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

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

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Abstract

Background—Cardiac rehabilitation is strongly recommended after myocardial infarction (MI), percutaneous coronary intervention (PCI), or coronary artery bypass surgery (CABG), but 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 ICD-9 codes to identify patients hospitalized for MI, PCI, or CABG from 2007–2011. After excluding patients who died within 30 days of hospitalization, we calculated the percent of patients who participated in one or more 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% (23,403/143,756) in Medicare and 10.3% (9,123/88,826) 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, while those in the Pacific region (Alaska, California, Hawaii, Oregon, and

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Washington) had the lowest participation in both Medicare (33.7% vs. 10.6%) and VA (16.6% vs. 5.1%) populations. Significant hospital-level variation was also present, with participation ranging from 3–75% in Medicare and 1–43% in VA.

Conclusions—Cardiac rehabilitation participation remains low overall in both Medicare and VA populations. However, there is remarkably similar regional variation, 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.

Keywords

cardiac rehabilitation; quality of health care; coronary artery disease; percutaneous coronary intervention; cardiovascular surgery

Journal Subject Codes

Secondary Prevention; Myocardial Infarction; Revascularization; Rehabilitation; Quality and Outcomes

Introduction

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), and 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 in referral 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 to 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 upon request.

Population

We used VA administrative data and a standard analytic dataset of a 5% random sample of Medicare beneficiaries[17] to identify unique patients discharged or undergoing procedures from January 1, 2007 to December 31, 2011 with diagnosis of MI (primary diagnosis only), PCI, or CABG using International Classification of Diseases, Ninth Revision, Clinical Modification and Current Procedural Terminology(CPT) 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 within 30 days of the index event. The UCSF 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 one or more procedure codes for cardiac rehabilitation (Current Procedural Terminology codes 93797, 93798, S9472, S9473, G0422, G0423) within 1 year after discharge. During the period of analysis, on-site 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 prior to and including the index event) and from outpatient data (2 claims in the year prior to 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 X^2 test. Hospitals with 10 or more patients were divided into quartiles of cardiac rehabilitation

participation and hospital characteristics were compared using the X^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). So that our methods were similar to a previous analysis, we based our approach on described methods.[8] The model included patient characteristics of age, gender, race/ethnicity, Medicaid status, hospitalization diagnoses, and all comorbidities 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 adjusted for patient characteristics (age, gender, race/ethnicity, Medicaid status, hospitalization diagnoses, and all comorbidities in Tables 1 and 2), hospital characteristics (hospital size, medical school affiliation, urban/rural, and presence of an on-site 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 odds ratio from the multi-level mixed effects model variances. The median odds ratio is a measure of between-group (hospital or state) variation that expresses the relative odds of cardiac rehabilitation participation for two identical patients living in one randomly selected group compared with a second randomly selected group. A median odds ratio is always greater than or equal to 1 and can be interpreted on the same scale as fixed effects odds ratios.[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 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% (9,123/88,826). Medicare patients (Table 1) were older and more were female compared to Veteran patients (Table 2). A greater proportion of the Veteran 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 amongst 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) (Supplemental Table 1). 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, Nebraska, Kansas, North Dakota, Minnesota, South Dakota, and Missouri) for both Medicare (33.7%) and VA (16.6%) populations (Table 4).

After adjusting for patient characteristics, hospital characteristics, and state-level socioeconomic status (Supplemental Tables 2 and 3), there remained significant variation at the state level for both Medicare (median odds ratio 1.81, 95%CI 1.63, 1.99) and VA patients (median odds ratio 2.05, 95%CI 1.54, 2.56) and at the hospital level for both Medicare (median odds ratio 1.78, 95%CI 1.74, 1.82) and VA patients (median odds ratio 2.57, 95%CI 2.17, 2.96).

A sensitivity analysis adjusting for cardiac rehabilitation program density using estimates from the 5% Medicare sample (Supplemental Tables 2 and 3) did not meaningfully alter estimates of regional and state variation (Supplemental Tables 4 and 5). A sensitivity analysis including only VA patients >65 years old demonstrated an overall participation rate of 8.5% (3,163/37,245) (Supplemental Table 6). Significant hospital- and state-level variation persisted (Supplemental Table 7), but variation across census regions was lower and no longer statistically significant (Supplemental Table 8).

Discussion

For the past 20 years, underuse of cardiac rehabilitation has been an intractable problem for patients with ischemic heart disease. Despite substantial advocacy 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 2007–2011 in two 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. Notably, 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. More importantly, 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 Veterans Affairs healthcare system. Additionally, 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. Also of note, 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.

Notably, there were greater racial and ethnic disparities in cardiac rehabilitation participation in Medicare than in VA. Though it is not possible to determine from administrative data what factors explain these differences or to examine all the socio-cultural variables that 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[21] and echocardiography[22] are higher in Medicare than in the VA health system. It has also previously been noted that regional variation in utilization of healthcare services is similar in both populations and is not attributable to differing utilization rates between the VA and Medicare. It has been previously reported that 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 the ability for VA patients 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 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] Though 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, since even hospitals having onsite cardiac rehabilitation 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 non-traditional cardiac rehabilitation. Medicare is considering 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 was 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 due to small numbers of eligible patients at some hospitals in the 5% Medicare sample. Finally, we analyzed cardiac rehabilitation program density, but the estimation of cardiac rehabilitation program density is unlikely to be accurate with the 5% Medicare sample, since 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.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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References

1. Balady GJ, Williams MA, Ades PA, Bittner V, Comoss P, Foody JM, Franklin B, Sanderson B. Southard D, American Heart Association Exercise CR, Prevention Committee tCoCC, American Heart Association Council on Cardiovascular N, American Heart Association Council on E, Prevention, American Heart Association Council on Nutrition PA, Metabolism, American Association of C and Pulmonary R. Core components of cardiac rehabilitation/secondary prevention programs: 2007 update: a scientific statement from the American Heart Association Exercise, Cardiac Rehabilitation, and Prevention Committee, the Council on Clinical Cardiology; the Councils on Cardiovascular Nursing, Epidemiology and Prevention, and Nutrition, Physical Activity, and Metabolism; and the American Association of Cardiovascular and Pulmonary Rehabilitation. Circulation. 2007; 115:2675–2682. [PubMed: 17513578]
2. Balady GJ, Ades PA, Bittner VA, Franklin BA, Gordon NF, Thomas RJ, Tomaselli GF, Yancy CW. American Heart Association Science A, Coordinating C. Referral, enrollment, and delivery of cardiac rehabilitation/secondary prevention programs at clinical centers and beyond: a presidential advisory from the American Heart Association. Circulation. 2011; 124:2951–2960. [PubMed: 22082676]
3. Anderson L, Thompson DR, Oldridge N, Zwisler AD, Rees K, Martin N, Taylor RS. Exercise-based cardiac rehabilitation for coronary heart disease. Cochrane Database Syst Rev. 2016; :CD001800.doi: 10.1002/14651858.CD001800.pub3 [PubMed: 26730878]
4. Suaya JA, Stason WB, Ades PA, Normand SL, Shepard DS. Cardiac rehabilitation and survival in older coronary patients. J Am Coll Cardiol. 2009; 54:25–33. [PubMed: 19555836]
5. Goel K, Lennon RJ, Tilbury RT, Squires RW, Thomas RJ. Impact of cardiac rehabilitation on mortality and cardiovascular events after percutaneous coronary intervention in the community. Circulation. 2011; 123:2344–2352. [PubMed: 21576654]
6. Hammill BG, Curtis LH, Schulman KA, Whellan DJ. Relationship between cardiac rehabilitation and long-term risks of death and myocardial infarction among elderly Medicare beneficiaries. Circulation. 2010; 121:63–70. [PubMed: 20026778]
7. Doll JA, Hellkamp A, Thomas L, Ho PM, Kontos MC, Whooley MA, Boyden TF, Peterson ED, Wang TY. Effectiveness of cardiac rehabilitation among older patients after acute myocardial infarction. Am Heart J. 2015; 170:855–864. [PubMed: 26542492]
8. Suaya JA, Shepard DS, Normand SL, Ades PA, Prottas J, Stason WB. Use of cardiac rehabilitation by Medicare beneficiaries after myocardial infarction or coronary bypass surgery. Circulation. 2007; 116:1653–1662. [PubMed: 17893274]
9. Schopfer DW, Krishnamurthi N, Shen H, Duvernoy CS, Forman DE, Whooley MA. Association of Veterans Health Administration Home-Based Programs With Access to and Participation in Cardiac Rehabilitation. JAMA internal medicine. 2018
10. Krumholz HM, Anderson JL, Bachelder BL, Fesmire FM, Fihn SD, Foody JM, Ho PM, Kosiborod MN, Masoudi FA, Nallamothu BK. American College of Cardiology/American Heart Association Task Force on Performance M, American Academy of Family P, American College of Emergency P, American Association of C, Pulmonary R, Society for Cardiovascular A, Interventions and Society of Hospital M. ACC/AHA 2008 performance measures for adults with ST-elevation and non-ST-elevation myocardial infarction: a report of the American College of Cardiology/American Heart Association Task Force on Performance Measures (Writing Committee to develop performance measures for ST-elevation and non-ST-elevation myocardial infarction): developed in collaboration with the American Academy of Family Physicians and the American College of Emergency Physicians: endorsed by the American Association of Cardiovascular and Pulmonary

Rehabilitation, Society for Cardiovascular Angiography and Interventions, and Society of Hospital Medicine. Circulation. 2008; 118:2596–2648. [PubMed: 19001027]

11. Thomas RJ, King M, Lui K, Oldridge N, Pina IL, Spertus J. Writing Committee M. AACVPR/ACCF/AHA 2010 update: performance measures on cardiac rehabilitation for referral to cardiac rehabilitation/secondary prevention services: a report of the American Association of Cardiovascular and Pulmonary Rehabilitation and the American College of Cardiology Foundation/American Heart Association Task Force on Performance Measures (Writing Committee to Develop Clinical Performance Measures for Cardiac Rehabilitation). Circulation. 2010; 122:1342–1350. [PubMed: 20805435]
12. Amsterdam EA, Wenger NK, Brindis RG, Casey DE Jr, Ganiats TG, Holmes DR Jr, Jaffe AS, Jneid H, Kelly RF, Kontos MC, Levine GN, Liebson PR, Mukherjee D, Peterson ED, Sabatine MS, Smalling RW, Zieman SJ. Members AATF. 2014 AHA/ACC guideline for the management of patients with non-ST-elevation acute coronary syndromes: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. Circulation. 2014; 130:e344–426. [PubMed: 25249585]
13. Hillis LD, Smith PK, Anderson JL, Bittl JA, Bridges CR, Byrne JG, Cigarroa JE, Disesa VJ, Hiratzka LF, Hutter AM Jr, Jessen ME, Keeley EC, Lahey SJ, Lange RA, London MJ, Mack MJ, Patel MR, Puskas JD, Sabik JF, Selnes O, Shahian DM, Trost JC, Winniford MD. 2011 ACCF/AHA Guideline for Coronary Artery Bypass Graft Surgery: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. Circulation. 2011; 124:e652–735. [PubMed: 22064599]
14. Smith SC Jr, Benjamin EJ, Bonow RO, Braun LT, Creager MA, Franklin BA, Gibbons RJ, Grundy SM, Hiratzka LF, Jones DW, Lloyd-Jones DM, Minissian M, Mosca L, Peterson ED, Sacco RL, Spertus J, Stein JH, Taubert KA. World Heart F, the Preventive Cardiovascular Nurses A. AHA/ACCF Secondary Prevention and Risk Reduction Therapy for Patients with Coronary and other Atherosclerotic Vascular Disease: 2011 update: a guideline from the American Heart Association and American College of Cardiology Foundation. Circulation. 2011; 124:2458–2473. [PubMed: 22052934]
15. Drozda J Jr, Messer JV, Spertus J, Abramowitz B, Alexander K, Beam CT, Bonow RO, Burkiewicz JS, Crouch M, Goff DC Jr, Hellman R, James T 3rd, King ML, Machado EA Jr, Ortiz E, O'Toole M, Persell SD, Pines JM, Rybicki FJ, Sadwin LB, Sikkema JD, Smith PK, Torcson PJ, Wong JB. ACCF/AHA/AMA-PCPI 2011 performance measures for adults with coronary artery disease and hypertension: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Performance Measures and the American Medical Association-Physician Consortium for Performance Improvement. Circulation. 2011; 124:248–270. [PubMed: 21670226]
16. Beatty AL, Li S, Thomas L, Amsterdam EA, Alexander KP, Whooley MA. Trends in referral to cardiac rehabilitation after myocardial infarction: data from the National Cardiovascular Data Registry 2007 to 2012. J Am Coll Cardiol. 2014; 63:2582–2583. [PubMed: 24768872]
17. Chronic Condition Data Warehouse. CCW Medicare Administrative Data User Guide. 2017. https://www.ccwdata.org/documents/10280/19002246/ccw-medicare-data-user-guide.pdf
18. Cohen ME, Dimick JB, Bilimoria KY, Ko CY, Richards K, Hall BL. Risk adjustment in the American College of Surgeons National Surgical Quality Improvement Program: a comparison of logistic versus hierarchical modeling. J Am Coll Surg. 2009; 209:687–693. [PubMed: 19959035]
19. Larsen K, Merlo J. Appropriate assessment of neighborhood effects on individual health: integrating random and fixed effects in multilevel logistic regression. Am J Epidemiol. 2005; 161:81–88. [PubMed: 15615918]
20. Merlo J, Chaix B, Ohlsson H, Beckman A, Johnell K, Hjerpe P, Rastam L, Larsen K. A brief conceptual tutorial of multilevel analysis in social epidemiology: using measures of clustering in multilevel logistic regression to investigate contextual phenomena. J Epidemiol Community Health. 2006; 60:290–297. [PubMed: 16537344]
21. McWilliams JM, Dalton JB, Landrum MB, Frakt AB, Pizer SD, Keating NL. Geographic variation in cancer-related imaging: Veterans Affairs health care system versus Medicare. Ann Intern Med. 2014; 161:794–802. [PubMed: 25437407]

22. Kini V, McCarthy FH, Rajaei S, Epstein AJ, Heidenreich PA, Groeneveld PW. Variation in use of echocardiography among veterans who use the Veterans Health Administration vs Medicare. Am Heart J. 2015; 170:805–811. [PubMed: 26386805]

23. Gaalema DE, Higgins ST, Shepard DS, Suaya JA, Savage PD, Ades PA. State-by-state variations in cardiac rehabilitation participation are associated with educational attainment, income, and program availability. J Cardiopulm Rehabil Prev. 2014; 34:248–254. [PubMed: 24820451]

24. Bachmann JM, Huang S, Gupta DK, Lipworth L, Mumma MT, Blot WJ, Akwo EA, Kripalani S, Whooley MA, Wang TJ, Freiberg MS. Association of Neighborhood Socioeconomic Context With Participation in Cardiac Rehabilitation. J Am Heart Assoc. 2017; :6. pii: e006260. doi: 10.1161/JAHA.117.006260

25. Karmali KN, Davies P, Taylor F, Beswick A, Martin N, Ebrahim S. Promoting patient uptake and adherence in cardiac rehabilitation. Cochrane Database Syst Rev. 2014; :CD007131.doi: 10.1002/14651858.CD007131.pub3 [PubMed: 24963623]

26. Grace SL, Gravely-Witte S, Brual J, Monette G, Suskin N, Higginson L, Alter DA, Stewart DE. Contribution of patient and physician factors to cardiac rehabilitation enrollment: a prospective multilevel study. Eur J Cardiovasc Prev Rehabil. 2008; 15:548–556. [PubMed: 18830085]

27. Grace SL, Russell KL, Reid RD, Oh P, Anand S, Rush J, Williamson K, Gupta M, Alter DA, Stewart DE. Cardiac Rehabilitation Care Continuity Through Automatic Referral Evaluation I. Effect of cardiac rehabilitation referral strategies on utilization rates: a prospective, controlled study. Arch Intern Med. 2011; 171:235–41. [PubMed: 21325114]

28. Gravely-Witte S, Leung YW, Nariani R, Tamim H, Oh P, Chan VM, Grace SL. Effects of cardiac rehabilitation referral strategies on referral and enrollment rates. Nat Rev Cardiol. 2010; 7:87–96. [PubMed: 19997077]

29. Mazzini MJ, Stevens GR, Whalen D, Ozonoff A, Balady GJ. Effect of an American Heart Association Get With the Guidelines program-based clinical pathway on referral and enrollment into cardiac rehabilitation after acute myocardial infarction. Am J Cardiol. 2008; 101:1084–1087. [PubMed: 18394437]

30. Taylor RS, Dalal H, Jolly K, Zawada A, Dean SG, Cowie A, Norton RJ. Home-based versus centre-based cardiac rehabilitation. Cochrane Database Syst Rev. 2015; :CD007130.doi: 10.1002/14651858.CD007130.pub3 [PubMed: 26282071]

31. Shanmugasegaram S, Oh P, Reid RD, McCumber T, Grace SL. A comparison of barriers to use of home- versus site-based cardiac rehabilitation. J Cardiopulm Rehabil Prev. 2013; 33:297–302. [PubMed: 23823905]

32. Ades PA, Keteyian SJ, Wright JS, Hamm LF, Lui K, Newlin K, Shepard DS, Thomas RJ. Increasing Cardiac Rehabilitation Participation From 20% to 70%: A Road Map From the Million Hearts Cardiac Rehabilitation Collaborative. Mayo Clin Proc. 2017; 92:234–242. [PubMed: 27855953]

Clinical Perspective

1) 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 2007–2011.
- Patients in the West North Central region (Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota,) had the highest participation, while those in the Pacific region (Alaska, California, Hawaii, Oregon, Washington) had the lowest participation in both Medicare (33.7 vs. 10.6%) and Veterans Affairs (16.6% vs. 5.1%) populations.

2) 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.

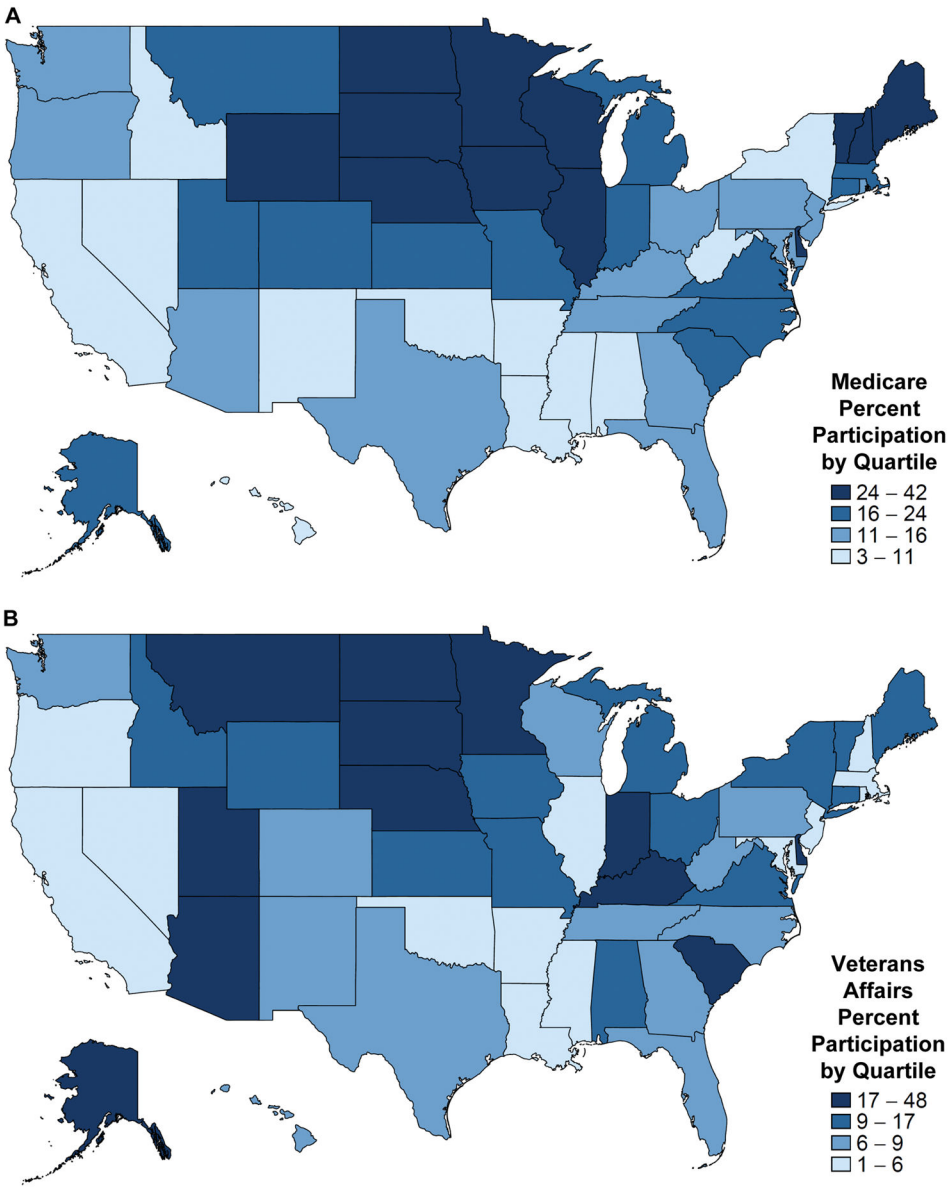

Figure 1. Standardized rates of participation in cardiac rehabilitation by state

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

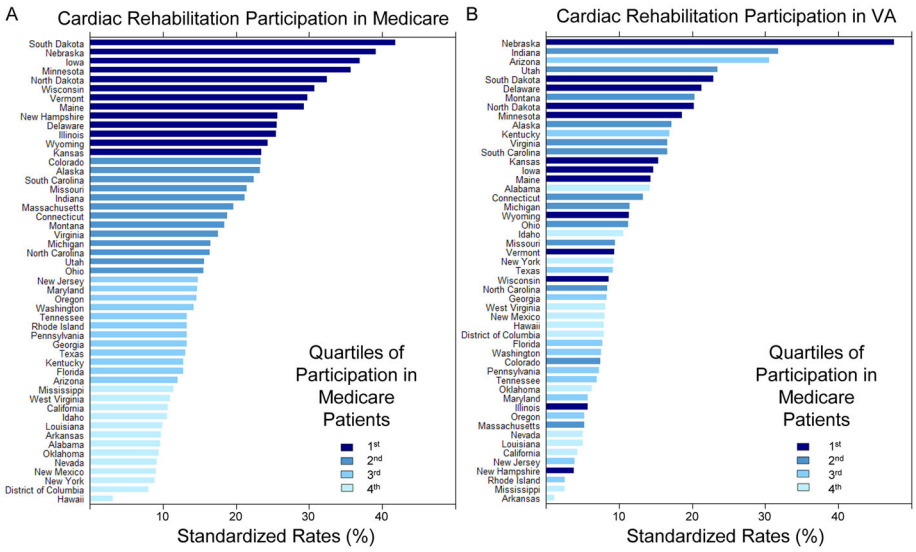

Figure 2. Variation in participation in cardiac rehabilitation by state

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

Table 1

Characteristics of Medicare patients eligible for cardiac rehabilitation.

	Total N = 143,756	Participant N = 23,403	Non-participant N = 120,353	P-value†
Patient Characteristics, N(%)				
Age, years				<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, American Indian	4,215 (2.9)	367 (1.6)	3,848 (3.2)	
Unknown/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, N(%)				
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	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
COPD	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*, N(%)				<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)	

	Total N = 143,756	Participant N = 23,403	Non-participant N = 120,353	P-value†
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)	

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 participants and non-participants by X^2 test

Table 2

Characteristics of Veterans Affairs patients eligible for cardiac rehabilitation.

	Total N = 88,826	Participant N = 9,123	Non-participant N = 79,703	P-value†
Patient Characteristics, N(%)				
Age, years				<0.001
≤65	51,579 (58.1)	5,960 (65.3)	45,619 (57.2)	
66–75	18,860 (21.2)	1,949 (21.4)	16,911 (21.2)	
76–85	14,494 (16.3)	1,070 (11.7)	13,424 (16.8)	
>85	3,891 (4.4)	144 (1.6)	3,747 (4.7)	
Race/Ethnicity				<0.001
White	69,716 (78.5)	7,219 (79.1)	62,497 (78.5)	
Black	10,457 (11.8)	926 (10.2)	9,531 (12.0)	
Hispanic	4,904 (5.5)	587 (6.4)	4,317 (5.4)	
Asian, Pacific Islander, American Indian	1,190 (1.3)	118 (1.3)	1072 (1.3)	
Unknown/Missing	2,559 (2.9)	273 (3.0)	2,286 (2.9)	
Female	1,426 (1.6)	143 (1.6)	1,283 (1.6)	0.76
Medicaid	5,571 (6.3)	579 (6.3)	4,992 (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	2,867 (3.2)	537 (5.9)	2,330 (2.9)	
PCI and CABG	1,628 (1.8)	396 (4.3)	1,232 (1.5)	
MI, PCI, and CABG	777 (0.9)	171 (1.9)	606 (0.8)	
Comorbid Conditions, N(%)				
Hypertension	69,561 (78.3)	7,066 (77.5)	62,495 (78.4)	0.04
Heart failure	16,574 (18.7)	1,163 (12.7)	15,411 (19.3)	<0.001
Arrhythmias	14,731 (16.6)	1,181 (12.9)	13,550 (17.0)	<0.001
Peripheral vascular disease	13,069 (14.7)	1,079 (11.8)	11,990 (15.0)	<0.001
Valvular heart disease	10,438 (11.8)	1,152 (12.6)	9,286 (11.7)	0.006
Cerebrovascular disease	6,012 (6.8)	432 (4.7)	5,580 (7.0)	<0.001
Diabetes	39,007 (43.9)	4,031 (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
COPD	15,877 (17.9)	1,259 (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*, N(%)				<0.001
New England	2,922 (3.4)	267 (3.0)	2,655 (3.4)	

	Total N = 88,826	Participant N = 9,123	Non-participant N = 79,703	P-value†
Mid Atlantic	5,694 (6.5)	432 (4.9)	5,262 (6.7)	
South Atlantic	19,637 (22.5)	2,105 (23.8)	17,532 (22.4)	
East North Central	10,574 (12.1)	1,360 (15.4)	9,214 (11.8)	
East South Central	8,105 (9.3)	632 (7.2)	7,473 (9.5)	
West North Central	7,643 (8.8)	1,271 (14.4)	6,372 (8.1)	
West South Central	13,495 (15.5)	814 (9.2)	12,681 (16.2)	
Mountain	10,074 (11.6)	1,486 (16.8)	8,588 (11.0)	
Pacific	9,046 (10.4)	464 (5.3)	8,582 (11.0)	

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 participants and non-participants by X^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, N patients (%)								
Hospital bed size <200	622 (2.4)	1,410 (7.0)	1,679 (9.1)	1,817 (12.2)	2,160 (10.9)	5,669 (31.9)	3,510 (22.4)	3,096 (20.5)
Academic affiliation	7,847 (29.8)	5,209 (25.9)	4,540 (24.6)	4,610 (31.0)	9,745 (49.1)	7,393 (41.6)	6,072 (38.7)	6,190 (41.0)
Non-metropolitan	443 (1.7)	408 (2.0)	1,065 (5.8)	1,582 (10.6)	0 (0)	0 (0)	95 (0.6)	407 (2.7)
Cardiac rehabilitation center onsite	12,344 (45.6)	9,506 (47.2)	9,110 (49.1)	6,211 (41.4)	1,842 (7.6)	8,031 (39.9)	12,458 (79.5)	13,058 (79.4)

P-values <0.001 for all characteristics

Table 4

Regional variation in participation in cardiac rehabilitation in Medicare and Veterans Affairs populations.

	Medicare		Veterans Affairs	
Participation Rank	**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)	East South Central	1.07 (0.85, 1.34)
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), and state socioeconomic indicators (median household income and high school graduation rate).