8)	1582 (10.6)	0 (0)	0 (0)	95 (0.6)	407 (2.7)
Cardiac rehabilitation center onsite	12 344 (45.6)	9506 (47.2)	9110 (49.1)	6211 (41.4)	1842 (7.6)	8031 (39.9)	12 458 (79.5)	13 058 (79.4)

The *P* value is <0.001 for all characteristics.

cant hospital- and state-level variation persisted (Table VII in the online-only Data Supplement), but variation across census regions was lower and no longer statistically significant (Table VIII in the online-only Data Supplement).

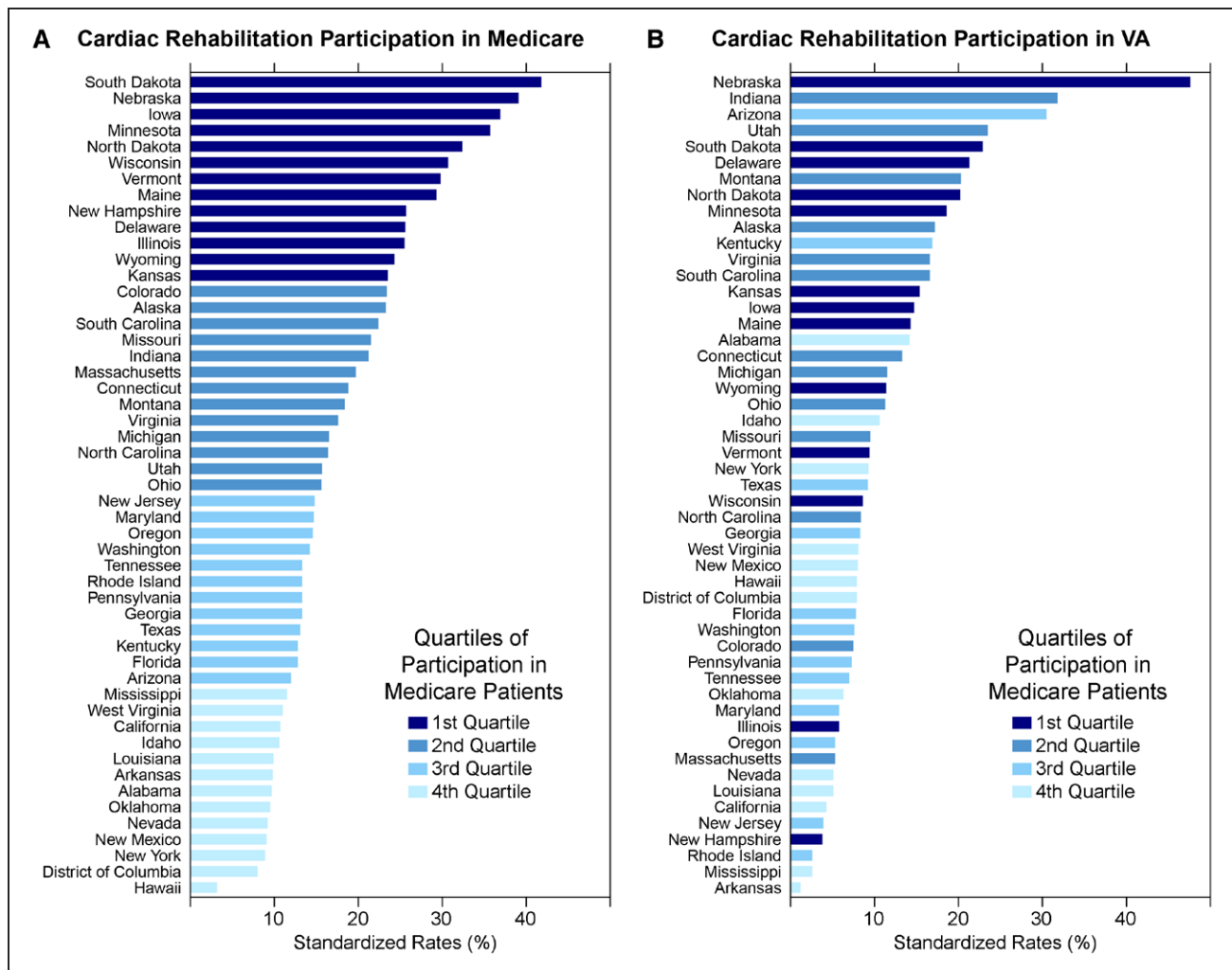
## DISCUSSION

For the past 20 years, underuse of cardiac rehabilitation has been an intractable problem for patients with ischemic heart disease. Despite substantial advocacy



**Figure 1. Standardized rates of participation in cardiac rehabilitation, by state.**

**A**, Medicare and **(B)** Veterans Affairs patients after myocardial infarction, percutaneous coronary intervention, or coronary artery bypass surgery, 2007 to 2011.



**Figure 2. Variation in participation in cardiac rehabilitation, by state.**

**A**, Medicare and (**B**) Veterans Affairs (VA) patients after myocardial infarction, percutaneous coronary intervention, or coronary artery bypass surgery, 2007 to 2011. Color of bars represents quartile of participation in Medicare.

and improvements in cardiac rehabilitation referral,<sup>2,16</sup> there has been little improvement in cardiac rehabilitation participation over time.<sup>8</sup> We examined variation in cardiac rehabilitation participation from 2007 to 2011 in 2 large healthcare systems. Standardized participation rates by state ranged from 3.2% to 41.8% in Medicare and 1.2% to 47.6% in VA. It is important to note that some states achieved remarkably high levels of participation in both healthcare systems. Adjustment for patient- and hospital-level characteristics had little impact on this variation. These findings suggest that regional differences in healthcare delivery may have a large effect on cardiac rehabilitation participation. They provide an opportunity for us to investigate what high-performing regions are doing to achieve high levels of participation so that best practices can be disseminated to low-performing regions and hospitals.

Variation in participation in cardiac rehabilitation has previously been described in the Medicare population.<sup>8</sup>

Our study demonstrates that this variation is not unique to Medicare and can also be seen in the VA healthcare system. In addition, it appears that regional variation follows a similar pattern in both populations, suggesting that regional practice patterns influence cardiac rehabilitation delivery. Some of this similarity in regional variation could be a result of many VA medical centers not having cardiac rehabilitation centers and relying on community cardiac rehabilitation centers to provide this service. It is also important to note that significant hospital-level variation was present in both populations, suggesting that, in addition to regional practice patterns, hospital practice patterns may influence cardiac rehabilitation participation.

There were greater racial and ethnic disparities in cardiac rehabilitation participation in Medicare than in VA. Although it is not possible to determine from administrative data what factors explain these differences or to examine all the sociocultural variables that

**Table 4. Regional Variation in Participation in Cardiac Rehabilitation in Medicare and Veterans Affairs Populations**

Participation Rank	Medicare		Veterans Affairs	
	Region*	Odds Ratio† (95% CI)	Region*	Odds Ratio† (95% CI)
1 (highest)	West North Central	2.37 (2.00–2.81)	West North Central	1.41 (1.12–1.78)
2	East North Central	1.36 (1.20–1.55)	Mountain	1.22 (0.99–1.50)
3	New England		East North Central	
4	Mountain		South Atlantic	
5	South Atlantic		New England	
6	East South Central		1.01 (0.88–1.14)	
7	West South Central	Mid-Atlantic		
8	Mid-Atlantic	West South Central		
9 (lowest)	Pacific	1.0 (referent)	Pacific	1.0 (referent)

\*New England: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont; Mid-Atlantic: New Jersey, New York, and Pennsylvania; South Atlantic: Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, and West Virginia; East North Central: Indiana, Illinois, Michigan, Ohio, and Wisconsin; East South Central: Alabama, Kentucky, Mississippi, and Tennessee; West North Central: Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota; West South Central: Arkansas, Louisiana, Oklahoma, and Texas; Mountain: Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming; Pacific: Alaska, California, Hawaii, Oregon, and Washington.

†Adjusted for patient characteristics (age, sex, race/ethnicity, Medicaid status, hospitalization diagnoses, and all comorbidities in Table 1), hospital characteristics (hospital bed size, medical school affiliation, urban/rural, and presence of onsite cardiac rehabilitation center), and state socioeconomic indicators (median household income and high school graduation rate).

might contribute to these differences, it is possible that the uniformity of VA health coverage may contribute to fewer racial and ethnic disparities in care.

We observed that participation in cardiac rehabilitation was overall lower in the VA population than in the Medicare population. It has previously been observed that utilization of healthcare services is often lower in the VA population than in Medicare for other conditions. For instance, use of cancer-related imaging<sup>21</sup> and echocardiography<sup>22</sup> is higher in Medicare than in the VA health system. It has also previously been noted that regional variation in the utilization of healthcare services is similar in both populations and is not attributable to differing utilization rates between the VA and Medicare.<sup>22</sup> It has been previously reported that the presence of a VA cardiac rehabilitation program and patient proximity to a VA facility are associated with greater participation in cardiac rehabilitation among veterans.<sup>9</sup> Despite VA patients' ability to receive cardiac rehabilitation in the community when no VA cardiac rehabilitation center is available, there may still be barriers that prevent veterans from attending cardiac rehabilitation in the community, which could also contribute to lower rates of participation among veterans.

State-level socioeconomic status was associated with cardiac rehabilitation participation but did not fully explain variation in cardiac rehabilitation participation. This finding is consistent with previous analyses demonstrating that some variation is associated with socioeconomic status.<sup>23</sup> A recent study also revealed that higher neighborhood-level socioeconomic status was a strong predictor of cardiac rehabilitation participation,

suggesting that greater efforts are needed to provide access to vulnerable populations.<sup>24</sup>

In both populations, some regions and hospitals achieved high rates of participation. New strategies are needed to reduce variation and increase participation in cardiac rehabilitation, particularly in low-performing regions and hospitals.<sup>2</sup> Although we do not know whether there were specific strategies used by high-performing hospitals in this study, evidence-based strategies to promote uptake of cardiac rehabilitation by all eligible patients should be instituted at all hospitals, such as automatic referral of all eligible patients and early staff contact to encourage enrollment in cardiac rehabilitation.<sup>25</sup> Automatic referral increases the number of patients referred to and enrolling in cardiac rehabilitation and, when coupled with early staff contact about cardiac rehabilitation, results in high levels of participation.<sup>26–29</sup> Automatic referral of all eligible patients may also help to reduce disparities in cardiac rehabilitation referral and participation. In addition, because hospitals with onsite cardiac rehabilitation even have suboptimal rates of participation, new delivery models, such as home cardiac rehabilitation, should be considered to reach patients unable to attend center-based cardiac rehabilitation.

Home cardiac rehabilitation can be administered remotely and has the potential to better meet the needs of rural patients, patients with work or caregiving responsibilities, or those served by facilities without an existing cardiac rehabilitation center.<sup>30,31</sup> However, home-based programs are unlikely to be widely adopted unless payment reform is enacted to include reimbursement for nontraditional cardiac rehabilitation. Medicare has con-

sidered programs for incentives to hospitals based on cardiac rehabilitation participation and bundled payment initiatives with an aim toward reducing rehospitalizations, at least in part by increasing use of cardiac rehabilitation. In addition, the Million Hearts initiative has identified increasing cardiac rehabilitation participation as a strategy for preventing cardiovascular events and has outlined a road map for interventions to improve participation.<sup>32</sup> These initiatives could promote greater adoption of strategies to improve cardiac rehabilitation referral, enrollment, and participation. Future research should focus on novel approaches to improving cardiac rehabilitation participation that can be easily delivered across diverse regions and healthcare settings.

Several limitations to our findings should be noted. First, we relied on administrative data to determine the denominator of potentially eligible patients. Some patients deemed ineligible for cardiac rehabilitation by their providers are included within our denominator. However, other analyses have demonstrated rates of ineligibility <10%.<sup>16</sup> Second, because administrative data were used for this analysis, some potentially important factors were not included in our analysis, such as smoking status. Third, the ability to evaluate hospital-level participation is limited because of small numbers of eligible patients at some hospitals in the 5% Medicare sample. We analyzed cardiac rehabilitation program density, but the estimation of cardiac rehabilitation program density is unlikely to be accurate with the 5% Medicare sample because many programs with smaller numbers of participants were missed. Future analyses are needed to accurately examine the effects of cardiac rehabilitation program density on cardiac rehabilitation participation.

## CONCLUSIONS

Overall participation in cardiac rehabilitation remains suboptimal despite being strongly endorsed. Significant regional- and hospital-level variation in participation in cardiac rehabilitation is present, with some regions and hospitals achieving high rates of participation. The adoption of new strategies is needed to reduce variation and achieve high levels of participation in cardiac rehabilitation nationwide in all hospitals and healthcare systems.

## ARTICLE INFORMATION

Received May 12, 2017; accepted December 15, 2017.

The online-only Data Supplement, podcast, and transcript are available with this article at <http://circ.ahajournals.org/lookup/suppl/doi:10.1161/CIRCULATIONAHA.117.029471/-DC1>.

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## Sources of Funding

This study was supported by the Veterans Health Administration Measurement Science Quality Enhancement Research Initiative (IP1 HX 002002) and by an award from the Patient-Centered Outcomes Research Institute (PCORI) (IH-1304-6787). Dr Beatty is supported by Career Development Award #16-5150 from Veterans Affairs Health Services Research and Development. Support for Veterans Affairs/Medicare data are provided by the Department of Veterans Affairs, Veterans Health Administration, Office of Research and Development, Health Services Research and Development, Veterans Affairs Information Resource Center (project nos. SDR 02-237 and 98-004). The views expressed in this article are those of the authors and do not necessarily reflect the position or policy of the Department of Veterans Affairs or the US government.

## Disclosures

Dr Beatty has received research grant funding from the VA Virtual Specialty Care QUERI, John L. Locke Jr. Charitable Trust, and Alpha Phi Foundation for work related to cardiac rehabilitation (significant). The other authors report no conflicts of interest.

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## Geographic Variation in Cardiac Rehabilitation Participation in Medicare and Veterans Affairs Populations: Opportunity for Improvement

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*Circulation*. 2018;137:1899-1908; originally published online January 5, 2018;  
doi: 10.1161/CIRCULATIONAHA.117.029471

*Circulation* is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231  
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Print ISSN: 0009-7322. Online ISSN: 1524-4539

The online version of this article, along with updated information and services, is located on the  
World Wide Web at:

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Data Supplement (unedited) at:

<http://circ.ahajournals.org/content/suppl/2018/01/04/CIRCULATIONAHA.117.029471.DC1>

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## **SUPPLEMENTAL MATERIAL**

**Geographic variation in cardiac rehabilitation participation in Medicare and Veterans Affairs populations: an opportunity for improvement?**

**Supplemental Table 1.** Rates of participation in cardiac rehabilitation in Medicare and Veterans Affairs patients by state.

State	Medicare			Veterans Affairs		
	N participating / N eligible	Adjusted %	Standardized %	N participating / N eligible (%)	Adjusted %	Standardized %
Alabama	296/2,811	10.6	9.7	132/1,152	11.8	14.2
Alaska	42/147	28.0	23.3	18/69	25.4	17.2
Arizona	372/2,690	13.9	12.0	602/2,390	25.2	30.5
Arkansas	218/1,924	11.4	9.8	18/2,580	0.8	1.2
California	954/10,617	9.0	10.7	247/6,156	4.1	4.3
Colorado	328/1,267	26.0	23.4	52/874	6.1	7.5
Connecticut	263/1,759	15.1	18.8	77/789	9.7	13.3
Delaware	143/537	26.6	25.6	48/181	26.2	21.3
District of Columbia	<10*/190	4.9	8.0	<10*/83	4.3	7.9
Florida	1,460/11,151	13.3	12.8	819/7,274	7.7	7.8
Georgia	510/3,618	14.3	13.3	163/2,416	6.6	8.3
Hawaii	<10*/389	2.2	3.2	<10*/28	8.9	7.9
Idaho	71/520	13.9	10.6	365/3,367	10.9	10.6
Illinois	1,574/6,537	24.3	25.5	112/2,302	4.9	5.8
Indiana	850/3,630	23.1	21.2	264/918	28.5	31.8
Iowa	747/1,808	41.4	36.9	81/540	15.0	14.7
Kansas	393/1,470	28.3	23.5	120/1,084	11.0	15.4
Kentucky	385/2,741	14.1	12.8	300/2,517	12.1	16.9
Louisiana	225/2,186	10.5	9.9	35/1,186	2.9	5.1
Maine	191/812	24.0	29.3	97/450	22.0	14.3
Maryland	358/2,608	13.7	14.7	64/992	6.4	5.8
Massachusetts	500/2,993	17.2	19.7	49/852	6.1	5.3
Michigan	1,021/6,244	16.5	16.5	333/1,996	16.5	11.5
Minnesota	813/2,057	39.6	35.7	504/1,749	28.7	18.6
Mississippi	219/1,643	13.5	11.5	14/1,074	1.6	2.6
Missouri	845/3,535	24.0	21.5	29/3,418	8.5	9.5
Montana	111/456	24.5	18.4	123/575	21.2	20.3
Nebraska	457/961	47.7	39.1	140/364	37.8	47.6
Nevada	86/891	9.9	9.2	43/933	4.6	5.1
New Hampshire	171/588	29.1	25.7	16/345	5.5	3.8
New Jersey	672/4,872	13.9	14.8	<10*/365	2.8	3.9
New Mexico	64/739	8.3	9.1	60/958	6.2	8.0
New York	734/9,377	8.0	8.9	296/3,261	10.0	9.3
North Carolina	732/4,273	17.2	16.4	235/3,174	7.4	8.4
North Dakota	142/388	37.3	32.4	48/154	30.3	20.2
Ohio	1,046/6,373	16.6	15.6	452/3,316	13.8	11.3
Oklahoma	244/2,144	10.5	9.5	198/2,405	8.3	6.3
Oregon	246/1,475	16.8	14.6	75/1,494	5.1	5.3
Pennsylvania	976/7,278	13.6	13.3	75/1,494	4.9	7.3
Rhode Island	48/470	10.3	13.3	<10*/288	2.9	2.6
South Carolina	567/2,247	25.4	22.4	233/1,865	13.1	16.6
South Dakota	199/439	45.1	41.8	88/334	26.1	22.9
Tennessee	486/3,445	14.1	13.3	186/3,362	5.5	7.0
Texas	1,256/9,669	13.3	13.1	563/7,324	9.9	9.2
Utah	141/708	19.9	15.7	218/766	28.6	23.5
Vermont	108/369	29.1	29.8	22/198	11.0	9.4
Virginia	587/3,296	17.9	17.6	454/2,397	18.9	16.6
Washington	341/2,290	15.0	14.2	122/1,299	9.5	7.6
West Virginia	163/1,341	12.3	11.0	85/1,255	7.2	8.1
Wisconsin	979/2,852	34.5	30.7	199/2,042	9.7	8.6
Wyoming	68/202	33.4	24.3	23/211	10.9	11.4
<b>Total</b>	<b>23,403/143,756</b>			<b>9,123/88,826</b>		

\* Less than 10 individuals, therefore actual numbers not published to comply with Medicare policy

**Supplemental Table 2.** Percent high school graduate or higher, median household income, and cardiac rehabilitation program density in the 5% Medicare sample by state.

State	High School Graduate or Higher (2010) (%)	Median Household Income (2010) (\$)	# Cardiac Rehab Programs in sample	Cardiac Rehab Programs / 100 Eligible patients in sample	# Cardiac Rehab Programs (VA)
Alabama	82.1	40474	13	0.46	0
Alaska	91.0	64576	2	1.36	0
Arizona	85.6	46789	8	0.30	1
Arkansas	82.9	38307	7	0.36	0
California	80.7	57708	20	0.19	2
Colorado	89.7	54046	12	0.95	0
Connecticut	88.6	64032	6	0.34	0
Delaware	87.7	55847	0	0.00	0
District of Columbia	87.4	60903	2	1.05	1
Florida	85.5	44409	25	0.22	4
Georgia	84.3	46430	11	0.30	1
Hawaii	89.9	63030	0	0.00	0
Idaho	88.3	43490	1	0.19	0
Illinois	86.9	52972	36	0.55	1
Indiana	87.0	44613	26	0.72	0
Iowa	90.6	47961	28	1.55	0
Kansas	89.2	48257	19	1.29	0
Kentucky	81.9	40062	18	0.66	1
Louisiana	81.9	42505	5	0.23	0
Maine	90.3	45815	11	1.35	0
Maryland	88.1	68854	12	0.46	0
Massachusetts	89.1	62072	10	0.33	1
Michigan	88.7	45413	35	0.56	1
Minnesota	91.8	55459	21	1.02	1
Mississippi	81.0	36851	5	0.30	0
Missouri	86.9	44301	28	0.79	2
Montana	91.7	42666	2	0.44	1
Nebraska	90.4	48408	13	1.35	0
Nevada	84.7	51001	6	0.67	0
New Hampshire	91.5	61042	12	2.04	0
New Jersey	88.0	67681	15	0.31	1
New Mexico	83.3	42090	1	0.14	0
New York	84.9	54148	35	0.37	5
North Carolina	84.7	43326	29	0.68	0
North Dakota	90.3	48670	3	0.77	0
Ohio	88.1	45090	50	0.78	2
Oklahoma	86.2	42072	7	0.33	1
Oregon	88.8	46560	11	0.75	0
Pennsylvania	88.4	49288	31	0.43	1
Rhode Island	83.5	52254	4	0.85	0
South Carolina	84.1	42018	16	0.71	0
South Dakota	89.6	45904	5	1.14	2
Tennessee	83.6	41461	15	0.44	0
Texas	80.7	48615	52	0.54	1
Utah	90.6	54744	2	0.28	1
Vermont	91.0	49406	3	0.81	0
Virginia	86.5	60674	27	0.82	1
Washington	89.8	55631	14	0.61	1

<b>West Virginia</b>	83.2	38218	10	0.75	0
<b>Wisconsin</b>	90.1	49001	25	0.88	1
<b>Wyoming</b>	92.3	53512	2	0.99	0

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**Supplemental Table 3.** Percent high school graduate or higher, median household income, and cardiac rehabilitation program density in the 5% Medicare sample by state quartiles of participation in cardiac rehabilitation.

	Quartile 1*	Quartile 2 <sup>†</sup>	Quartile 3 <sup>‡</sup>	Quartile 4 <sup>§</sup>	p-value <sup>  </sup>
<b>Standardized participation range (%)</b>	<b>41.8→23.5</b>	<b>23.4→15.6</b>	<b>14.8→12.0</b>	<b>11.5→3.2</b>	
<b>High school graduate or higher (%), mean (SD)</b>	90.1 (1.5)	88.2 (2.3)	85.7 (3.0)	84.4 (2.9)	<0.001
<b>Median household income (\$), median (IQR)</b>	49,001 (48,257, 53,512)	45,413 (44,301, 60,674)	47,702 (45,420, 53,943)	42,505 (40,474, 54,148)	0.29
<b>Cardiac rehab programs / 100 eligible patients (N), mean (SD)</b>	0.1 (0.3)	0.3 (0.8)	0.03 (0.08)	0.02(0.05)	0.66

\*Quartile 1: South Dakota, Nebraska, Iowa, Minnesota, North Dakota, Wisconsin, Vermont, Maine, New Hampshire, Delaware, Illinois, Wyoming, Kansas

<sup>†</sup>Quartile 2: Colorado, Alaska, South Carolina, Missouri, Indiana, Massachusetts, Connecticut, Montana, Virginia, Michigan, North Carolina, Utah, Ohio

<sup>‡</sup>Quartile 3: New Jersey, Maryland, Oregon, Washington, Tennessee, Rhode Island, Pennsylvania, Georgia, Texas, Kentucky, Florida, Arizona

<sup>§</sup>Quartile 4: Mississippi, West Virginia, California, Idaho, Louisiana, Arkansas, Alabama, Oklahoma, Nevada, New Mexico, New York, District of Columbia, Hawaii

||p-value for comparison by Wilcoxon rank sum test

Abbreviations: SD – standard deviation, IQR – interquartile range

**Supplemental Table 4.** Median odds ratios for state-level variation in participation in cardiac rehabilitation in the Medicare and Veterans Affairs populations, adjusted for patient and hospital characteristics, state socioeconomic indicators, and cardiac rehabilitation program density.

<b>Adjustment Model</b>	<b>Medicare median OR (95%CI)</b>	<b>VA median OR (95%CI)</b>
Model 1 *	2.29 (1.44, 2.13)	2.17 (2.01, 3.11)
Model 2†	1.81 (1.63, 1.99)	2.05 (1.54, 2.56)
Model 3‡	1.75 (1.59, 1.92)	2.04 (1.53, 2.55)

\* Model 1: adjusted for patient characteristics (age, gender, race/ethnicity, Medicaid status, hospitalization diagnoses, and all comorbidities in Table 1), hospital characteristics (hospital bed size, medical school affiliation, urban/rural, and presence of an on-site cardiac rehabilitation center), and census region.

†Model 2: adjusted for Model 1 characteristics and state socioeconomic indicators (median household income and high school graduation rate).

‡Model 3: adjusted for Model 1 and Model 2 characteristics and state cardiac rehabilitation program density.

**Supplemental Table 5.** Regional variation in participation in cardiac rehabilitation in the Medicare and Veterans Affairs populations, adjusted for patient and hospital characteristics, state socioeconomic status indicators, and cardiac rehabilitation program density

Participation Rank	Medicare		Veterans Affairs	
	Region*	Odds Ratio† (95%CI)	Region*	Odds Ratio† (95%CI)
1 (highest)	West North Central	2.38 (2.00, 2.82)	West North Central	1.43 (1.13, 1.80)
2	East North Central	1.37 (1.20, 1.56)	Mountain	1.24 (1.01, 1.53)
3	New England		East North Central	
4	Mountain		South Atlantic	
5	South Atlantic		New England	
6	East South Central	1.01 (0.88, 1.14)	East South Central	1.09 (0.87, 1.37)
7	West South Central		Mid Atlantic	
8	Mid Atlantic		West South Central	
9 (lowest)	Pacific	1.0 (referent)	Pacific	1.0 (referent)

\*New England: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont; Mid Atlantic: New Jersey, New York, Pennsylvania; South Atlantic: Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia; East North Central: Indiana, Illinois, Michigan, Ohio, Wisconsin; East South Central: Alabama, Kentucky, Mississippi, Tennessee; West North Central: Iowa, Nebraska, Kansas, North Dakota, Minnesota, South Dakota, Missouri; West South Central: Arkansas, Louisiana, Oklahoma, Texas; Mountain: Arizona, Colorado, Idaho, New Mexico, Montana, Utah, Nevada, Wyoming; Pacific: Alaska, California, Hawaii, Oregon, Washington.

† Adjusted for patient characteristics (age, gender, race/ethnicity, Medicaid status, hospitalization diagnoses, and all comorbidities in Table 1) and hospital characteristics (hospital bed size, medical school affiliation, urban/rural, and presence of an on-site cardiac rehabilitation center), state socioeconomic indicators (median household income and high school graduation rate), and cardiac rehabilitation program density.

**Supplemental Table 6.** Characteristics of Veterans Affairs patients aged >65 eligible for cardiac rehabilitation.

	<b>Total</b> N = 37,245	<b>Participant</b> N = 3,163	<b>Non-participant</b> N = 34,082	<b>P-value†</b>
<b>Patient Characteristics, N(%)</b>				
Age, years				<0.001
66-75	18,860 (50.6)	1,949 (61.6)	16,911 (49.6)	
76-85	14,494 (38.9)	1,070 (33.8)	13,424 (39.4)	
>85	3,891 (10.4)	144 (4.6)	3,747 (11.0)	
Race/Ethnicity				<0.001
White	29,946 (80.4)	2,563 (81.0)	27,383 (80.3)	
Black	3,452 (9.3)	231 (7.3)	3,221 (9.5)	
Hispanic	2,300 (6.2)	228 (7.2)	2,072 (6.1)	
Asian, Pacific Islander, American Indian	428 (1.1)	31 (1.0)	397 (1.2)	
Unknown/Missing	1,119 (3.0%)	110(3.5%)	1,009 (3.0%)	
Female	435 (1.2)	36 (1.1)	399 (1.2)	0.87
Medicaid	2353 (6.3)	198 (6.3)	2,155 (6.3)	0.89
Hospitalization				<0.001
MI only	10,083 (27.1)	352 (11.1)	9731 (28.6)	
PCI only	12,612 (33.9)	616 (19.5)	11,996 (35.2)	
CABG only	7,550 (20.3)	1,466 (46.3)	6084 (17.9)	
MI and PCI	5,073 (13.6)	370 (11.7)	4703 (13.8)	
MI and CABG	1,188 (3.2)	206 (6.5)	982 (2.9)	
PCI and CABG	489 (1.3)	99 (3.1)	390 (1.1)	
MI, PCI, and CABG	250 (0.7)	54 (1.7)	196 (0.6)	
<b>Comorbid Conditions, N(%)</b>				
Hypertension	30,995 (83.2)	2,583 (81.7)	28,412 (83.4)	0.01
Heart failure	9,327 (25.0)	504 (15.9)	8,823 (25.9)	<0.001
Arrhythmias	9,107 (24.5)	570 (18.0)	8,537 (25.0)	<0.001
Peripheral vascular disease	7,100 (19.1)	471 (14.9)	6,629 (19.5)	<0.001
Valvular heart disease	6,173 (16.6)	598 (18.9)	5,575 (16.4)	<0.001
Cerebrovascular disease	3,270 (8.8)	182 (5.8)	3,088 (9.1)	<0.001
Diabetes	17,069 (45.8)	1,422 (45.0)	15,647 (45.9)	0.30
Dementia	865 (2.3)	16 (0.5)	849 (2.5)	<0.001
Cancer	7,815 (21.0)	571 (18.1%)	7,244 (21.3)	<0.001
COPD	8,140 (21.9)	509 (16.1%)	7,631 (22.4)	<0.001
Chronic kidney disease	7,694 (20.7)	459 (14.5)	7,235 (21.2)	<0.001
<b>Region*, N(%)</b>				
New England	1,496 (4.1)	82 (2.7)	1,414 (4.3)	
Mid Atlantic	2,780 (7.7)	155 (5.1)	2,625 (7.9)	
South Atlantic	7,966 (22.0)	698 (23.1)	7,268 (21.9)	
East North Central	4,056 (11.2)	462 (15.3)	3,594 (10.9)	
East South Central	3,110 (8.6)	176 (5.8)	2,934 (8.9)	
West North Central	3,273 (9.1)	470 (15.6)	2,803 (8.5)	
West South Central	5,055 (14.0)	216 (7.2)	4,839 (14.6)	

Mountain	4,491 (12.4)	570 (18.9)	3,921 (11.8)
Pacific	3,912 (10.8)	189 (6.3)	3,723 (11.2)

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Abbreviations: CABG: coronary artery bypass grafting, COPD: chronic obstructive pulmonary disease, IQR: interquartile range, MI: myocardial infarction, PCI: percutaneous coronary intervention

\*New England: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont; Mid Atlantic: New Jersey, New York, Pennsylvania; South Atlantic: Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia; East North Central: Indiana, Illinois, Michigan, Ohio, Wisconsin; East South Central: Alabama, Kentucky, Mississippi, Tennessee; West North Central: Iowa, Nebraska, Kansas, North Dakota, Minnesota, South Dakota, Missouri; West South Central: Arkansas, Louisiana, Oklahoma, Texas; Mountain: Arizona, Colorado, Idaho, New Mexico, Montana, Utah, Nevada, Wyoming; Pacific: Alaska, California, Hawaii, Oregon, Washington.

†P-values for comparison between participating and not participating by  $X^2$  test

**Supplemental Table 7.** Median odds ratios for participation in cardiac rehabilitation in the Veterans Affairs population, age>65, adjusted for patient and hospital characteristics.

	Veterans Affairs, Age >65 (median OR, 95%CI)*
State-level variation	2.10 (1.58, 2.62)
Hospital-level variation	2.41 (2.02, 2.80)

\* Adjusted for patient characteristics (age, gender, race/ethnicity, Medicaid status,

hospitalization diagnoses, and all comorbidities in Supplemental Table 3), hospital

characteristics (hospital bed size, medical school affiliation, urban/rural, and presence of an on-site cardiac rehabilitation center), and census region.

**Supplemental Table 8.** Regional variation in participation in cardiac rehabilitation in the Veterans Affairs population, age>65

Participation Rank	Veterans Affairs, Age >65	
	Region*	Odds Ratio† (95%CI)
1 (highest)	West North Central	1.25 (0.84, 1.87)
2	Mountain	1.07 (0.75, 1.52)
3	East North Central	
4	South Atlantic	
5	New England	
6	East South Central	0.87 (0.59, 1.28)
7	Mid Atlantic	
8	West South Central	
9 (lowest)	Pacific	1.0 (referent)

\*New England: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont; Mid Atlantic: New Jersey, New York, Pennsylvania; South Atlantic: Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia; East North Central: Indiana, Illinois, Michigan, Ohio, Wisconsin; East South Central: Alabama, Kentucky, Mississippi, Tennessee; West North Central: Iowa, Nebraska, Kansas, North Dakota, Minnesota, South Dakota, Missouri; West South Central: Arkansas, Louisiana, Oklahoma, Texas; Mountain: Arizona, Colorado, Idaho, New Mexico, Montana, Utah, Nevada, Wyoming; Pacific: Alaska, California, Hawaii, Oregon, Washington.

† Adjusted for patient characteristics (age, gender, race/ethnicity, Medicaid status, hospitalization diagnoses, and all comorbidities in Supplemental Table 1) and hospital characteristics (hospital bed size, medical school affiliation, urban/rural, presence of an on-site cardiac rehabilitation center).