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Thirty-Day Re osts after ST-Segment–I ited States: A National Rea

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Abstract

Background

Readmission after ST- nous economic burden to the US healt n understanding the timing and causes of th causes, timing, and cost of 30-day readmis

Methods and Res

All STEMI hospitalizations were selected in the Nationwide Readmissions Database (NRD) from 2010 to 2014. The 30-day readmission rate as well as the primary cause and cost of readmission were examined. Multivariate regression analysis was performed to identify the predictors of 30-day readmission and increased cumulative cost. From 2010 to 2014, the 30-day readmission rate after STEMI was 12.3%. Within 7 days of discharge, 43.9% were readmitted, and 67.3% were readmitted within 14 days. The annual rate of 30-day readmission decreased by 19% from 2010 to 2014 (P<0.001). Female sex, AIDS, anemia, chronic kidney disease, collagen vascular disease, diabetes mellitus, hypertension, pulmonary hypertension, congestive heart failure, atrial fibrillation, and increased length of stay were independent predictors of 30-day readmission. A large proportion of patients (41.6%) were readmitted for noncardiac reasons. After multivariate adjustment, 30-day readmission was associated with a 47.9% increase in cumulative cost (P<0.001).

Conclusions

Two thirds of patients were readmitted within the first 14 days after STEMI, and a large proportion of patients were readmitted for noncardiac reasons. Thirty-day readmission was associated with an ≈50% increase in cumulative hospitalization costs. These findings highlight the importance of closer surveillance of both cardiac and general medical conditions in the first several weeks after STEMI discharge.

Clinical Perspective

What is New?

- Thirty-day readmission rates after ST-segment–elevation myocardial infarction have declined in recent years.
- Nearly two thirds scharge.
- A large proportio reasons, particularly after
- Thirty-day readm ospitalization cost.

What Are the Clinical Im

- These data sugg nce and attention to both cardiac and period.
- Further research ns after ST-segment–elevati missions after ST-segment–elevati al performance and better outcomes.

Introduction

Recent advances in th MI) have resulted in improved outcomes ov use of morbidity and mortality in the Un e spent in 2013 for hospital care of STEM medical therapy for those presenting with S talization in earlier studies.[5] Not surprisin JS healthcare system and impacts patient quality of life. Significant efforts have been spent on identifying factors associated with 30-day readmissions.[6]

The Medicare Payment Advisory Commission has identified acute myocardial infarction as one of the 7 conditions that frequently result in costly readmission, and the Centers for Medicare & Medicaid Services have tried to address this issue through the Hospital Readmission Reduction Program.[7] In July 2009, the Centers for Medicare & Medicaid Services began reporting 30-day readmission for 3 common medical conditions, one of which was acute myocardial infarction.[8] These measures have become part of a federal strategy to provide incentives to improve quality of care by reducing preventable readmissions.[9] However, to achieve this goal, further understanding of the timing, underlying causes and cost of readmission is needed. Although value-based medical care is becoming of greater emphasis and a measure of hospital performance, modifiable causes of readmissions remain elusive for the majority of these conditions. Identifying common and preventable etiologies of 30-day all-cause readmissions would allow institutions to focus already limited resources and prevent unnecessary readmissions. Using the National Readmission Database (NRD), we aimed to investigate contemporary causes, timing, and cost of 30-day readmissions after STEMI from 2010 to 2014. The impact of percutaneous coronary intervention (PCI), coronary artery bypass grafting (CABG), or medical therapy (no revascularization) during the index STEMI admission on 30-day readmissions was also examined.

Methods

Data Source and Study Population

The authors declare that all supporting data are available within the article and its online supplementary files. Data were obtained from the Agency for Healthcare Research and Quality, which administers the Healthcare Cost and Utilization Project. We used the NRD from 2010 to 2014. The NRD is an annual database constructed using 1 calendar year of discharge data and is drawn from the Healthcare Cost and Utilization Project State Inpatient Databases, with verified patient linkage numbers used to track the patients across hospita upport national readmission analyses tabase. In the year 2014, the NRD contair hospitals in 22 states, representing 3 formation on the patient's diagnoses an *national Classification of Disea* ell as Clinical Classification Software statistical analyses. We identifie hospital outcomes using a combination of itutional Review Board approval and int ata collection was derived from a deident

Study Population a

From 2010 to 2014, all *-CM* codes for initial STEMI 410.x1 (n=303 codes 410.7x (subendocardial MI) w d to identify patients who underwer 6, and 36.07) or CABG (36.1x). Patient arrest were identified using *ICD-9-* a-aortic balloon pump and percutaneou procedure codes 37.61 and 37.68, respe re included in the study to allow for comp alyzing the in-hospital mortality rates died during the index hospitalization. Furthermore, patients with missing data on length of hospital stay were excluded to properly capture interval until readmission. Patients discharged between October and December were additionally excluded during the analysis of 90-day readmission.

Patient- and hospital-level variables were included as baseline characteristics. NRD variables were used to identify age; sex; median household income quartiles; primary payer; and hospital teaching status, location, and bed size. The overall severity of comorbidities was defined by using the Elixhauser comorbidity score.[11] Length of hospital stay was stratified to ≤3 days, 4 to 5 days, and ≥6 days.

Study End Points

The primary outcome of interest was 30-day all-cause readmission rate according to the methodology described by the Healthcare Cost and Utilization Project.[12] Time to readmission was computed as the number of days from discharge date of index admission to readmission date. Only the first readmission within 30 days after discharge was included, and transfer to another hospital was not counted as a readmission. The primary cause of 30-day readmission was identified based on Clinical Classification Software code in the first diagnosis field of each readmission record and dichotomized into noncardiac and cardiac causes.[12] Noncardiac causes included respiratory, infectious, gastrointestinal, neuropsychiatric/substance, stroke/transient ischemic attack, endocrine/metabolic, genitourinary, hematologic/oncologic, peripheral vascular disease, trauma, complication of medical procedure, and other noncardiac causes. Cardiac causes included angina and chronic ischemic heart disease, heart failure, acute myocardial infarction, nonspecific chest pain, arrhythmia, and other cardiac causes. Furthermore, we identified most common diagnoses of 30-day readmission using *ICD-9-CM* codes in the primary diagnosis field.[13] Exploratory analysis was performed to identify the causes of 90-day readmissions.

Statistical Analysis

All analyses were performed using SAS software, version 9.4 (SAS Institute, Cary, NC). Discharge weight provided by NRD was used for all analyses to obtain national estimates.[10] Domain analysis was used for accurate variance calculations for subgroup analyses. All analyses accounted for hospital-level clustering of patients and complex survey sampling design. For descriptive analyses, we compared baseline patient and hospital characteristics admission. Categorical variables a d as mean or median. For comparisc ither the Mann-Whitney-Wilcoxon non continuous variables. To identify p we created a multivariate Cox propo mission by including covariates that had uni sis, the estimated cost for each hospitaliz atio files provided by the Healthcare Cost ar pitalization with the respective cost-to-char plus the cost of the index admission. Cumu uivalent to their cost of the index admission rforming survey-specific multivariate lin stribution, as previously described.[1] nce.

Results

Study Population a

For each year from 20 pitals in 2010 to 2048 hospitals in 2014 709 548 patients presented with STEMI l [CI], 8.6–8.8), 4.6% (95% CI, 4.5–4.7 erall cohort, PCI cohort, CABG cohort, a nose who survived the index admission with STEMI, 12.3% were readmitted within 30 days of discharge (Table 1). Specifically, 30-day readmission rates were 11.1% (95% CI, 11.0–11.1), 14.9% (95% CI, 14.5–15.3) and 17.6% (95% CI, 17.4–17.9) for PCI cohort, CABG cohort, and no revascularization cohort, respectively. Of the total cohort, 17.8% of patients were readmitted more than once during the 30-day period. During index hospitalizations for STEMI, 78.5% and 4.8% of patients underwent PCI and CABG, respectively, while 16.0% patients were medically treated (without revascularization). The median length of stay during the index hospitalization was 2.5 days (interquartile range [IQR], 1.6–4.4 days), 2.3 days (IQR, 1.5–3.6), 8.7 days (IQR, 6.2–13.1) and 3.0 days (IQR, 1.6–5.5) for the overall cohort, PCI cohort, CABG cohort, and no revascularization cohort, respectively (P<0.001).

Table 1 Baseline Individual- and Hospital-Level Characteristics for Patients Discharged Alive After Index Hospitalization With STEMI, 2010 to 2014

Characteristics	Overall	30-Day Readmissiona		*P* Valueb
		No	Yes	
Number of admissions	709 548	622 134 (87.7)	87 415 (12.3)	
Patient characteristics				

Characteristics	Overall	30-Day Readmissiona		P Valueb
		No	Yes	
Age, mean (SD				<0.001c
Age group, y				
<50			2)	
50–64			3)	<0.001
≥65			5)	
Female sex			5)	<0.001
Smoking			4)	<0.001
Hypertension			9)	<0.001
Diabetes melli			.0)	<0.001
Dyslipidemia			9)	<0.001
Known corona disease			5)	<0.001
Previous myocardial infarction	59 615 (8.4)	51 207 (8.2)	8408 (9.6)	<0.001
Previous PCI	85 965 (12.1)	74 762 (12.0)	11 203 (12.8)	<0.001
Previous CABG	24 968 (3.5)	20 986 (3.4)	3982 (4.6)	<0.001
Family history of coronary artery disease	83 557 (11.8)	75 771 (12.2)	7786 (8.9)	<0.001
History of CHF	139 035 (19.6)	110 408 (17.7)	28 627 (32.7)	<0.001
Peripheral vascular disease	41 121 (5.8)	33 318 (5.4)	7803 (8.9)	<0.001
Pulmonary hypertension	15 542 (2.2)	12 141 (2.0)	3402 (3.9)	<0.001
Chronic pulmonary disease	80 588 (11.4)	66 217 (10.6)	14 372 (16.4)	<0.001
Chronic kidney disease	68 870 (9.7)	53 443 (8.6)	15 427 (17.6)	<0.001

Characteristics	Overall	30-Day Readmissiona		P Valueb
		No	Yes	
Liver disease				<0.001
Anemia			0)	<0.001
Atrial fibrillatio			4)	<0.001
Coagulopathy				<0.001
AIDS				0.002
Collagen vasc				<0.001
Drug abuse				0.050
Fluid/electrolyt			3)	<0.001
Obesity			3)	0.235
Other neurolog				<0.001
Pulmonary circ disorders				<0.001
Valvular heart disease	1325 (0.2)	1025 (0.2)	300 (0.3)	<0.001
Elixhauser comorbidity scores >4	145 051 (20.4)	114 620 (18.4)	30 432 (34.8)	<0.001
Median household income				
First quartile	220 748 (31.1)	191 497 (30.8)	29 251 (33.5)	<0.001
Second quartile	185 618 (26.2)	162 855 (26.2)	22 763 (26.0)	
Third quartile	167 067 (23.5)	147 394 (23.7)	19 673 (22.5)	
Fourth quartile	136 116 (19.2)	120 388 (19.3)	15 728 (18.0)	
Primary payer				
Medicare	315 231 (44.4)	264 153 (42.5)	51 078 (58.4)	<0.001
Medicaid	52 020 (7.3)	44 309 (7.1)	7711 (8.8)	

Characteristics	Overall	30-Day Readmissiona		P Valueb
		No	Yes	
Private / HMO			8)	
Self-pay / charge/				
Index STEMI Presentatio				
Weekend adm			5)	0.013
Cardiogenic sh			5)	<0.001
Cardiac arrest				<0.001
Revascularizat				
Thromb only				
All PCI			5)	<0.001
CABG o				
No revascularization	113 642 (16.0)	93 594 (15.0)	20 048 (22.9)	
IABP	52 471 (7.4)	42 932 (6.9)	9539 (10.9)	<0.001
PLVAD	1903 (0.3)	1558 (0.3)	345 (0.4)	<0.001
Hospital characteristics				
Hospital teaching status				
Teaching	368 248 (51.9)	323 791 (52.0)	44 457 (50.9)	0.003
Nonteaching	341 301 (48.1)	298 343 (48.0)	42 958 (49.1)	
Hospital location				
Rural	370 365 (52.2)	326 957 (52.6)	43 409 (49.7)	<0.001
Urban	339 183 (47.8)	295 177 (47.4)	44 006 (50.3)	

Characteristics	Overall	30-Day Readmissiona		P Valueb
		No	Yes	
Hospital bed s				
Small				
Medium			0)	0.966
Large			9)	
Length of hosp median (IQR),			')	<0.001d
Length of hosp				
≤3			2)	
4–5			2)	<0.001
≥6			6)	
Disposition				
Home			5)	
Facilitye	71 660 (10.1)	55 792 (9.0)	15 868 (18.1)	<0.001
AMA/unknown	6150 (0.9)	4938 (0.8)	1211 (1.4)	
Charge, median (IQR), $	63 363 (43 321–97 520)	62 661 (43 189–95 453)	69 679 (44 449–114 471)	<0.001d
Cost, median (IQR), $	18 316 (13 504–26 023)	18 169 (13 498–25 548)	19 515 (13 565–30 049)	<0.001d

AMA indicates against medical advice; CABG, coronary artery bypass graft; CHF, congestive heart failure; HMO, health maintenance organization; IABP, intra-aortic balloon pump; IQR, interquartile range; PCI, percutaneous coronary intervention; PLVAD, percutaneous left ventricular assist device; SE, standard error; STEMI, ST-segment–elevation myocardial infarction.

[a]Values are presented as number (percentage) of patients unless otherwise indicated.

[b]Rao-Scott χ^2 test was used for all statistical tests in Table 1 unless stated otherwise.

[c]Survey-specific linear regression was performed.

[d]Mann-Whitney-Wilcoxon test was used.

[e]Facility includes skilled nursing facility, intermediate care facility, and inpatient rehabilitation facility.

The annual rate of 30-day readmission (Figure 1) decreased by 19% from 135 449 readmissions per million adults per year (13.5%) in 2010 to 108 526 readmission per million adults per year (10.9%) in 2014 (P<0.001). There was a 14% decrease in the annual rate of 30-day readmission in the unrevascularized cohort, from 185 050 p adults per year (15.9%) in 2014 (P<0.0 % for patients who underwent PCI for STE 7 866 per million adults per year (9.8%) ot change over time for those who underwe during the readmission was 2.6 d –4.7) for the overall cohort. The median ler and 3.4 days (IQR, 1.7–6.2) for PCI cohor 0.001). Furthermore, in-hospit 8% (95% CI, 3.3–4.4) and 8.8% (95% C cohort, respectively (P<0.001).

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Figure 1 Temporal t MI (ST-segment–elevation myocardia ates coronary artery bypass graft;

Table 1 compares base by 30-day readmission. Patients readmitted within the 30 days were older and more likely to be female and have hypertension, diabetes mellitus, previous myocardial infarction, previous coronary revascularization, congestive heart failure, peripheral vascular disease, chronic obstructive pulmonary disease, pulmonary hypertension, and chronic kidney disease. In addition, 34.8% of readmitted patients had an Elixhauser comorbidity score >4 versus 18.4% in the nonreadmitted cohort. Patients who presented with either cardiogenic shock or cardiac arrest or those who were not revascularized during the initial admission with STEMI were more likely to be readmitted within 30 days. Furthermore, 30-day readmission was more frequent with >3 days of hospital stay during the index hospitalization, and particularly if the index length of stay was >6 days.

Predictors of 30-Day Readmission After STEMI

Table 2 lists univariate and multivariate predictors of 30-day readmission after initial hospitalization with STEMI. After adjusting for clinical and hospital characteristics, AIDS, anemia, chronic kidney disease, collagen vascular disease, diabetes mellitus, hypertension, pulmonary hypertension, congestive heart failure, and atrial fibrillation were found to be associated with an increased risk of 30-day readmission. Although age was not associated with increased risk of readmission, female sex was a strong predictor of 30-day readmission. More importantly, increased length of stay (LOS) during the index hospitalization was highly predictive of 30-day readmission (62% increase in the group with LOS ≥6 days and 40% increase in the group with LOS 4 to 5 days versus the LOS ≤3 days group). In addition, private-payer insurance and self-pay status compared with Medicare were associated with fewer 30-day readmissions. Unadjusted readmission rates were higher after CABG versus PCI, however, after multivariate adjustment, CABG was found to be predictive of fewer readmissions.

Table 2 Independent Predictors of 30-Day Readmission After Index Hospitalization With STEMI

Predictors	Univariate Regression[a]		Multivariate Regression[b]	
			(95% CI)	*P* Value
Female sex			1)	<0.001
Hypertension			2)	<0.001
Diabetes mellitus			4)	<0.001
Dyslipidemia			6)	<0.001
Family history of coronary			9)	0.030
History of CHF			1)	<0.001
Peripheral vascular disea			2)	<0.001
Pulmonary hypertension			9)	0.002
Chronic pulmonary disea			2)	<0.001
Chronic kidney disease	2.12 (2.05–2.19)	<0.001	1.27 (1.23–1.32)	<0.001
Liver disease	1.40 (1.27–1.53)	<0.001	1.14 (1.04–1.25)	0.007
Anemia	1.93 (1.87–2.00)	<0.001	1.12 (1.08–1.16)	<0.001
Atrial fibrillation	1.76 (1.70–1.81)	<0.001	1.17 (1.13–1.21)	<0.001
AIDS	1.48 (1.15–1.91)	0.002	1.37 (1.06–1.76)	0.017
Collagen vascular disease	1.38 (1.27–1.49)	<0.001	1.13 (1.04–1.22)	0.002
Fluid/electrolyte disorders	1.65 (1.60–1.70)	<0.001	1.05 (1.02–1.09)	0.005
Median household income				
First quartile	1 (reference)		1 (reference)	
Second quartile	0.92 (0.89–0.95)	<0.001	0.95 (0.92–0.98)	0.003
Third quartile	0.88 (0.85–0.92)	<0.001	0.91 (0.88–0.95)	<0.001

Predictors	Univariate Regression[a]		Multivariate Regression[b]	
	Unadjusted HR (95% CI)	*P* Value	Adjusted HR (95% CI)	*P* Value
Fourth quartile			3)	<0.001
Primary payer				
Medicare				
Medicaid			2)	0.055
Private includi			5)	<0.001
Self-pay/no ch			7)	<0.001
Revascularization				
All PCI				
CABG only			4)	<0.001
No revasculari			9)	0.014
IABP			2)	<0.001
Hospital teaching status				
Teaching	0.96 (0.93–0.98)	0.003	0.96 (0.93–0.99)	0.007
Hospital location				
Rural	1 (reference)		1 (reference)	
Urban	1.11 (1.08–1.15)	<0.001	1.09 (1.06–1.12)	<0.001
Length of hospital stay, d				
≤3	1 (reference)		1 (reference)	
4 to 5	1.73 (1.68–1.78)	<0.001	1.40 (1.36–1.45)	<0.001
≥6	2.46 (2.39–2.53)	<0.001	1.62 (1.56–1.68)	<0.001
Disposition				

Predictors	Univariate Regression[a]		Multivariate Regression[b]	
	Unadjusted HR (95% CI)	*P* Value	Adjusted HR (95% CI)	*P* Value
Home				
Facility[c]			2)	<0.001
AMA/unknown			6)	<0.001
Age group, y				
<50				
50 to 64			2)	0.275
≥65			8)	0.400
Smoking			1)	0.100
Known coronary artery di			8)	0.051
Previous myocardial infar			8)	0.125
Previous PCI			7)	0.162
Previous CABG	1.33 (1.26–1.42)	<0.001	1.02 (0.96–1.08)	0.622
Other neurological disorders	1.46 (1.39–1.55)	<0.001	1.00 (0.95–1.06)	0.945
Pulmonary circulation disorders	2.21 (1.62–3.02)	<0.001	0.96 (0.69–1.34)	0.822
Valvular heart disease	1.92 (1.56–2.37)	<0.001	0.86 (0.69–1.08)	0.186
Elixhauser comorbidity scores >4	2.20 (2.14–2.26)	<0.001	1.01 (0.96–1.05)	0.822
Weekend admission	0.97 (0.94–0.99)	0.014	1.00 (0.98–1.03)	0.754
Cardiogenic shock	1.68 (1.61–1.75)	<0.001	1.02 (0.97–1.07)	0.382
Cardiogenic arrest	1.25 (1.18–1.33)	<0.001	0.95 (0.89–1.00)	0.065
PLVAD	1.51 (1.27–1.81)	<0.001	0.98 (0.81–1.18)	0.834

AMA indicates against medical advice; CABG, coronary artery bypass graft; CHF, congestive heart failure; CI, confidence interval; HMO, health maintenance organization; HR, hazard ratio; PCI,

percutaneous coronary intervention; PLVAD, percutaneous left ventricular assist device; STEMI, ST-segment-elevation myocardial infarction.

[a]Univariate Cox proportional hazards regression model was created with an outcome of 30-day readmission for each covariate from Table 1 and the covariates with $P<0.1$ are listed.

[b]Multivariate Cox pro of 30-day readmission including

[c]Facility includes skill tation facility.

Independent predictors who underwent PCI, CABG, or no revascula rough S3). Chronic kidney disease, chroni art failure, and increased LOS during reased 30-day readmission regardles reater likelihood of readmission in the reva –1.27 in PCI cohort; adjusted hazard ratio,

Timing and Causes

Figure 2 and Figure S1 well as for subgroups stratified by portantly, 43.9% were readmitted within in the overall cohort, with median time to rea status did not impact the timing of readmissi e to noncardiac causes (Figure 3); this e S2). In patients who underwent CABG eadmissions (Figure S2B). In the ov st pain, angina, or ischemia. In addition, nfarction, while 13.9% and 4.2% were attributable to heart failure and arrhythmic causes, respectively. Among noncardiac causes, infectious etiology (pneumonia and sepsis), chronic obstructive pulmonary disease/respiratory failure, gastrointestinal bleeding, stroke, and acute renal failure were most prevalent. Figure 4 and Figure S3 demonstrate that there is a separation in the frequency of cardiac versus noncardiac causes of 30-day readmission, particularly within the first 2 weeks after discharge. In fact, Figure S4 demonstrates that readmissions due to recurrent myocardial infarction (13.3% versus 7.2, $P<0.001$) or heart failure (14.7% versus 12.1%, $P<0.001$) are more common in the first 2 weeks after discharge compared with 15 to 30 days after discharge from index admission. By 90 days, 42.5% of patients were still readmitted for noncardiac causes in the overall cohort, 39.7% in the PCI cohort, 62.7% in the CABG cohort, and 46.7% in the nonrevascularized cohort (Figure S5).

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Figure 2 Timing of 30-day readmission by postdischarge day in all patients after index admission for STEMI (ST-segment–elevation myocardial infarction). *43.9% and 55.0% readmitted within 7 and 10 days, respectively. †Median time to readmission (IQR): 9 (3–17) days: 51.6% admitted within 9 days of discharge.

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Figure 3 Common causes of 30-day readmission in patients after index admission with STEMI. COPD indicates chr stinal; MI, myocardial infarctio

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Figure 4 Cumulativ uses in post-STEMI (ST-segmen al infarction.

Cost of Hospitaliza

The median cumulative thin 30 days was $31 072 (IQR, $21 374 y readmission was $18 169 (IQR, $13 498 articularly pronounced in medical eadmitted within 30 days was $20 959 (without 30-day readmission was $927 ciation of 30-day readmission and cumu eadmission was associated with 47.9% omitant comorbidities including congestive heart failure, anemia, previously known coronary artery disease, obesity, peripheral vascular disease, valvular disease, and pulmonary circulation disorders also were independently associated with increased cumulative cost. In addition, cardiogenic shock (16% increase), cardiac arrest (18% increase), and the use of an intra-aortic balloon pump (17% increase) or a percutaneous left ventricular assist device (66% increase) were associated with an increased cumulative cost. As expected, increased LOS (>4 days) was associated with higher cumulative cost, whereas lack of revascularization was associated with lower cumulative hospitalization cost.

Table 3 Independent Predictors of Higher 30-Day Total Cost of Hospitalization in Patients Treated After STEMI

Predictors	Univariate Regression[a]		Multivariate Regression[b]	
	β (95% CI)	*P* Value	β (95% CI)	*P* Value
30-day readmission	0.556 (0.547–0.564)	<0.001	0.479 (0.472–0.486)	<0.001
Age group, y				
<50	1 (reference)		1 (reference)	

Predictors	Univariate Regression[a]		Multivariate Regression[b]	
	β (95% CI)	*P* Value	β (95% CI)	*P* Value
50–64				<0.001
≥65			012)	0.381
Female sex			-0.052)	<0.001
Anemia			)	<0.001
Obesity			)	<0.001
Known coronary artery di			)	<0.001
Previous CABG			-0.018)	<0.001
Coagulopathy			)	<0.001
Diabetes mellitus			2)	<0.001
Peripheral vascular disea			)	<0.001
Fluid/electrolyte disorders			)	<0.001
History of CHF	0.266 (0.254–0.278)	<0.001	0.029 (0.021–0.037)	<0.001
Pulmonary hypertension	0.189 (0.162–0.215)	<0.001	0.023 (0.008–0.038)	0.003
Pulmonary circulation disorders	1.246 (1.120–1.371)	<0.001	0.487 (0.389–0.586)	<0.001
Valvular heart disease	1.184 (1.073–1.294)	<0.001	0.519 (0.448–0.590)	<0.001
Elixhauser comorbidity scores >4	0.258 (0.246–0.271)	<0.001	−0.016 (−0.024 to −0.008)	<0.001
Median household income				
First quartile	1 (reference)		1 (reference)	
Second quartile	0.053 (0.040–0.066)	<0.001	0.053 (0.042–0.064)	<0.001
Third quartile	0.097 (0.081–0.112)	<0.001	0.090 (0.076–0.104)	<0.001
Fourth quartile	0.165 (0.146–0.185)	<0.001	0.157 (0.139–0.176)	<0.001

Predictors	Univariate Regression[a]		Multivariate Regression[b]	
	β (95% CI)	*P* Value	β (95% CI)	*P* Value
Primary payer				
Medicare				
Medicaid			3)	<0.001
Private includi			5)	<0.001
Self-pay/no charge/other			011)	0.727
Cardiogenic arrest			)	<0.001
Cardiogenic shock			3)	<0.001
IABP			2)	<0.001
PVAD			)	<0.001
Length of hospital stay, d				
≤3				
4 to 5	0.241 (0.232–0.250)	<0.001	0.230 (0.221–0.238)	<0.001
≥6	0.839 (0.830–0.850)	<0.001	0.674 (0.663–0.684)	<0.001
Revascularization				
All PCI	1 (reference)		1 (reference)	
CABG only	0.791 (0.774–0.808)	<0.001	0.171 (0.155–0.187)	<0.001
No revascularization	−0.640 (−0.653 to −0.626)	<0.001	−0.730 (−0.743 to −0.717)	<0.001
Weekend admission	0.012 (0.005–0.018)	<0.001	0.020 (0.015–0.024)	<0.001
Hospital bed size				
Small	1 (reference)		1 (reference)	
Medium	0.064 (0.010–0.118)	0.021	−0.021 (−0.070 to 0.028)	0.393

Predictors	Univariate Regression[a]		Multivariate Regression[b]	
	β (95% CI)	*P* Value	β (95% CI)	*P* Value
Large			.027)	0.393
Hospital location				
Rural				
Urban			028)	0.448
Hospital teaching status				
Teaching			3)	0.002
Disposition				
Home				
Facility[c]			-0.017)	<0.001
AMA/unknown			-0.105)	<0.001

AMA indicates agains gestive heart failure; CI, confidence tic balloon pump; PCI, percutaneous coronary intervention; PVAD, percutaneous ventricular assist device; STEMI, ST-segment-elevation myocardial infarction.

[a]Survey-specific univariate linear regression model was created with an outcome of log-transformed cumulative cost for each covariate from Table 1 and the covariates with $P<0.1$ are listed.

[b]Survey-specific multivariate linear regression model was created with an outcome of log-transformed cumulative cost including all predictors with $P<0.1$ in the univariate analysis.

[c]Facility includes skilled nursing facility, intermediate care facility, and inpatient rehabilitation facility.

Discussion

There are several important and novel findings in this large, contemporary, all-payer observational study of the National Readmission Database in the years 2010 to 2014. First, in this overall cohort of >700 000 STEMI patients, the 30-day readmission rate was 12.3%, lower than the previously reported rate of ≈20%.[8] The median length of index hospitalization was short (2.5 days) and median length of readmission stay was 2.6 days, while index admission in-hospital mortality was 8.7% and readmission in-hospital mortality was 4.6%. Second, over the 5-year period, the 30-day readmission rates after STEMI have declined, particularly in those undergoing PCI and in medically treated patients. Third, of patients readmitted, two thirds were readmitted early (within the first 14 days after discharge). Fourth, a large proportion of patients (≈40%) were readmitted within 30 or 90 days for noncardiac reasons, whereas in the post-CABG population, two thirds of 30- and 90-day readmissions were for noncardiac reasons. Finally, 30-day readmission was associated with

a 47.9% increase in the cumulative hospitalization cost, with the cumulative cost increase of $12 903 in those with 30-day readmission.

This study has extended prior literature by revealing that the rate of 30-day readmissions after STEMI declined between 2010 and 2014. In the 2007–2009 Medicare fee-for-service claims data, the rate of 30-day readmission after STEMI hospitalization was 19.0%.[5] Our data suggest that the 30-day readmission rate declined to 13.5% ... ns after STEMI has been also seen in the ... eficiaries between 2009 and 2012.[15] The ... ad use of primary PCI (≈80% in our study ... reater national focus by the Centers fo ... s. Angina and ischemic heart disease ... ions in our study. A minority of these readm ... ts in the United States are readmitted ... nonly, CABG.[16]

Similar to previous wo ... eadmitted early after STEMI, with 67.3 ... o readmission of 9 days in our cohort wa ... median time to readmission was 10 da ... cur during days 15 through 30 after hospit ... d the initial follow-up visit within 1 to 2 we ... erventions have been ineffective in redu ... acking.[17] The timing of 30-day readmissions ... tudinal surveillance strategies within 30 to ... tive discharge interventions have bee ... d to avoid readmissions.[19] Comp ... terventions and utilize tools that facilita ... missions.[20] Programs focusing on ... one third of all readmissions occur for ... readmitted for medical conditions within 30 days. Therefore, continuity of care with primary care providers from the inpatient setting to strategic follow-up after discharge should be of great importance. This is particularly important in the post-CABG population, where many patients may benefit from earlier and closer medical surveillance (especially in the setting of the global surgical fee). Furthermore, institutions with poorer patient safety performance have been associated with greater unplanned readmissions.[22] Additional follow-up measures, including provider-initiated telephone or videophone communication, the use of remote telemonitoring, provider home visits, and patient-directed rehabilitation efforts, should be considered and intensified.[19]

Thirty-day hospital readmissions are common and costly, particularly in the elderly and high-risk patients with STEMI.[23] Similar to our data, prior studies have also indicated that the risk of readmission was higher in women compared with men, particularly in younger patients.[24] The analysis of the 2013 National Readmissions Database confirmed an unequal burden of readmissions on women, particularly in younger women.[25] This may be partly explained by the fact that women have atypical presentation symptoms and different risk factors and receive suboptimal care because of being underdiagnosed with STEMI.[26] Therefore, reperfusion in women is often delayed, which may lead to higher rates of adverse events and more rehospitalizations.[26] Women are also at a higher risk for bleeding and vascular complications after PCI, with lower adoption of radial PCI, which can also lead to more readmissions.[27] Importantly, age was not found to be an independent predictor of 30-day readmissions. Other studies have indicated that patients >65 years of age had higher risk-adjusted odds for readmission.[24] However, despite conflicting data regarding the association of 30-day readmission with advanced age, the burden of readmission among younger patients still remains substantial. Thus, it is important to continue monitoring for differences in the

quality of STEMI care and adherence to process measures based on age, sex, and other sociodemographic characteristics.

Our study further confirms the relationship between LOS and readmission rates. The LOS after STEMI has dramatically declined in the United States during the past quarter century.[28] The median LOS for the index admission with STEMI ths of stay compared with other c ealthcare system that rewards early disc hours) may result in suboptimal outcome days) was associated with fewer As one might predict, patients with a of the clinical presentation and adve likely to be readmitted within 30 d ologists and primary care providers) should ith prolonged LOS given the high risk of s

There is a growing inte s.[4] Recent data on post-PCI readmissions ose with readmissions ($39 634 at readmission accounted for a 45% ir e findings to the STEMI population ($3 nt, the 30-day readmission after STE his is of particular importance, given the enalizes hospitals with higher risk-adjuste ion.[33] Such reimbursement policies s to prevent expensive 30-day reac that extend to 90 days) are being intr such bundles given that ≈40% of 90-day re would be forced to absorb the high cost o whether the bundled payment structure will result in better post-STEMI outcomes and whether hospitals should be penalized for noncardiac readmissions after STEMI. Furthermore, policymakers need to ensure that 30-day readmission rates after STEMI is a good-quality metric that leads to better outcomes, which recently has been questioned in the heart failure literature.[34] Further research is needed to examine the preventability of 30-day readmissions after STEMI and to explore whether short-term readmissions after STEMI should serve as a reliable quality metric of hospital performance and better clinical outcomes.

The results of this study should be interpreted in the context of several limitations. First, this is a retrospective study based on data from the NRD, with the sample designed to approximate the national distribution of key hospital characteristics. Our estimates were derived from a 50% sample of US hospitals, and it is possible that the readmission cohort was either underrepresented or overrepresented by this sample. However, the NRD has been used extensively to examine national healthcare trends, and its sampling design has been validated in numerous publications.[14] Second, miscoded and missing data can occur in large administrative data sets; however, Healthcare Cost and Utilization Project quality control procedures are routinely performed to confirm that NRD data values are valid, consistent, and reliable.[35] Third, the NRD does not include detailed information about patient clinical characteristics, such as coronary anatomy, heart failure class, left ventricular function, or admission/discharge medications. Data on discharge medications or long-term compliance with medications were not available. Fourth, we have reported mortality during the 30-day readmission (although not the main focus of our analysis), since the NRD does not have data regarding out-of-hospital mortality in patients discharged after STEMI. Therefore, our post-STEMI mortality estimates could be lower than the actual 30-day post-STEMI mortality. Also, we were not able to define readmissions because of planned staged PCI. Nonetheless, inclusion of planned

staged PCI as readmission is important for estimation of total costs.[37] Furthermore, we used *ICD-9* codes for defining clinical scenarios and procedures, which may lead to misclassification bias. Noncardiac causes of readmission may have been underestimated by not including readmissions due to the revascularization strategy (eg, bleeding or vascular complications from transfemoral access, acute renal failure from contrast-induced nephropathy, pneumonia after intubation, infection from central line placement, or sternotomy). Finally, the NRD includ and represents a national population; ho e.

Conclusions

This study examined p n of readmissions on overall 30-day cost clined, particularly in those undergoing PCI re readmitted early, within the first 14 days ithin 30 or 90 days for noncardiac reason with an ≈50% increase in the cumula ons could be prevented by closer su ditions before and within the early dischar prevent 30-day readmissions after STE l should serve as a quality metric of hospit

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Disclosures

None.

Footnotes

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