ORIGINAL RESEARCH

Cardiac Rehabilitation Participation and Mortality After Percutaneous Coronary Intervention: Insights From the Veterans Affairs Clinical Assessment, Reporting, and Tracking Program

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***Background*—**Cardiac rehabilitation (CR) is strongly recommended after percutaneous coronary intervention (PCI), but it is underused. We sought to evaluate CR participation variation after PCI and its association with mortality among veterans.

***Methods and Results*—**Patients undergoing PCI between 2007 and 2011 were identified in the Veterans Affairs Clinical Assessment, Reporting, and Tracking database and followed up until January 25, 2017. We excluded patients who died within 30 days of PCI and calculated the percentage participating in ≥1 outpatient CR visits within 12 months after PCI. We constructed multivariable hierarchical logistic regression models for CR participation, clustered by facility. We estimated propensity scores for CR participation, matched participants and nonparticipants by propensity score, calculated mortality rates, and estimated the association with mortality using Cox proportional hazards models. Participation in CR after PCI was 6.9% (2986/43 319) and varied significantly by PCI facility (range, 0%–36%). After 6.1 years median follow-up, CR participants had a 33% lower mortality rate than all nonparticipants (3.8 versus 5.7 deaths/100 person-years; hazard ratio, 0.67; 95% confidence interval, 0.61–0.75; $P<0.001$) and a 26% lower mortality rate than 2986 propensity-matched nonparticipants (3.8 versus 5.1 deaths/100 person-years; hazard ratio, 0.74; 95% confidence interval, 0.65–0.84; $P<0.001$). Participants attending ≥36 sessions had the lowest mortality rate (2.4 deaths/100 person-years; hazard ratio, 0.47; 95% confidence interval, 0.36–0.60; $P<0.001$).

***Conclusions*—**CR participation after PCI among veterans is low overall, with significant facility-level variation. CR participation is associated with lower mortality rates in veterans. Additional efforts are needed to promote CR participation after PCI among veterans. **(*J Am Heart Assoc*. 2018;7:e010010. DOI: 10.1161/JAHA.118.010010.)**

Key Word: cardiac rehabilitation • health services • percutaneous coronary intervention • quality and outcomes • secondary prevention

Cardiac rehabilitation (CR) is an evidence-based program of exercise training, risk factor modification, and psychosocial counseling.[1,2] Participation in CR is associated with lower cardiovascular mortality and fewer hospitalizations.[3–9] Although current professional society guidelines and performance measures strongly recommend CR after myocardial infarction or revascularization,[10–16] <20% of eligible patients participate in the United States.[17,18]

The Veterans Health Administration (VA) is a national healthcare system that provides both percutaneous coronary intervention (PCI) and CR services and may present an opportunity for improving use of CR after PCI. However, a recent analysis demonstrated only 10% participation among VA patients after myocardial infarction, PCI, or coronary artery bypass surgery.[18,19] It has also been observed that there is significant variation in participation by hospital and region, but the reasons for this variation are not entirely understood.[17–20] Additionally, it is unknown whether participation in CR is associated with lower mortality among veterans.

Improved understanding of facility-level variation in CR participation could lead to targeted interventions to promote CR. Therefore, we used the VA Clinical Assessment, Reporting,

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Clinical Perspective

What Is New?

- Participation in cardiac rehabilitation after percutaneous coronary intervention is associated with a 26% lower mortality rate among veterans, but there is significant facility-level variation in participation (range, 0%–36%).

What Are the Clinical Implications?

- There is opportunity for facilities to adopt new approaches to improve participation in cardiac rehabilitation.
- Increasing participation in cardiac rehabilitation may improve outcomes after percutaneous coronary intervention.

and Tracking (CART) database, linked with VA and non-VA healthcare data, to evaluate variation in CR participation after PCI at VA facilities and to estimate the association of CR participation with long-term mortality in veterans.

Methods

The data, analytic methods, and study materials will not be made available to other researchers for purposes of reproducing the results or replicating the procedure because of policies for use of VA and Medicare data.

Population

We used data from the VA CART database to identify patients undergoing PCI from January 1, 2007, to December 31, 2011. The VA CART program is a national quality program supporting all VA cardiac catheterization laboratories, where invasive cardiac procedures are performed. A key feature of the CART program is the CART software application, which is embedded in the VA electronic health record that systematically collects all procedural data on catheterization procedures, both diagnostic and interventional, performed in the VA system.[21,22] We excluded patients who died within 30 days of PCI. The University of California, San Francisco Committee on Human Research, San Francisco VA Medical Center Research and Development Committee, and VA Puget Sound Health Care System Institutional Review Board and Research and Development Committees approved the study and waived the requirement for informed consent.

Outcomes

CR participation was defined as ≥1 encounters for CR (*Current Procedural Terminology* codes 93797, 93798, S9472, S9473, G0422, and G0423) within 1 year after discharge. We determined CR participation from data on encounters from VA care, non-VA care purchased by VA, and Medicare. Mortality was determined from VA vital status files. The last date of follow-up was January 25, 2017.

Patient Characteristics, Comorbidities, and Procedure Characteristics

Patient characteristics (age, sex, race/ethnicity, and insurance status) were obtained from VA electronic health record data. Comorbidities and procedural characteristics (procedure status and coronary anatomical characteristics) were entered into the CART application by clinical providers. When CART data were missing or unavailable, comorbidities were obtained from VA inpatient and outpatient data. A comorbid condition was considered present if it was listed as a diagnosis in 2 outpatient encounters or 1 inpatient encounter during the year before and including the index event. Procedure characteristics (procedure status, PCI, and extent of coronary disease) were coded by clinical providers in the CART application.

Facility Characteristics

Geographic region was described on the basis of PCI facility location, categorized by US Census Regions (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). PCI volume was determined from the CART database as the number of PCIs performed at each facility per year that PCIs were performed at the facility. Facility PCI volume was dichotomized at 200 procedures per year.[23] CR center status was determined from a 2011 survey of VA facilities.

Statistical Analysis

Differences in patient characteristics by CR participation were compared using Wilcoxon rank-sum test for continuous variables and the χ^2 test for categorical variables. We described percentage of PCI patients participating in CR by facility. We constructed multivariable hierarchical logistic regression models for participation in CR, clustered by facility, using generalized estimating equation models with logit link. Variables included in the model were year of procedure and all

Table 1. Characteristics of PCI Patients by CR Participation Status

Characteristics	All (N=43 319)	Participants (N=2986)	Nonparticipants (N=40 333)	*P* Value*
Patient characteristics				
Age, median (IQR), y	63 (59–70)	63 (59–68)	64 (59–71)	<0.001
Female sex, N (%)	704 (2)	54 (2)	650 (2)	0.41
Race/ethnicity, N (%)				
White	33 816 (78)	2334 (78)	31 482 (78)	0.04
Black	5088 (12)	376 (13)	4712 (12)	
Hispanic	1756 (4)	130 (4)	1626 (4)	
Asian/Pacific Islander/American Indian	667 (2)	41 (1)	626 (2)	
Unknown/missing	1992 (5)	105 (4)	1879 (5)	
Medicaid, N (%)	2561 (6)	169 (6)	2392 (6)	0.55
Current tobacco use, N (%)	9393 (22)	561 (19)	8832 (22)	<0.001
Hypertension, N (%)	37 400 (86)	2562 (86)	34 838 (86)	0.38
Hyperlipidemia, N (%)	37 030 (85)	2600 (87)	34 430 (85)	0.01
Diabetes mellitus type 2, N (%)	19 242 (44)	1354 (45)	17 888 (44)	0.29
Heart failure, N (%)	7990 (18)	472 (16)	7518 (19)	<0.001
Cerebrovascular disease, N (%)	5586 (13)	357 (12)	5229 (13)	0.11
Peripheral vascular disease, N (%)	7994 (18)	423 (14)	7517 (19)	<0.001
COPD, N (%)	9376 (22)	560 (19)	8816 (22)	<0.001
Chronic kidney disease, N (%)	6804 (16)	389 (13)	6415 (16)	<0.001
Hemodialysis, N (%)	767 (2)	22 (1)	745 (2)	<0.001
Depression, N (%)	7868 (18)	616 (21)	7252 (18)	<0.001
Valvular heart disease, N (%)	4249 (10)	316 (11)	3933 (10)	0.14
Arrhythmias, N (%)	7391 (17)	515 (17)	6876 (17)	0.78
Cancer, N (%)	6544 (15)	415 (14)	6129 (15)	0.06
Dementia, N (%)	221 (1)	(0)†	(1)†	0.01
Status, N (%)				
Elective	27 757 (64)	1742 (58)	26 015 (65)	<0.001
Urgent	11 882 (27)	855 (29)	11 027 (27)	
Emergent/salvage	2814 (7)	339 (11)	2475 (6)	
Unknown/missing	866 (2)	50 (2)	816 (2)	
Three-vessel disease, N (%)	11 430 (26)	828 (28)	10 602 (26)	0.08
Facility characteristics				
Region, N (%)‡				
New England	736 (2)	76 (3)	660 (2)	<0.001
Mid Atlantic	2459 (6)	183 (6)	2276 (6)	
South Atlantic	9227 (21)	658 (22)	8569 (21)	
East North Central	4993 (12)	302 (10)	4691 (12)	
East South Central	4944 (11)	368 (12)	4576 (11)	
West North Central	5883 (14)	479 (16)	5404 (13)	
West South Central	7159 (17)	387 (13)	6772 (17)	
Mountain	3381 (8)	388 (13)	2993 (7)	

Continued

Table 1. Continued

Characteristics	All (N=43 319)	Participants (N=2986)	Nonparticipants (N=40 333)	*P* Value*
Pacific	4249 (10)	111 (4)	4138 (10)	
Puerto Rico	288 (1)	34 (1)	254 (1)	
PCI volume ≥200/y, N (%)	17 884 (41)	993 (33)	16 891 (42)	<0.001
On-site cardiac rehabilitation center, N (%)	16 793 (39)	1609 (54)	15 184 (38)	<0.001

COPD indicates chronic obstructive pulmonary disease; CR, cardiac rehabilitation; IQR, interquartile range; and PCI, percutaneous coronary intervention.
*P value for comparison of participants and nonparticipants by Wilcoxon rank-sum test or χ^2.
†Number suppressed because of corresponding cell size <10.
‡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.

variables in Table 1. We also used this model to generate a propensity score from year of procedure and all variables in Table 1. We matched CR participants to CR nonparticipants in a 1:1 ratio by propensity score using nearest neighbor matching. We calculated mortality rates among those participating, those not participating, and propensity-matched nonparticipants and generated a cumulative hazard plot for propensity-matched participants and nonparticipants. These models included only CR participation status and death. We compared propensity-matched pairs using Cox proportional hazards, using the Stata option "vce cluster" by facility, which allows for intragroup correlation in estimating SEs. We used Cox proportional hazards models to estimate the association with number of CR sessions attended with mortality. These models included only number of CR sessions attended and death. All analyses were performed with Stata, version 15. Figures were created using Stata or Tableau. Dr Beatty had full access to all the data and takes responsibility for their integrity and the data analysis.

Results

Between 2007 and 2011, there were 43 319 veterans who underwent PCI at a VA facility and survived at least 30 days. Of those veterans, 2986 (6.9%) participated in CR (Table 1), either at a VA facility or at another facility through care purchased by the VA or Medicare. There was substantial variation in participation in CR by facility, ranging from 0% to 36% participation (Figure 1). CR participation during the year after PCI increased between 2007 and 2011 (5.0%–8.3%; P<0.001 for trend).

In an adjusted model including all variables from Table 1, older age, tobacco use, peripheral vascular disease, hemodialysis, and dementia were associated with decreased odds of participation in CR (Table 2). Black race, hyperlipidemia, depression, valvular heart disease, urgent/emergent procedure, and 3-vessel disease were associated with greater odds of participation in CR (Table 2). There was regional variation, with significantly lower participation in the West South Central (Arkansas, Louisiana, Oklahoma, Texas) and Pacific (Alaska, California, Hawaii, Oregon, Washington) regions (Table 2). Other candidate factors from Table 1 were not significantly associated with CR participation (P>0.05).

Median follow-up time was 6.1 years (interquartile range, 4.9–7.5 years). There were 678 deaths among CR participants and 13 279 deaths among non-CR participants. There were 886 deaths among the 2986 non-CR participants who were 1:1 propensity matched with CR participants. CR participants had a 33% lower mortality rate than all nonparticipants (3.8 versus 5.7 deaths/100 person-years; hazard ratio, 0.67; 95% confidence interval, 0.61–0.75; P<0.001) and a 26% lower mortality rate than 2986 propensity-matched nonparticipants (3.8 versus 5.1 deaths/100 person-years; hazard ratio, 0.74; 95% confidence interval, 0.65–0.84; P<0.001) (Figure 2). For each 10 CR sessions attended, CR participants had 18% lower

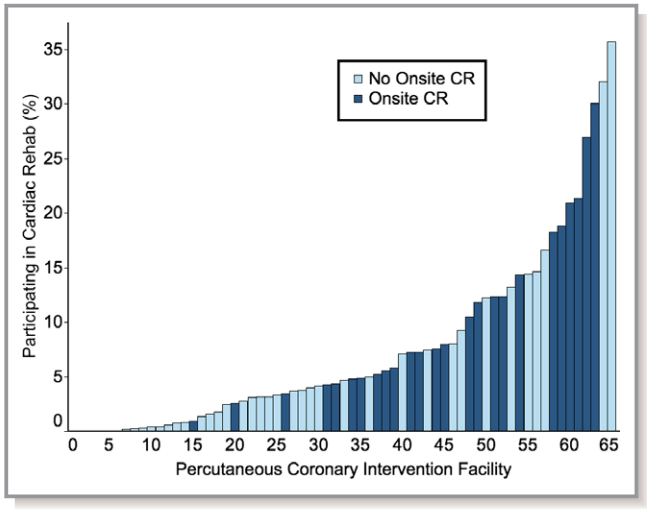

Figure 1. Participation in cardiac rehabilitation (CR) by facility among veterans undergoing percutaneous coronary intervention from 2007 to 2011.

Table 2. Predictors of Participation in CR After PCI

Characteristics	Adjusted Odds Ratio*	95% Confidence Interval	*P* Value
Decreased odds of participation			
Age (per 10-y increase)	0.83	0.80–0.88	<0.001
Current tobacco use	0.70	0.63–0.77	<0.001
Peripheral vascular disease	0.82	0.74–0.91	<0.001
Hemodialysis	0.47	0.32–0.70	<0.001
Dementia	0.39	0.18–0.85	0.01
Region (vs New England)†			
Mid Atlantic	0.57	0.18–2.08	<0.001
South Atlantic	0.55	0.17–1.73	
East North Central	0.54	0.16–1.75	
East South Central	0.92	0.28–3.00	
West North Central	1.23	0.38–3.92	
West South Central	0.11	0.03–0.40	
Mountain	0.70	0.20–2.40	
Pacific	0.15	0.04–0.61	
Puerto Rico	0.92	0.15–5.29	
Increased odds of participation			
Race/ethnicity (vs white)			
Black	1.26	1.13–1.41	<0.001
Hispanic/Latino	1.20	0.98–1.47	
Asian/Pacific Islander/ American Indian	0.97	0.71–1.33	
Unknown/missing	0.85	0.70–1.04	
Hyperlipidemia	1.17	1.04–1.30	0.006
Depression	1.12	1.02–1.23	0.01
Valvular heart disease	1.22	1.08–1.38	0.001
Status (vs elective)			<0.001
Urgent	1.23	1.13–1.34	
Emergent/salvage	2.10	1.81–2.43	
Three-vessel disease	1.09	1.00–1.18	0.048
Year of procedure (vs 2007)			
2008	1.04	0.90–1.19	<0.001‡
2009	1.33	1.16–2.53	
2010	1.66	1.44–1.92	
2011	1.73	1.49–2.00	

CR indicates cardiac rehabilitation; and PCI, percutaneous coronary intervention.
*Adjusted for characteristics in Table 1 and year of procedure.
†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* value for linear trend by year.

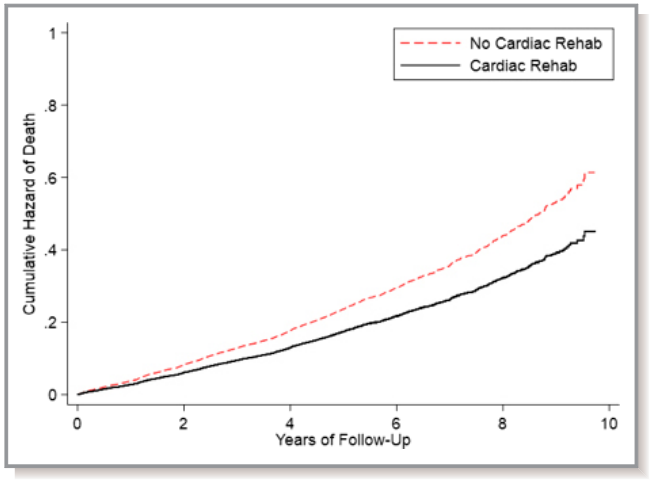

Figure 2. Cumulative hazard of death after percutaneous coronary intervention by participation in cardiac rehabilitation among propensity-matched pairs.

mortality (hazard ratio, 0.82; 95% confidence interval, 0.79–0.85; *P*<0.001) (Figure 3). There were 465 patients who attended a complete course of at least 36 CR sessions, of whom only 69 died (2.4 deaths/100 person-years; hazard ratio, 0.47; 95% confidence interval, 0.36–0.60; *P*<0.001 versus propensity-matched nonparticipants).

Discussion

This research aimed to evaluate variation in CR participation after PCI among veterans and estimate the association of CR participation with long-term mortality. There was significant facility-level variation in CR participation within the VA healthcare system, ranging from 0% to 36%. Veterans who participated in CR had a significantly lower mortality rate than nonparticipants after accounting for patient and facility characteristics. Attending a greater number of CR sessions was associated with a lower mortality rate.

This is the first study to report CR participation by facility, which enables this study to more closely examine factors such as the availability of on-site CR. Facilities with on-site CR had a higher percentage of patients participating in CR, but this study demonstrates that having an on-site CR center is neither necessary nor sufficient for achieving high rates of participation.[19] Indeed, the 2 top-performing sites do not have on-site CR. Previous research suggests that important factors for high participation are strong healthcare professional endorsement and an organizational climate that values CR and has systematic processes for CR referral and enrollment.[24] For example, one of the top performing facilities without on-site CR initiates CR referrals at a standard posthospitalization clinic visit within 2 to 4 weeks of hospital discharge, with CR "highly encouraged" by providers, and

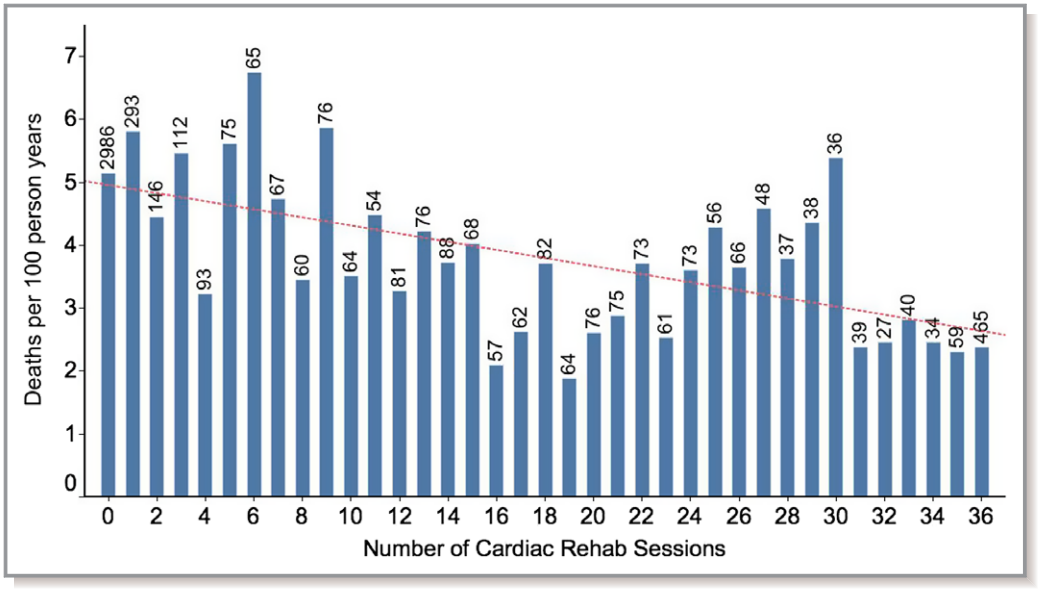

Figure 3. Mortality rate after percutaneous coronary intervention by number of sessions of cardiac rehabilitation attended among propensity-matched patients. The dotted red line represents the linear trend in mortality by number of sessions. The numbers above each bar represent the number of patients attending each number of sessions.

coordination of CR referrals is performed by a nurse case manager. Strategies used at other top performing facilities also include strong provider endorsement, automatic referral via electronic order sets, and contact by a CR liaison either in person in the hospital or within 1 week of referral by telephone.

Similar to prior research in other populations of patients with coronary heart disease,[4–8] veterans who participated in CR had lower mortality rates than veterans who did not participate in CR. The magnitude of the relative risk reduction observed in this study (27% lower risk) was comparable to previous studies (13%–47% lower risk).[4,5,7–9] Although people who participate in CR may be healthier than nonparticipants in ways that cannot be accounted for with analyses using coded encounter data, it is notable that the finding that CR participation is associated with lower mortality is consistently observed across different populations and analyses. In addition, we observed that participating in a greater number of CR sessions was associated with a lower mortality rate, consistent with previous studies.[6]

These data reveal several opportunities for improvement among some groups of patients undergoing PCI. Patients undergoing elective PCI had lower rates of participation in CR than those undergoing urgent or emergent procedures. Improving referral and promoting enrollment among patients undergoing elective PCI may be a potential strategy for improving participation. Additionally, we observed that patients with peripheral vascular disease had lower rates of participation. It is known that patients with peripheral vascular disease[25] benefit from supervised exercise therapy and are recommended to receive exercise training. Targeting populations with multiple indications for secondary prevention interventions may be especially beneficial.

This study highlights the potential benefits that may arise from improving the system of delivery of CR. The Million Hearts Initiative Cardiac Rehabilitation Collaborative has identified increasing participation in CR as a strategy for reducing cardiovascular events nationwide by 2022 and has estimated that increasing CR participation to 70% would save 25 000 lives annually in the United States.[26] Similarly, our findings suggest that increasing participation in CR among veterans will save veteran lives.

Strategies that have been shown to be effective for increasing CR referral and participation rates include the following: automatic referral of all eligible patients at discharge, strong provider recommendation of participation in CR, structured staff contacts to encourage participation in CR, and early enrollment in CR.[2,27–29] Novel delivery strategies, such as telehealth-delivered home-based CR, have similar efficacy and may improve overall participation rates and access to CR.[16,30,31,32] Because the VA is an integrated health system, it offers a unique opportunity to implement strategies for improving CR participation and measuring the impact of these efforts. Indeed, the VA began instituting home-based CR in 2010. Although participation in CR has increased at sites with home-based CR, participation rates remain <25%.[19] Future studies should focus on the implementation and effectiveness of evidence-based strategies to improve participation in CR.

Several limitations to these findings should be noted. First, this study relied on coded encounter data to determine the denominator of potentially eligible patients. Some patients deemed ineligible for CR by their providers are included within our denominator. However, other analyses have demonstrated rates of ineligibility of <10%.[33] Second, because coded encounter data were used for this analysis, we cannot account for all potentially important factors that could contribute to likelihood of attending CR. Third, our study has limited generalizability to women, nonveterans, and uninsured populations. Finally, this study included only patients undergoing PCI, and findings may not be generalizable to other populations of patients eligible for CR.

Conclusions

CR participation after PCI among veterans is low overall, with significant facility-level variation. CR participation is associated with lower long-term mortality rates. Additional efforts are needed to promote CR participation after PCI among veterans.

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Disclosures

None.

References

1. Balady GJ, Williams MA, Ades PA, Bittner V, Comoss P, Foody JM, Franklin B, Sanderson B, Southard D; American Heart Association Exercise, Cardiac Rehabilitation, and Prevention Committee, the Council on Clinical Cardiology; American Heart Association Council on Cardiovascular Nursing; American Heart Association Council on Epidemiology and Prevention; American Heart Association Council on Nutrition, Physical Activity, and Metabolism; American Association of Cardiovascular and Pulmonary Rehabilitation. 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.
2. Balady GJ, Ades PA, Bittner VA, Franklin BA, Gordon NF, Thomas RJ, Tomaselli GF, Yancy CW; American Heart Association Science Advisory and Coordinating Committee. 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.
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;1:CD001800.
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.
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.
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.
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.
8. Kureshi F, Kennedy KF, Jones PG, Thomas RJ, Arnold SV, Sharma P, Fendler T, Buchanan DM, Qintar M, Ho PM, Nallamothu BK, Oldridge NB, Spertus JA. Association between cardiac rehabilitation participation and health status outcomes after acute myocardial infarction. *JAMA Cardiol*. 2016;1:980–988.
9. Dunlay SM, Pack QR, Thomas RJ, Killian JM, Roger VL. Participation in cardiac rehabilitation, readmissions, and death after acute myocardial infarction. *Am J Med*. 2014;127:538–546.
10. Levine GN, Bates ER, Blankenship JC, Bailey SR, Bittl JA, Cercek B, Chambers CE, Ellis SG, Guyton RA, Hollenberg SM, Khot UN, Lange RA, Mauri L, Mehran R, Moussa ID, Mukherjee D, Nallamothu BK, Ting HH. 2011 ACCF/AHA/SCAI Guideline for Percutaneous Coronary Intervention: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines and the Society for Cardiovascular Angiography and Interventions. *Circulation*. 2011;124:e574–e651.
11. Nallamothu BK, Tommaso CL, Anderson HV, Anderson JL, Cleveland JC Jr, Dudley RA, Duffy PL, Faxon DP, Gurm HS, Hamilton LA, Jensen NC, Josephson RA, Malenka DJ, Maniu CV, McCabe KW, Mortimer JD, Patel MR, Persell SD, Rumsfeld JS, Shunk KA, Smith SC Jr, Stanko SJ, Watts B. ACC/AHA/SCAI/AMA-Convened PCPI/NCQA 2013 Performance Measures for Adults Undergoing Percutaneous Coronary Intervention: a report of the American College of Cardiology/American Heart Association Task Force on Performance Measures, the Society for Cardiovascular Angiography and Interventions, the American Medical Association-Convened Physician Consortium for Performance Improvement, and the National Committee for Quality Assurance. *Circulation*. 2014;129:926–949.
12. Writing Committee Members, Thomas RJ, King M, Lui K, Oldridge N, Pina IL, Spertus J. 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.
13. 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; ACC/AHA Task Force Members. 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–e426.
14. Jneid H, Addison D, Bhatt DL, Fonarow GC, Gokak S, Grady KL, Green LA, Heidenreich PA, Ho PM, Jurgens CY, King ML, Kumbhani DJ, Pancholy S. AHA/ACC Clinical Performance and Quality 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. *Circ Cardiovasc Qual Outcomes*. 2017;2017:10.
15. 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 Federation and the Preventive Cardiovascular Nurses Association. 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.
16. 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 III, 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.

17. 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.
18. Beatty AL, Truong M, Schopfer DW, Shen H, Bachmann JM, Whooley MA. Geographic variation in cardiac rehabilitation participation in Medicare and veterans affairs populations: an opportunity for improvement? *Circulation*. 2018;137:1899–1908.
19. 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 Intern Med*. 2018;178:715–717.
20. Vigen R, Spertus JA, Maddox TM, Ho PM, Jones PG, Arnold SV, Masoudi FA, Bradley SM. Hospital-level variation in angina and mortality at 1 year after myocardial infarction: insights from the Translational Research Investigating Underlying Disparities in Acute Myocardial Infarction Patients' Health Status (TRIUMPH) Registry. *Circ Cardiovasc Qual Outcomes*. 2014;7:851–856.
21. Maddox TM, Plomondon ME, Petrich M, Tsai TT, Gethoffer H, Noonan G, Gillespie B, Box T, Fihn SD, Jesse RL, Rumsfeld JS. A national clinical quality program for veterans affairs catheterization laboratories (from the VA Clinical Assessment, Reporting, and Tracking [CART] Program). *Am J Cardiol*. 2014;114:1750–1757.
22. Byrd JB, Vigen R, Plomondon ME, Rumsfeld JS, Box TL, Fihn SD, Maddox TM. Data quality of an electronic health record tool to support VA cardiac catheterization laboratory quality improvement: the VA Clinical Assessment, Reporting, and Tracking System for Cath Labs (CART) program. *Am Heart J*. 2013;165:434–440.
23. Harold JG, Bass TA, Bashore TM, Brindis RG, Brush JE Jr, Burke JA, Dehmer GJ, Deychak YA, Jneid H, Jollis JG, Landzberg JS, Levine GN, McClurken JB, Messenger JC, Moussa ID, Muhlestein JB, Pomerantz RM, Sanborn TA, Sivaram CA, White CJ, Williams ES; Presidents and Staff; American College of Cardiology Foundation; American Heart Association; Society of Cardiovascular Angiography and Interventions. ACCF/AHA/SCAI 2013 update of the clinical competence statement on coronary artery interventional procedures: a report of the American College of Cardiology Foundation/American Heart Association/American College of Physicians Task Force on Clinical Competence and Training (writing committee to revise the 2007 clinical competence statement on cardiac interventional procedures). *Circulation*. 2013;128:436–472.
24. Forman DE, Fix GM, McDannold S, McIntosh N, Schopfer DW, Whooley MA, Charns MP. Decisive bearing of organizational dynamics on the application and success of hospital-based cardiac rehabilitation. *Mayo Clin Proc*. 2016;91:975–977.
25. Lane R, Harwood A, Watson L, Leng GC. Exercise for intermittent claudication. *Cochrane Database Syst Rev*. 2017;12:CD000990.
26. 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.
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 (CRCARE) Investigators. Effect of cardiac rehabilitation referral strategies on utilization rates: a prospective, controlled study. *Arch Intern Med*. 2011;171:235–241.
28. 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;6:CD007131.
29. Sandesara PB, Lambert CT, Gordon NF, Fletcher GF, Franklin BA, Wenger NK, Sperling L. Cardiac rehabilitation and risk reduction: time to "Rebrand and Reinvigorate." *J Am Coll Cardiol*. 2015;65:389–395.
30. Anderson L, Sharp GA, Norton RJ, Dalal H, Dean SG, Jolly K, Cowie A, Zawada A, Taylor RS. Home-based versus centre-based cardiac rehabilitation. *Cochrane Database Syst Rev*. 2017;6:CD007130.
31. Wakefield B, Drwal K, Scherubel M, Klobucar T, Johnson S, Kaboli P. Feasibility and effectiveness of remote, telephone-based delivery of cardiac rehabilitation. *Telemed J E Health*. 2014;20:32–38.
32. Rohrbach G, Schopfer DW, Krishnamurthi N, Pabst M, Bettencourt M, Loomis J, Whooley MA. The design and implementation of a home-based cardiac rehabilitation program. *Federal practitioner*. 2017;34:30–35.
33. 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.