Original Article

Referral to Cardiac Rehabilitation After Percutaneous Coronary Intervention, Coronary Artery Bypass Surgery, and Valve Surgery

Data From the Clinical Outcomes Assessment Program

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Background—Despite guideline recommendations that patients undergoing percutaneous coronary intervention (PCI), coronary artery bypass surgery, or valve surgery be referred to cardiac rehabilitation, cardiac rehabilitation is underused. The objective of this study was to examine hospital-level variation in cardiac rehabilitation referral after PCI, coronary artery bypass surgery, and valve surgery.

Methods and Results—We analyzed data from the Clinical Outcomes Assessment Program, a registry of all nonfederal hospitals performing PCI and cardiac surgery in Washington State. We included eligible PCI, coronary artery bypass surgery, and valve surgery patients from 2010 to 2015. We analyzed PCI and cardiac surgery separately by performing multivariable hierarchical logistic regression for the outcome of cardiac rehabilitation referral at discharge, clustered by hospital. Patient-level covariates included age, sex, race/ethnicity, comorbidities, and procedure indication/status. Cardiac rehabilitation referral was reported in 48% (34 047/71 556) of PCI patients and 91% (21 831/23 972) of cardiac surgery patients. The hospital performing the procedure was a stronger predictor of referral than any individual patient characteristic for PCI (hospital referral range 3%–97%; median odds ratio, 5.94; 95% confidence interval, 4.10–9.49) and cardiac surgery (range 54%–100%; median odds ratio, 7.09; 95% confidence interval, 3.79–17.80). Hospitals having an outpatient cardiac rehabilitation program explained only 10% of PCI variation and 0% of cardiac surgery variation.

Conclusions—Cardiac rehabilitation referral at discharge was less prevalent after PCI than cardiac surgery. The strongest predictor of cardiac rehabilitation referral was the hospital performing the procedure. Efforts to improve cardiac rehabilitation referral should focus on increasing referral after PCI, especially in low referral hospitals. **(*Circ Cardiovasc Qual Outcomes*. 2017;10:e003364. DOI: 10.1161/CIRCOUTCOMES.116.003364.)**

Key Words: cardiac rehabilitation ■ coronary artery bypass ■ percutaneous coronary intervention ■ quality of health care

Cardiac rehabilitation is a multidisciplinary program of exercise training, risk factor modification, and psychosocial counseling that reduces mortality and hospitalizations and improves quality of life in patients with heart disease.[1–4] Guidelines recommend that patients be referred to cardiac rehabilitation in the setting of many cardiovascular conditions, including after percutaneous coronary intervention (PCI), coronary artery bypass surgery (CABG), or valve surgery.[5–10] Referral of eligible patients to cardiac rehabilitation at hospital discharge is included in performance measures.[11–14] However, referral to and participation in cardiac rehabilitation have historically been poor.[3,15–22]

Previous analyses of acute myocardial infarction and PCI patients have identified both patient and hospital characteristics as predictors of referral to cardiac rehabilitation.[15–17,19] Hospital characteristics have been shown to be among the strongest predictors of cardiac rehabilitation referral.[16,17] However, little is known about the magnitude and extent of hospital-level variation in cardiac rehabilitation referral after PCI and cardiac surgery. It is also unknown whether hospital-level variation is explained by whether the hospital has an outpatient cardiac rehabilitation program.

In this study, we sought to examine hospital-level variation in cardiac rehabilitation referral after PCI, CABG, and

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WHAT IS KNOWN

- Cardiac rehabilitation improves outcomes for patients with heart disease.
- Despite being recommended by guidelines, rates of referral to cardiac rehabilitation are historically suboptimal.

WHAT THE STUDY ADDS

- In Washington State, cardiac rehabilitation referral was lower after PCI (48%) than after cardiac surgery (91%).
- Cardiac rehabilitation referral varied dramatically across hospitals (3%–100%); hospitals having an outpatient cardiac rehabilitation program explained only 10% of PCI variation and 0% of cardiac surgery variation.
- Hospitals and departments should focus on increasing referral after PCI; automatic referral at hospital discharge is recommended.

valve surgery and whether having an outpatient cardiac rehabilitation program was associated with referral.

Methods

Data Source

Data were analyzed from the Clinical Outcomes Assessment Program, a quality improvement registry that includes all nonfederal hospitals in Washington State that perform cardiac revascularization or valve procedures. Data on consecutive patients undergoing PCI, CABG, and valve surgery at 37 PCI hospitals and 16 cardiac surgery hospitals were obtained, including baseline demographic and clinical characteristics, admission characteristics, procedure characteristics, and discharge characteristics. PCI data were collected using the National Cardiovascular Data Registry CathPCI data collection form version 4. Cardiac surgery data were collected using the Society for Thoracic Surgeons data collection form version 2. The determination that this deidentified data analysis was not human subjects research was made by the University of Washington Institutional Review Board.

Population

We included all adult patients (age ≥18) undergoing PCI, CABG, and valve surgery, between January 1, 2010 and December 31, 2015. We excluded patients who died during hospitalization. We excluded patients with missing data for cardiac rehabilitation referral after PCI (n=109, 0.14%) and cardiac surgery (n=23, 0.09%).

Primary Outcome

The primary outcome for this analysis was referral to cardiac rehabilitation as reported in the CathPCI or Society for Thoracic Surgeons data collection forms. For the CathPCI data collection form, referral was defined as written documentation of a referral for the patient (by the physician, nurse, or other personnel) to an outpatient cardiac rehabilitation program or a documented medical or patient-centered reason why such a referral was not made, and could be reported as Yes, No, or Ineligible. For the Society for Thoracic Surgeons data collection form, referral was defined as whether advice was given or discussion conducted with the patient (by physician, nurse, or other personnel) about the importance of joining a cardiac rehabilitation program, or an appointment made and could be reported as Yes, No, or Not Applicable. Reasons for ineligibility were not available from either data collection form.

Statistical Analysis

We analyzed data for PCI and cardiac surgery separately. Baseline characteristics by cardiac rehabilitation referral were compared using Wilcoxon rank-sum test for continuous variables or χ^2 test for categorical variables. Multivariable logistic regression was used to estimate the effect of covariates on cardiac rehabilitation referral. A multilevel mixed-effects model was used to account for both hospital- and patient-level effects. Patient covariates included all characteristics in Table 1 for PCI and Table 2 for cardiac surgery. Calendar year of procedure was also included in the model. To describe hospital-level variation, we calculated the median odds ratio (OR) from the mixed-effects model hospital-level variance.[23] The median OR is a measure of between-cluster variation that expresses the relative odds of cardiac rehabilitation referral for 2 identical patients at 1 randomly selected hospital compared with a second randomly selected hospital. A median OR is always ≥1. Higher median ORs reflect a larger amount of between-cluster variation, and the magnitude of variation can be interpreted on the same scale as fixed-effects ORs.[24] We investigated the effect of hospital characteristics of hospital bed size, procedure volume, and academic affiliation (defined as having an accredited graduate medical education program in medicine or thoracic surgery) by including these characteristics in the multivariable model. We further investigated the effect of the hospital having an outpatient cardiac rehabilitation program by including cardiac rehabilitation program status into the model adjusted for patient and hospital characteristics for both PCI and cardiac surgery. We calculated the intraclass correlation for each model and estimated the percent of variation explained by whether the hospital has a cardiac rehabilitation program by estimating the proportional reduction in variance using the formula for partitioned variance.[25] Among the 16 hospitals performing both PCI and cardiac surgery, we estimated the correlation between referral rate after PCI and referral rate after cardiac surgery using a Spearman rank correlation. To describe temporal trends in cardiac rehabilitation referral, we performed a linear test for trend using the multivariable model coefficients for calendar year.

We estimated risk- and reliability-adjusted rates of cardiac rehabilitation referral.[26,27] To perform risk adjustment, we performed a standard logistic regression for the outcome of cardiac rehabilitation referral with all patient characteristic variables and year and calculated the log(odds) of referral as a risk score. We then created a multilevel mixed-effects regression model with both patient- and hospital-level effects with the risk score as the only patient-level variable. We created empirical Bayes estimates of each hospital's random effect in log(odds), added this random effect to the average patient log(odds) risk, and performed an inverse logit to calculate the reliability-adjusted estimate for each hospital. We excluded the 4 cardiac surgery hospitals with the lowest rates of cardiac rehabilitation referral from the risk- and reliability-adjusted analysis because of influence on model estimates. Statistical analyses were performed using Stata, version 14.

Results

Of the 75 745 patients discharged alive after PCI, 4189 (6%) were reported as ineligible, leaving 71 556 patients for this analysis. Of the 25 807 patients discharged alive after cardiac surgery, 1835 (7%) were reported as ineligible, leaving 23 972 patients for this analysis. Cardiac rehabilitation referral occurred in 34 047 (48%) after PCI and 21 831 (91%) after cardiac surgery. Patient characteristics differed between patients referred and not referred after PCI (Table 1) and cardiac surgery (Table 2). The prevalence of cardiac rehabilitation referral by hospital ranged from 3% to 97% after PCI and 54% to 100% after cardiac surgery (Figure 1). Crude, risk-adjusted, and risk- and reliability-adjusted estimates of cardiac rehabilitation referral are reported by hospital (Table in the Data Supplement).

Table 1. Characteristics of Patients Eligible for Cardiac Rehabilitation After Percutaneous Coronary Intervention

Characteristic	Eligible n=71 556	Referred n=34 047	Not Referred n=37 509	*P* Value
Age, y	65 (57–73)	65 (56–73)	65 (57–74)	<0.001
Female	19 907 (27.8)	9558 (28.1)	10 349 (27.6)	0.15
Race				<0.001
White	63 978 (89.4)	30 637 (90.0)	33 341 (88.9)	
Black	1769 (2.5)	859 (2.5)	910 (2.4)	
Asian	2775 (3.9)	1054 (3.1)	1721 (4.6)	
American Indian/Alaska Native	690 (1.0)	366 (1.1)	324 (0.9)	
Native Hawaiian/Pacific Islander	457 (0.6)	241 (0.7)	216 (0.6)	
Missing/Other	1887 (2.6)	890 (2.6)	997 (2.7)	
Hispanic/Latino	1947 (2.7)	973 (2.9)	974 (2.6)	0.03
Smoking	17 047 (23.8)	8618 (25.3)	8429 (22.5)	<0.001
Body mass index, kg/m^2	29 (26–33)	29 (26–33)	29 (26–33)	<0.001
Hypertension	54 677 (76.4)	26 189 (76.9)	28 488 (75.9)	0.002
Hyperlipidemia	54 247 (75.8)	26 203 (77.0)	28 044 (74.8)	<0.001
History of diabetes mellitus	23 502 (32.8)	11 128 (32.7)	12 374 (33.0)	0.41
History of myocardial infarction	20 533 (28.7)	9851 (28.9)	10 682 (28.5)	0.16
History of heart failure	7510 (10.5)	3498 (10.3)	4012 (10.7)	0.07
History of percutaneous coronary intervention	26 856 (37.5)	12 369 (36.3)	14 487 (38.6)	<0.001
History of coronary artery bypass	11 567 (16.2)	5 169 (15.2)	6 398 (17.1)	<0.001
History of valve surgery	1257 (1.8)	513 (1.5)	744 (2.0)	<0.001
On dialysis	1276 (1.8)	529 (1.6)	747 (2.0)	<0.001
History of cerebrovascular accident	8134 (11.4)	3929 (11.5)	4205 (11.2)	0.16
History of peripheral vascular disease	7179 (10.0)	3446 (10.1)	3733 (10.0)	0.045
History of lung disease	8568 (12.0)	4097 (12.0)	4471 (11.9)	0.63
Procedure status				<0.001
Elective	26 317 (36.8)	11 389 (33.5)	14 928 (39.8)	
Urgent	29 260 (40.9)	14 328 (42.1)	14 932 (42.1)	
Emergent	15 954 (22.3)	8315 (24.4)	7639 (20.4)	
Procedure indication				<0.001
NSTEMI/UA	36 163 (50.5)	17 011 (50.0)	19 152 (51.1)	
STEMI	13 983 (19.5)	7653 (22.5)	6330 (16.9)	
Other/missing*	21 410 (29.9)	9383 (27.6)	12 027 (32.1)	

Data presented as median (interquartile range) or n (%). *P* value by Wilcoxon rank-sum or χ^2 test. NSTEMI, non–ST-segment–elevation myocardial infarction; STEMI, ST-segment–elevation myocardial infarction; and UA, unstable angina.

*Other/missing includes stable angina and other indications.

In multivariable models, the hospital in which the procedure was performed was a stronger predictor of referral than any individual patient characteristic for both PCI (median OR, 5.94; 95% confidence interval [CI], 4.10–9.49; intraclass correlation coefficient, 0.51) and cardiac surgery (median OR, 7.09; 95% CI, 3.79–17.80; intraclass correlation coefficient, 0.56; Table 3). The patient characteristics that were associated with lower cardiac rehabilitation referral after PCI were age (OR per 10-year increase, 0.95; 95% CI, 0.94–0.97), Hispanic ethnicity (OR, 0.88; 95% CI, 0.79–0.99), history of heart failure (OR, 0.93; 95% CI, 0.88–0.99), history of previous PCI (OR, 0.92; 95% CI, 0.88–0.96), history of CABG (OR, 0.92; 95% CI, 0.87–0.96), and hemodialysis (OR, 0.78; 95% CI, 0.68–0.89; Table 3). The patient characteristics that were associated with higher cardiac rehabilitation referral after PCI were procedure status (versus elective) of urgent (OR, 1.29; 95% CI, 1.23–1.36) or emergent (OR, 1.30; 95% CI, 1.20–1.42) and procedure

Table 2. Characteristics of Patients Eligible for Cardiac Rehabilitation After Coronary Artery Bypass Surgery or Valve Surgery

Characteristic	Eligible n=23 972	Referred n=21 831	Not Referred n=2141	*P* Value
Age, y	67 (59–74)	67 (59–74)	66 (58–74)	<0.001
Female	6512 (27.2)	5884 (27.0)	628 (29.3)	0.02
Race				0.04
White	21 375 (89.2)	19 471 (89.2)	1904 (88.9)	
Black	412 (1.7)	374 (1.7)	38 (1.8)	
Asian	881 (3.7)	781 (3.6)	100 (4.7)	
American Indian/Alaska Native	226 (0.9)	203 (0.9)	23 (1.1)	
Native Hawaiian/Pacific Islander	230 (1.0)	212 (1.0)	18 (0.8)	
Missing/other	848 (3.5)	790 (3.6)	58 (2.7)	
Hispanic/Latino	675 (2.8)	603 (2.8)	72 (3.4)	0.11
Smoking	3874 (16.2)	3520 (16.1)	354 (16.5)	0.62
Body mass index, kg/m^2	25 (20–33)	25 (20–33)	25 (19–34)	0.84
Hypertension	19 554 (81.6)	17 820 (81.6)	1734 (81.0)	0.44
History of diabetes mellitus	8844 (36.9)	8051 (36.9)	793 (37.0)	0.86
History of myocardial infarction	9344 (39.0)	8507 (39.0)	837 (39.1)	0.91
History of heart failure	8729 (36.4)	7888 (36.1)	841 (39.3)	0.005
History of valve surgery	577 (2.4)	502 (2.3)	75 (3.5)	<0.001
History of percutaneous coronary intervention	5221 (21.8)	4744 (21.7)	477 (22.3)	0.56
History of coronary artery bypass	827 (3.4)	748 (3.4)	79 (3.7)	0.52
On dialysis	478 (2.0)	430 (2.0)	75 (3.5)	0.39
History of cerebrovascular accident	3869 (16.1)	3507 (16.1)	362 (16.9)	0.31
History of peripheral vascular disease	2583 (10.8)	2342 (10.7)	241 (11.3)	0.45
History of lung disease	4850 (20.1)	4422 (20.3)	428 (20.0)	0.77
Procedure status				0.36
Elective	14 087 (58.8)	12 822 (58.7)	1265 (59.1)	
Urgent	9198 (38.4)	8393 (38.4)	805 (37.6)	
Emergent	687 (2.9)	616 (2.8)	71 (3.3)	
Procedure indication				0.95
NSTEMI/UA	10 290 (42.9)	9372 (42.9)	918 (42.9)	
STEMI	710 (3.0)	649 (3.0)	61 (2.8)	
Other/missing*	12 972 (54.1)	11 810 (54.1)	1162 (54.3)	
Type of surgery				<0.001
Coronary artery bypass	14 908 (62.2)	13 651 (62.5)	1257 (58.7)	
Valve repair or replacement	5931 (24.7)	5285 (24.2)	646 (30.2)	
Coronary artery bypass+valve	3133 (13.1)	2895 (13.3)	238 (11.1)	

Data presented as median (interquartile range) or n (%). *P* value by Wilcoxon rank-sum or χ^2 test. NSTEMI indicates non–ST-segment–elevation myocardial infarction; STEMI, ST-segment–elevation myocardial infarction; and UA, unstable angina.

*Other/missing includes asymptomatic, stable angina, and nonspecified other indication.

indication (versus other/missing) of non–ST-segment–elevation myocardial infarction (OR, 1.05; 95% CI, 1.00–1.11) or ST-segment–elevation myocardial infarction (OR, 1.71; 95% CI, 1.55–1.87; Table 3). The patient characteristics that were associated with lower cardiac rehabilitation referral after cardiac surgery were female sex (OR, 0.89; 95% CI, 0.80–1.00), obesity (OR, 0.82; 95% CI, 0.71–0.93), history of heart failure (OR, 0.88; 95% CI, 0.78–1.00), procedure indication of non–ST-segment–elevation myocardial infarction versus other or missing (OR, 0.84; 95% CI, 0.73–0.97),

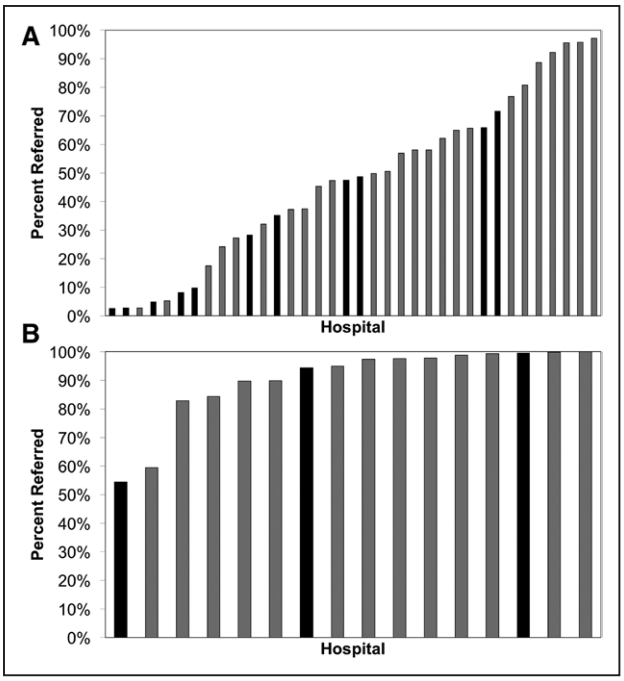

Figure 1. Hospital variation in referral to cardiac rehabilitation after (**A**) percutaneous coronary intervention and (**B**) coronary artery bypass surgery or valve surgery. Grey bars represent hospitals with cardiac rehabilitation programs; black bars represent hospitals without cardiac rehabilitation programs.

and procedure type of valve surgery compared with CABG (OR, 0.81; 95% CI, 0.69–0.95; Table 3).

Hospital bed size, procedure volume, and academic affiliation were not statistically significant predictors of cardiac rehabilitation referral. Hospitals with an outpatient cardiac rehabilitation program were more likely to refer patients after PCI (OR, 7.19; 95% CI, 2.03–25.39). Having a cardiac rehabilitation program was associated with higher odds of referral after cardiac surgery, but the result did not meet statistical significance (OR, 1.89; 95% CI, 0.13–28.43). The presence of a cardiac rehabilitation program explained 10% of the hospital-level variation in cardiac rehabilitation referral after PCI and 0% of the hospital-level variation after cardiac surgery. Among hospitals performing both PCI and cardiac surgery, there was not a statistically significant correlation between referral rates after PCI and cardiac surgery (Spearman rank correlation coefficient, 0.18; P=0.51).

We found small, but statistically significant, increases in referral over time for both PCI and cardiac surgery (Figure 2). Referral to cardiac rehabilitation after PCI increased from 42% to 49% from 2010 to 2015 (P<0.001 for trend). Referral to cardiac rehabilitation after cardiac surgery remained high at 91% in 2010 and 95% in 2015 (P<0.001 for trend).

Discussion

In Washington State from 2010 to 2015, referral to cardiac rehabilitation at discharge was higher after cardiac surgery than after PCI. We found that the strongest predictor of referral to cardiac rehabilitation at discharge was the hospital in which the procedure was performed.

Table 3. Predictors of Cardiac Rehabilitation Referral After Percutaneous Coronary Intervention and Cardiac Surgery

	OR	95% CI
Percutaneous coronary intervention		
Age (per 10 y)	0.95	(0.94–0.97)
Hispanic ethnicity	0.88	(0.79–0.99)
History of heart failure	0.93	(0.88–0.99)
History of percutaneous coronary intervention	0.92	(0.88–0.96)
History of coronary artery bypass surgery	0.92	(0.87–0.96)
Hemodialysis	0.78	(0.68–0.89)
Procedure status (vs elective)		
Urgent	1.29	(1.23–1.36)
Emergent	1.30	(1.20–1.42)
Procedure indication (vs other/missing)		
NSTEMI/UA	1.05	(1.00–1.11)
STEMI	1.71	(1.55–1.87)
Hospital (median OR)	5.94	(4.10–9.49)
Cardiac surgery		
Female	0.89	(0.80–1.00)
Obese	0.82	(0.71–0.93)
History of heart failure	0.88	(0.78–1.00)
Procedure indication (vs other/missing)		
NSTEMI/UA	0.84	(0.73–0.97)
STEMI	0.97	(0.69–1.37)
Type of surgery (vs coronary artery bypass)		
Valve surgery	0.81	(0.69–0.95)
Coronary artery bypass+valve surgery	1.17	(0.94–1.33)
Hospital (median OR)	7.09	(3.79–17.80)

CI indicates confidence interval; NSTEMI, non–ST-segment–elevation myocardial infarction; OR, odds ratio; STEMI, ST-segment–elevation myocardial infarction; and UA, unstable angina.

Previous studies of predictors of referral after PCI have suggested that hospital characteristics were among the strongest predictors of referral.[16,17] However, the relative magnitude of hospital-level variation in referral was not reported. In this analysis, we demonstrated that, by far, the most important predictor of referral was hospital in which the procedure was performed. Even though having a cardiac rehabilitation program is an important predictor of referral to cardiac rehabilitation, it explains only a minority of the variation in cardiac rehabilitation referral.

Two particularly striking findings emerge from this study. First, referral to cardiac rehabilitation after cardiac surgery is remarkably high, but referral to cardiac rehabilitation after PCI is dramatically lower. This suggests that high levels of cardiac rehabilitation referral are achievable. Even though both PCI and cardiac surgery patients experience better outcomes by participating in cardiac rehabilitation, it is known that patients are less likely to participate after PCI than after

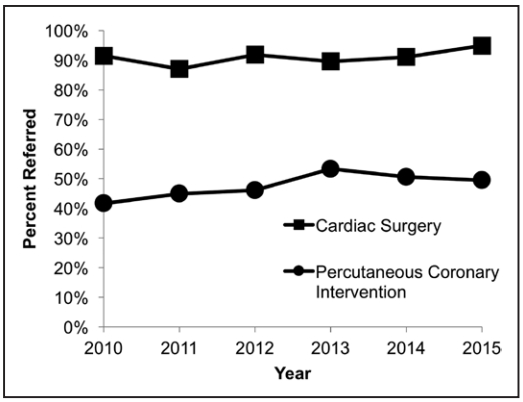

Figure 2. Referral to cardiac rehabilitation after percutaneous coronary intervention and cardiac surgery, 2010 to 2015. *P*<0.001 for trend for percutaneous coronary intervention and cardiac surgery.

cardiac surgery.[18] This difference may be related to systematic factors, such as departmental policies, hospital policies, and discharge procedures, but may also reflect differing perceptions of the perceived need for rehabilitation in PCI versus cardiac surgery patients. After cardiac surgery, most patients have significant physical limitations; after PCI, most patients can return to their normal activities within days (or sometimes hours). A lower perceived need for cardiac rehabilitation after PCI could contribute to differences in predictors of referral and to lower referral after PCI, but this phenomenon is not fully understood.[28]

Second, the strongest predictor of referral to cardiac rehabilitation after cardiac procedures was the hospital in which the procedure was performed. Hospital factors, such as location and size, are known to be associated with cardiac rehabilitation referral.[15,17] In this study of a single geographic region, we did not find hospital size to be a significant predictor of referral. A previous study found a similar magnitude of hospital-level variation in cardiac rehabilitation referral after acute myocardial infarction, and relative to other discharge performance measures, referral to cardiac rehabilitation had the greatest hospital-level variation.[29] Interestingly, we did not find a correlation between referral rates after PCI and cardiac surgery at hospitals performing both procedures, which suggests that department-level variation may also be an important factor in variation in cardiac rehabilitation referral. Department and hospital policies and practices are modifiable factors that can be systematically altered to influence discharge procedures. A previous analysis of data from Clinical Outcomes Assessment Program from 2004 to 2007 demonstrated that referral to cardiac rehabilitation after PCI was 48% and after CABG was 71%.[30] Referral after PCI has remained stagnant, but referral after cardiac surgery has substantially improved. Indeed, there are numerous hospitals in Washington State referring >95% of eligible patients to cardiac rehabilitation, suggesting that it is possible to achieve a very high level of cardiac rehabilitation referral at discharge.

Because our findings suggest that the biggest contributor to variation in cardiac rehabilitation referral is the hospital in which the procedure was performed, future work should focus on department- and hospital-level interventions to increase referral to cardiac rehabilitation at discharge after cardiac procedures, especially after PCI. One of the most effective interventions for increasing referral to cardiac rehabilitation is the implementation of automatic referral to cardiac rehabilitation at discharge, which is achievable with modern electronic health record systems.[3,31,32] Interventions achieving the highest rates of cardiac rehabilitation enrollment have used automatic referral coupled with discussion of cardiac rehabilitation with the patient by a member of the healthcare team.[31–33]

Although hospitals having an outpatient cardiac rehabilitation program had higher odds of referring patients to cardiac rehabilitation, having a cardiac rehabilitation program explained only a small amount of the hospital-level variation in cardiac rehabilitation referral. Some hospitals without cardiac rehabilitation programs referred a large proportion of their patients to cardiac rehabilitation; some hospitals with cardiac rehabilitation programs referred a small proportion of their patients to cardiac rehabilitation. Having a cardiac rehabilitation program, while important, is not necessary or sufficient for achieving high rates of referral to cardiac rehabilitation.

Our findings have several limitations. First, our population included all nonfederal hospitals performing cardiac procedures in Washington State. Even though Washington State has similar rates of cardiac rehabilitation participation as the US average,[18] the results may not be generalizable to other regions. Second, we used registry data for this analysis, which may not accurately capture all relevant variables. However, the missing data rate for our primary outcome of the cardiac rehabilitation referral was only 0.14% for PCI and 0.09% for cardiac surgery. In addition, these registry data are unable to study the presence of automatic referral or strength of the cardiac rehabilitation referral, which could range from weak advice to a strongly recommended and effectively communicated referral. Third, the high rates of referral after cardiac surgery limit our ability to identify predictors of referral in this population. Finally, this analysis was unable to examine participation in cardiac rehabilitation. Although referral to cardiac rehabilitation is a strong predictor of participation in cardiac rehabilitation,[21,34,35] we cannot determine the predictors of participation in cardiac rehabilitation or the impact on outcomes with this analysis.

Conclusions

Cardiac rehabilitation referral at discharge was less prevalent after PCI than cardiac surgery. The strongest predictor of cardiac rehabilitation referral was hospital in which the procedure was performed, and department-level variation may exist within hospitals. Efforts to improve cardiac rehabilitation referral should focus on hospital and departmental policies increasing referral after PCI, especially in low referral hospitals.

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Disclosures

None.

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Referral to Cardiac Rehabilitation After Percutaneous Coronary Intervention, Coronary Artery Bypass Surgery, and Valve Surgery: Data From the Clinical Outcomes Assessment Program

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SUPPLEMENTAL MATERIAL

Supplemental Table. Crude, risk-adjusted, and risk- and reliability-adjusted rates of cardiac rehabilitation referral by hospital.

Hospital	Percutaneous Coronary Intervention				Cardiac Surgery			
	N	Crude %	Risk-adjusted %	Risk and Reliability-adjusted %	N	Crude %	Risk-adjusted %	Risk and Reliability-adjusted %
1	768	3	3	3	---	---	---	---
2	549	3	3	3	---	---	---	---
3	1,222	3	3	3	---	---	---	---
4	2,020	5	5	6	1,484	54	---	---
5	1,669	5	5	6	---	---	---	---
6	198	8	8	8	---	---	---	---
7	3,741	10	10	12	784	99	99	99
8	2,694	17	17	19	---	---	---	---
9	3,286	24	24	27	1,695	84	---	---
10	4,969	27	27	30	1,757	100	100	100
11	304	28	29	28	---	---	---	---
12	736	32	31	32	---	---	---	---
13	94	35	35	40	---	---	---	---
14	2,750	37	37	39	1,356	99	99	98
15	131	37	38	35	---	---	---	---
16	1,109	45	45	47	617	59	---	---
17	3,059	47	47	52	1,149	90	90	82
18	139	47	48	49	---	---	---	---
20	5,567	49	49	54	2,063	94	94	90
21	4,920	50	50	52	2,198	83	---	---
22	2,969	51	51	59	1,722	100	100	100
23	1,471	57	57	56	---	---	---	---
24	4,177	58	58	63	939	98	98	96
25	74	58	58	57	---	---	---	---
26	5,648	62	62	68	2,678	95	95	91
27	4,040	65	65	68	2,222	98	98	96
28	1,221	66	66	71	---	---	---	---
29	123	66	66	62	---	---	---	---
30	1,075	72	72	73	---	---	---	---
31	1,930	77	77	80	759	97	97	95
32	1,690	81	81	83	---	---	---	---
33	863	89	88	89	---	---	---	---
34	3,620	92	92	94	1,770	99	99	99
35	158	96	95	95	---	---	---	---
36	655	96	96	96	---	---	---	---
37	1,917	97	97	97	779	90	90	84