



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 ≤ 30 days of hospitalization, we calculated the percentage of patients who participated in ≥ 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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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.^{1,2} Participation in cardiac rehabilitation is associated with lower cardiovascular mortality, fewer hospitalizations, and improved quality of life.^{3–7} 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,⁸ and a recent analysis demonstrated 8.1% to 13.2% participation in VA patients with ischemic heart disease.⁹ 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.^{10–15} Although referral to cardiac rehabilitation has increased since these publications,¹⁶ 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 beneficiaries¹⁷ 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 ≤ 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 ≥ 1 procedure codes for cardiac rehabilitation (Current Procedural Terminology codes 93797, 93798, S9472, S9473, G0422, and G0423) in ≤ 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 χ^2 test. Hospitals with ≥ 10 patients were divided into quartiles of cardiac rehabilitation participation, and hospital characteristics were compared using the χ^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.⁸ 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).¹⁸ 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 ≥ 1 and can be interpreted on the same scale as fixed-effects ORs.^{19,20} 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 χ^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 χ^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

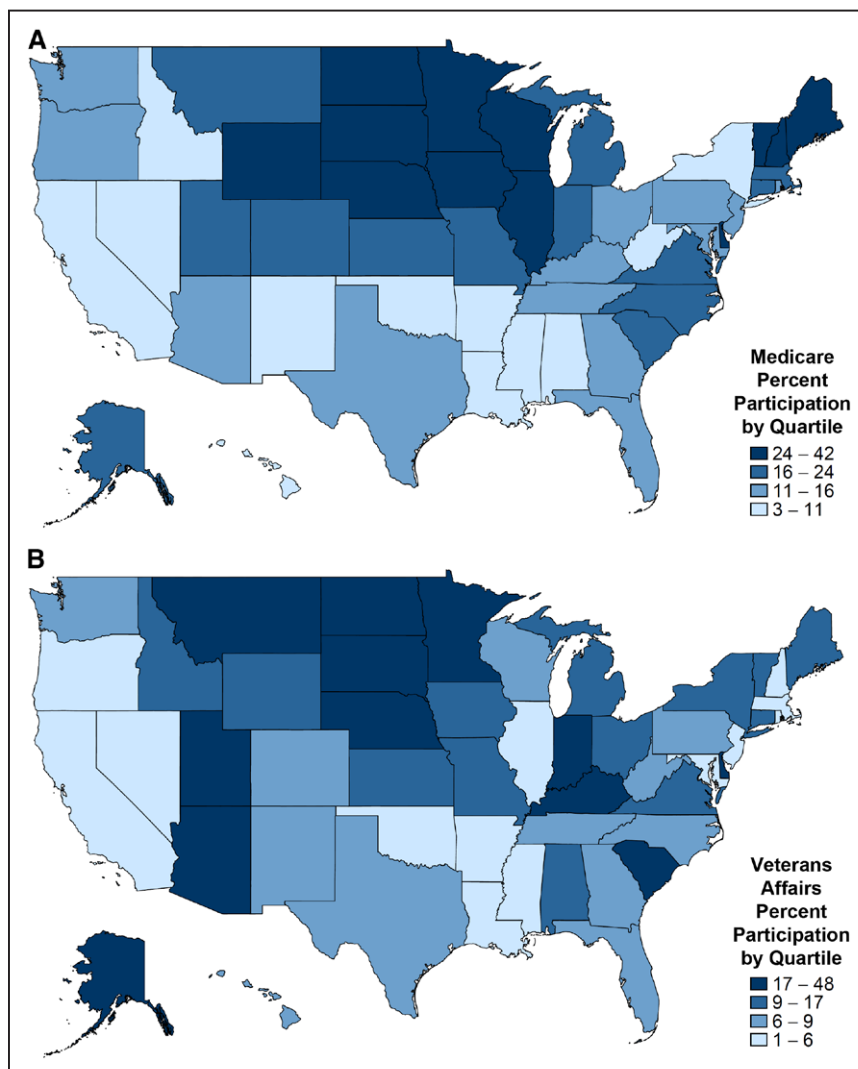


Figure 1. Standardized rates of participation in cardiac rehabilitation, by state.

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

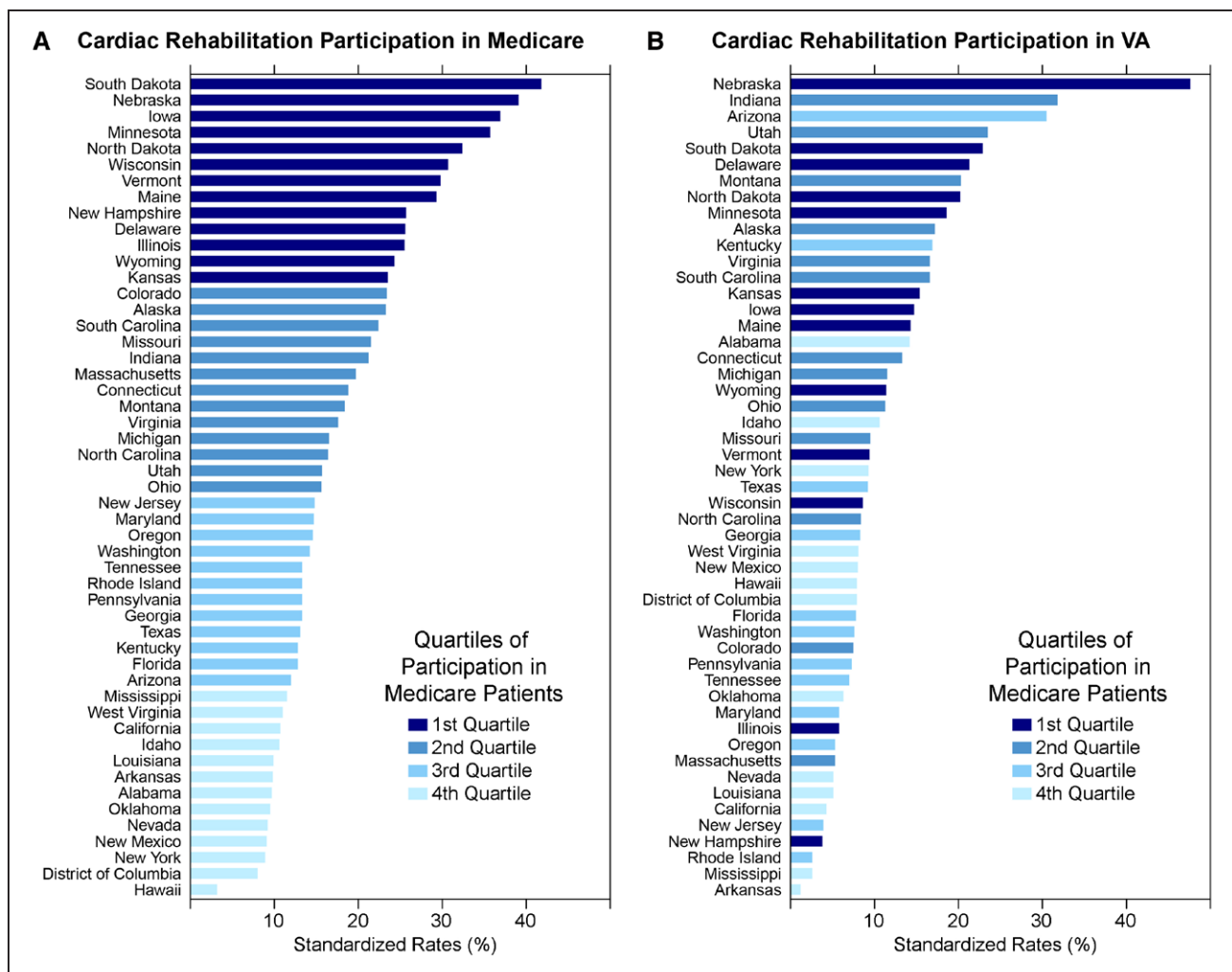


Figure 2. Variation in participation in cardiac rehabilitation, by state.

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,^{2,16} there has been little improvement in cardiac rehabilitation participation over time.⁸ 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.⁸

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 imaging²¹ and echocardiography²² 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.²² 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.⁹ 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.²³ 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.²⁴

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.² 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.²⁵ 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.^{26–29} 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.^{30,31} 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.³² 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%.¹⁶ 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.

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

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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 |
| Total | 23,403/143,756 | | | 9,123/88,826 | | |

* 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 |

| | | | | | |
|----------------------|------|-------|----|------|---|
| West Virginia | 83.2 | 38218 | 10 | 0.75 | 0 |
| Wisconsin | 90.1 | 49001 | 25 | 0.88 | 1 |
| Wyoming | 92.3 | 53512 | 2 | 0.99 | 0 |

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 [†] | Quartile 3 [‡] | Quartile 4 [§] | p-value |
|--|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-----------------------|
| Standardized participation range (%) | 41.8→23.5 | 23.4→15.6 | 14.8→12.0 | 11.5→3.2 | |
| High school graduate or higher (%), mean (SD) | 90.1 (1.5) | 88.2 (2.3) | 85.7 (3.0) | 84.4 (2.9) | <0.001 |
| Median household income (\$), median (IQR) | 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 |
| Cardiac rehab programs / 100 eligible patients (N), mean (SD) | 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

[†]Quartile 2: Colorado, Alaska, South Carolina, Missouri, Indiana, Massachusetts, Connecticut, Montana, Virginia, Michigan, North Carolina, Utah, Ohio

[‡]Quartile 3: New Jersey, Maryland, Oregon, Washington, Tennessee, Rhode Island, Pennsylvania, Georgia, Texas, Kentucky, Florida, Arizona

[§]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.

| Adjustment Model | Medicare median OR (95%CI) | VA median OR (95%CI) |
|-------------------------|---------------------------------------|---------------------------------|
| 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.

| | Total N = 37,245 | Participant N = 3,163 | Non-participant N = 34,082 | P-value† |
|---|----------------------------|---------------------------------|--------------------------------------|-----------------|
| Patient Characteristics, N(%) | | | | |
| 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) | |
| Comorbid Conditions, N(%) | | | | |
| 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 |
| Region*, N(%) | | | | |
| 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) |

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).