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Trends in Referral to Cardiac Rehabilitation After Myocardial Infarction

Data From the National Cardiovascular Data Registry 2007 to 2012

To the Editor: Cardiac rehabilitation (CR) is a guideline-recommended therapy that reduces mortality after acute myocardial infarction (MI) (1). However, it is notoriously underutilized. Between 2000 and 2007, only 56% of eligible patients were referred to CR (1,2). In 2007, professional societies established CR referral from inpatient settings as a performance measure for acute MI (3,4). We examined whether CR referral has changed since 2007 by using data from the National Cardiovascular Data Registry Acute Coronary Treatment and Intervention Outcomes Network Registry–Get With the Guidelines Program (ACTION Registry–GWTG) (www.ncdr.com/webncdr/ACTION/Default.aspx).

We evaluated patients admitted with a primary diagnosis of ST-segment or non–ST-segment MI from January 1, 2007, through June 30, 2012, who were discharged from the hospital and had CR referral data (Online Fig. 1). CR referral was defined as "an official communication between the health care provider and the patient to recommend and carry out a referral order to an early outpatient CR program. This includes the provision of all necessary information to the patient that will allow the patient to enroll in an early outpatient CR program. This also includes a communication between the health care provider or health care system and the CR program that includes the patient's referral information for the program. A hospital discharge summary or office note may potentially be formatted to include the necessary patient information." Ineligibility was defined as documented patient-based barriers, patient-based criteria, or healthcare system barriers.

Covariates included age, sex, race/ethnicity, insurance type, body mass index, current/recent smoking, hypertension, dyslipidemia, diabetes, current dialysis, previous MI, previous percutaneous coronary intervention (PCI), previous coronary artery bypass graft surgery (CABG), previous stroke, peripheral arterial disease, length of stay, ST-segment elevation MI on admission electrocardiogram, in-hospital PCI, in-hospital CABG, in-hospital catheterization, left ventricular ejection fraction, in-hospital cardiogenic shock, in-hospital heart failure, in-hospital major bleeding, hospital region (West, Northeast, Midwest, or South), teaching hospital status, and hospital bed size.

Multivariate predictors of CR referral were estimated by using a generalized estimating equations logistic regression model with backward selection ($p < 0.05$). The model was implemented with empirical (sandwich) SE estimates and was adjusted for clustering of observations from the same hospital. We also conducted multivariate analyses to estimate the odds of CR referral in each year (compared with 2007). Missing data (<1.5% for all covariates) were imputed by using standard techniques. All analyses were performed by using SAS version 9.2 (SAS Institute, Inc., Cary, North Carolina).

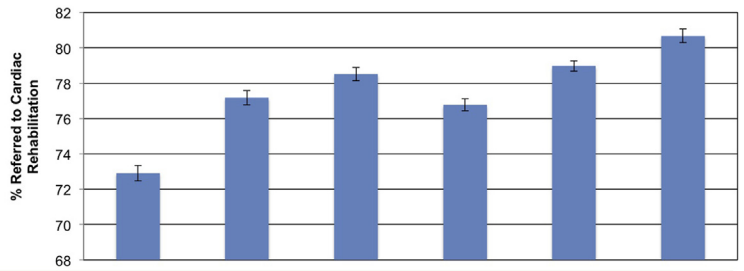
Between January 1, 2007, and June 30, 2012, a total of 329,698 registry patients with acute MI were discharged from participating hospitals with CR referral data. Of these, 301,247 patients (91.4%) from 624 hospitals were reported eligible for CR (Online Table 1); 28,451 (8.6%) were reported ineligible. From 2007 to 2012, CR referral increased by approximately 8% (from 72.9% to 80.7%; $p < 0.0001$ for trend) (Fig. 1).

After multivariate adjustment, independent patient-level predictors of CR referral included age, male sex, white race, body mass index, dyslipidemia, not having diabetes mellitus, not currently on dialysis, no previous PCI, ST-segment elevation MI at admission, in-hospital catheterization, in-hospital PCI, in-hospital CABG, mild left ventricular systolic dysfunction, and length of stay (Online Table 2). Independent hospital-level predictors of CR referral included hospital in Midwest region, hospital bed size, and nonacademic hospital. After adjustment for multivariate predictors of CR referral, referral was significantly greater in 2011 (odds ratio: 1.38 [95% confidence interval: 1.02 to 1.88]) and 2012 (odds ratio: 1.57 [95% confidence interval: 1.15 to 2.14]) compared with 2007 (Fig. 1).

CR referral improved across sex and racial/ethnic groups but remained highest in male subjects and white subjects (Online Table 3). For hospitals in the lowest quartile of adherence to American College of Cardiology/American Heart Association 2008 performance measures (other than CR referral) (4), referral increased from 54% in 2007 to 64% in 2011. This rate is still significantly behind the 87% referral rate for the highest quality quartile hospitals in 2007 and 2011.

We note several limitations. First, ACTION Registry–GWTG is a voluntary registry and may not be representative of hospitals lacking the resources or desire to contribute. Our results may overestimate referral to CR and may not be fully generalizable. Data are drawn solely from inpatient medical records abstracted for the registry. Misclassification of CR eligibility could have occurred. The registry's liberal definition of referral may overestimate meaningful referral (3). Finally, interhospital variation in what constitutes CR referral and eligibility may be present.

In summary, referral to CR has significantly increased since its introduction as a quality measure in 2007, with 81% of eligible patients now being referred. Nonetheless, referral rates remain below achievable benchmarks. Compared with other acute MI discharge performance measures, CR referral has the lowest adherence, with measures such as aspirin prescription, beta-blocker prescription, and smoking cessation counseling achieving adherence in ≥95% of patients (5). Improvement strategies may include identifying key personnel to direct the process of introducing CR in the inpatient setting and developing systems for automatic referral (1).



Year	2007	2008	2009	2010	2011	2012
N Total	39525	40224	44739	61543	74163	41053
N Referred	28818	31040	35124	47247	58568	33123
Unadjusted OR (95%CI)	1.0 (Ref)	1.26 (1.08, 1.46)	1.36 (1.05, 1.75)	1.23 (0.92, 1.64)	1.40 (1.05, 1.86)	1.55 (1.15, 2.09)
Adjusted OR* (95%CI)	1.0 (Ref)	1.20 (1.01, 1.43)	1.26 (0.95, 1.69)	1.19 (0.87, 1.64)	1.38 (1.02, 1.88)	1.57 (1.15, 2.14)

Figure 1 **Cardiac Rehabilitation Referral After Acute Myocardial Infarction, 2007–2012**

Error bars represent 95% confidence intervals (CIs); $p < 0.0001$ for trend. *Adjusted for age, sex, race/ethnicity, body mass index, dyslipidemia, diabetes, dialysis status, previous percutaneous coronary intervention, ST-segment elevation myocardial infarction at admission, in-hospital catheterization, in-hospital percutaneous coronary, in-hospital coronary artery bypass surgery, ejection fraction, length of stay, hospital region, hospital size, and teaching hospital status. OR = odds ratio; Ref = reference.

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APPENDIX

For supplemental tables and a figure, please see the online version of this article.

Supplemental Figures and Tables

Supplemental Table 1. Characteristics of patients by cardiac rehabilitation referral 2007-12.

	Overall (n = 301247)	**Not Referred** (n = 67327)	**Referred** (n = 233920)
Age, years (median)	62	64	61
Female, %	32	37	31
Race/Ethnicity, %			
White	83	77	85
Black	10	13	9
Asian	1	2	1
Hispanic	4	6	4
Other	1	1	1
Insurance, %			
HMO/Private	58	54	59
Medicare	23	27	22
Medicaid	4	5	4
Self/None	12	12	12
Clinical History			
BMI, kg/m^2 (median)	29	28	29
Current Smoker, %	38	34	40
Hypertension, %	70	74	69
Dyslipidemia, %	59	60	59
Diabetes Mellitus, %	29	33	28

On Dialysis, %	3	3	1
Prior Heart Failure, %	9	14	8
Prior PCI, %	24	26	23
Hospitalization			
STEMI on admission, %	42	31	45
Catheterization, %	92	83	95
PCI (NSTEMI) , %	55	41	61
CABG, %	9	4	10
Ejection Fraction , %			
≥ 50%, Normal	58	59	58
40-49%, Mild	22	20	23
25-39%, Moderate	16	15	16
<25%, Severe	4	4	3
Length of Stay, days (median)	3	3	3
Hospital Characteristics			
Region, %			
West	13	17	12
Northeast	8	11	7
Midwest	32	20	35
South	47	52	46
Academic, %	25	28	25
Bed size, number of beds (median)	407	402	407

Values presented as column % or median. $p<0.0001$ for all characteristics by Wilcoxon rank sum test for continuous variables and Mantel-Haenszel chi-square test for categorical variables. For multi-level categorical variables, significance at the overall group level. Abbreviations: HMO: health maintenance organization; BMI: body mass index; PCI: percutaneous coronary intervention; CABG: coronary artery bypass graft; STEMI: ST elevation myocardial infarction; NSTEMI: non-ST elevation myocardial infarction.

Supplemental Table 2. Multivariate predictors of referral to cardiac rehabilitation in 2007 – 12.

Predictor	**X^2**	**Adjusted OR (95%CI)**	**p value**
CABG in the hospital	312	4.82 (4.05, 5.74)	<0.0001
PCI in the hospital	285	2.41 (2.17, 2.67)	<0.0001
Catheterization in the hospital	86	1.62 (1.47, 1.80)	<0.0001
LV ejection fraction (vs. ≥ 50 %)	44		<0.0001
40-49% (mildly reduced)		1.08 (1.02, 1.14)	0.005
25-39% (moderately reduced)		1.05 (0.99, 1.11)	0.12
< 25% (severely reduced)		1.01 (0.92, 1.11)	0.81
Missing or not evaluated		0.76 (0.69, 0.84)	<0.0001
STEMI on admission	39	1.33 (1.22, 1.45)	<0.0001
Hospital Region (vs. West)	37		<0.0001
Northeast		1.18 (0.58, 2.41)	0.65
Midwest		2.94 (1.97, 4.37)	<0.0001
South		1.34 (0.90, 2.00)	0.15
Race/Ethnicity (vs. White)	31		<0.0001
Black		0.75 (0.65, 0.87)	0.0001
Asian		0.81 (0.64, 1.03)	0.08
Hispanic		0.64 (0.52, 0.79)	<0.0001
Other		0.79 (0.60, 1.03)	0.08
On Dialysis	28	0.77 (0.70, 0.85)	<0.0001
Female gender	21	0.95 (0.93, 0.97)	<0.0001
Age (per 5 year increase)	18		<0.0001

Patients ≤ 60		1.01 (0.99, 1.02)	0.41
Patients > 60		0.97 (0.96, 0.99)	<0.0001
Prior PCI	14	0.92 (0.88, 0.96)	0.0002
Length of stay (per 1 day increase)	14		0.001
Patients with LOS ≤ 3 days		1.10 (1.04, 1.17)	0.002
Patients with LOS > 3 days		0.99 (0.98, 1.01)	0.30
Hospital size (per 50 bed increase)	11		0.004
Hospitals with ≤ 500 beds		1.12 (1.04, 1.20)	0.001
Hospitals with > 500 beds		1.00 (1.00, 1.00)	0.49
BMI (per 5 kg/m^2 increase)	8		0.02
Patients with BMI ≤ 30		1.03 (1.01, 1.05)	0.005
Patients with BMI > 30		1.00 (1.00, 1.00)	0.51
Academic hospital	7	0.57 (0.38, 0.87)	0.009
Dyslipidemia	7	1.09 (1.02, 1.16)	0.01
Diabetes Mellitus	6	0.96 (0.94, 0.99)	0.01

Adjusted for all variables in table. Abbreviations: BMI: body mass index; CABG: coronary artery bypass graft; PCI: percutaneous coronary intervention; LV: left ventricular; STEMI: ST elevation myocardial infarction; LOS: length of stay.

Supplemental Table 3. Referral to cardiac rehabilitation among selected subgroups in 2007 vs. 2011.

	2007 % referred* (N = 39525)	**2011 % referred* (N = 74163)**	**4-year increase† (%)**	**P-value for interaction with time**
Overall	73	79	6	
Gender				0.71
Male	75	80	6	
Female	69	76	7	
Race/Ethnicity				0.28
White	75	81	6	
Black	63	71	8	
Asian	67	75	8	
Hispanic	57	68	11	
Other	71	81	10	
Region				<0.0001
West	65	76	11	
Northeast	59	76	16	
Midwest	83	88	6	
South	71	75	3	
Hospital Quality				<0.0001
Quartile I (lowest 25%)	54	64	10	
Quartile II	64	70	6	

Quartile III	76	81	5
Quartile IV (highest 25%)	87	87	0

* p-value <0.0001 for differences within categories.

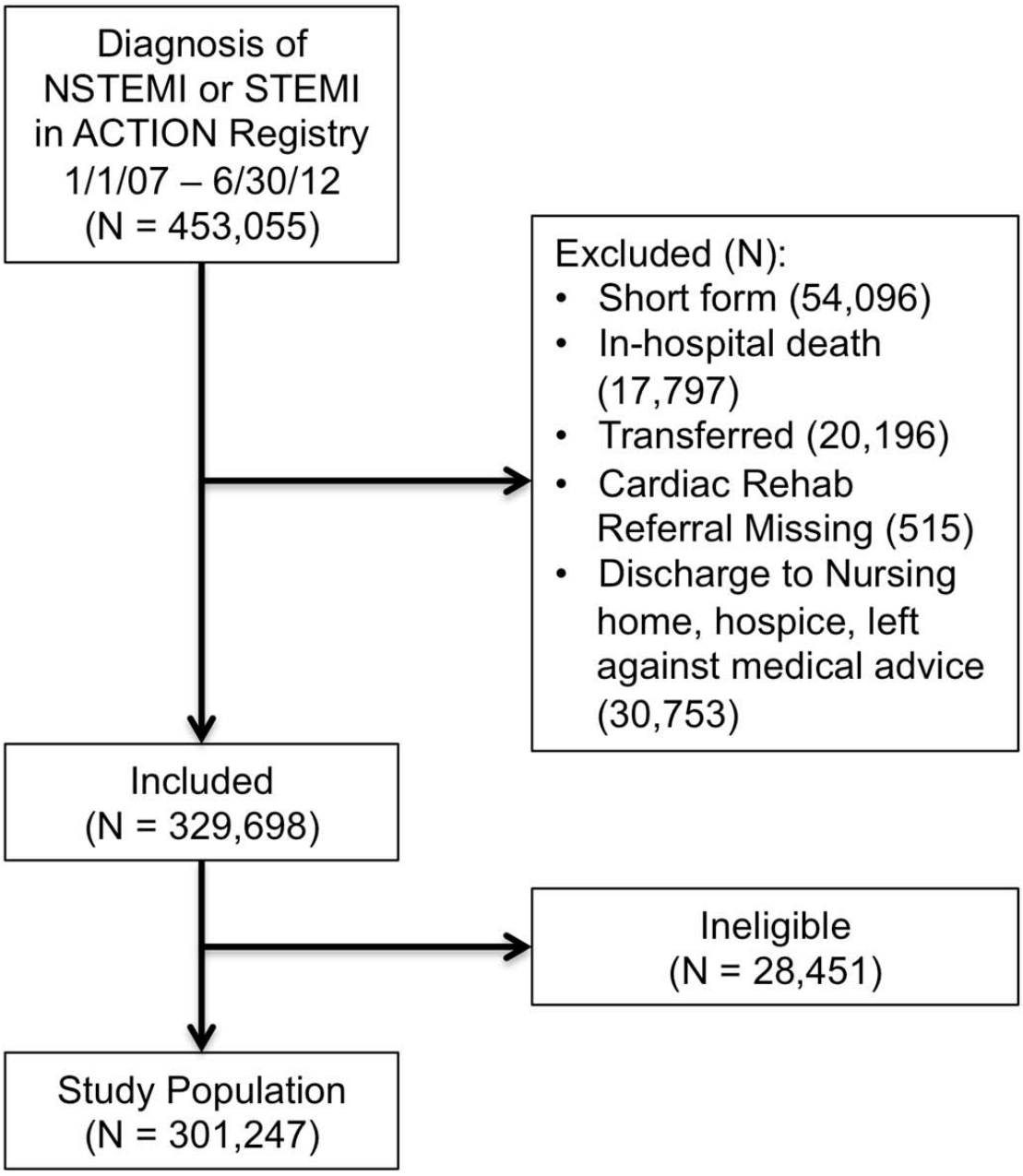
† 4-year increase may differ from subtraction of displayed values due to rounding.

Abbreviations: BMI: body mass index; PCI: percutaneous coronary intervention; CABG: coronary artery bypass graft; STEMI: ST elevation myocardial infarction; NSTEMI: non-ST elevation myocardial infarction.

Supplemental Figure Legend

Supplemental Figure 1.

Inclusion and exclusion of participants in study population.


Diagnosis of NSTEMI or STEMI in ACTION Registry 1/1/07 – 6/30/12 (N = 453,055)
Excluded (N):
• Short form (54,096)
• In-hospital death (17,797)
• Transferred (20,196)
• Cardiac Rehab Referral Missing (515)
• Discharge to Nursing home, hospice, left against medical advice (30,753)
Included (N = 329,698)
Ineligible (N = 28,451)
Study Population (N = 301,247)