Relation of Length of Stay to Unplanned Readmissions for Patients Who Undergo Elective Percutaneous Coronary Intervention

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The cost of inpatient percutaneous coronary interventions (PCI) procedure is related to length of stay (LOS). It is unknown, how LOS may be associated with readmission rates and costs of index PCI and readmissions in elective PCI. This study aims to evaluate rates, predictors, causes, and costs associated with 30-day unplanned readmissions according to lLOS in patients, who underwent elective PCI. We included patients in the Nationwide Readmission Database, who were admitted to hospital from 2010 to 2014, who underwent uncomplicated elective PCI. LOS was defined as 0, 1, 2, and ≥3 days. A total of 324,345 patients were included in the analysis and the 30-day unplanned readmission was 4.75%, 4.67%, 6.44%, and 9.42% in the LOS groups 0, 1, 2, and ≥3 days, respectively. Prolonged LOS was associated with increased average total 30-day cost (index and readmission cost, 0 days $15,063, 1 day $14,693, 2 days $18,136, and ≥3 days $24,336). Compared with 0 days, the odds of readmissions were greater for 2 days (odds ratio 1.41, 95% confidence interval 1.07 to 1.87, p = 0.016) and ≥3 days (odds ratio 1.70, 95% confidence interval 1.28 to 2.24, p < 0.001). Comorbidities were strong predictors of LOS and noncardiac causes, account for more than half of all causes for readmission. Longer LOS was associated with reduced incidence of readmissions for noncardiac causes such as noncardiac chest pain, but a greater rate of readmissions for heart failure. In conclusion, shorter length of stay was associated with reduced healthcare costs in elective PCI. **(Am J Cardiol 2019;123:33−43)**

Percutaneous coronary intervention (PCI) is the most common form of coronary revascularization undertaken in the United States[1] with in-hospital mortality rates less than 1%.[2,3] Length of stay (LOS) in PCI is an area of interest, because a significant proportional cost of the procedure is associated with LOS in hospital.[4] To date, several studies have been conducted demonstrating the safety of same day discharge (SDD) in the elective setting.[5−8] The financial considerations of SDD and readmissions in PCI have previously been reported in the EASY trial of 1,005 patients from a single Canadian center a decade ago,[9,10] although index and readmission costs have not been evaluated from a national perspective previously. Previous studies of the cost implications of SDD in PCI from the National Cardiovascular Data Registry linked to Medicare only considered index hospital costs, and did not consider readmissions or the costs associated with readmissions.[11]

Early readmission rates, predictors of readmission, and causes of readmission in the elective PCI patient group according to LOS have not been explored before at a national level, and in particular whether SDD is associated with increased 30-day unplanned readmissions, thereby offsetting the initial financial savings achieved during SDD. In this study, we aimed to examine: (1) whether SDD and LOS were associated with increased 30-day unplanned readmission rates, (2) the cost associated with SDD and total costs including first readmissions within 30 days, and (3) predictors and causes of readmission after elective PCI stratified by LOS by using the Nationwide Readmission Database (NRD), the largest all-payer database of hospital readmissions in the United States.

Methods

The NRD contains a nationally representative sample of all-age, all-payer discharges from US nonfederal hospitals produced by the Healthcare Cost and Utilization Project of

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the Agency for Healthcare Research and Quality.[12] This database is derived from discharge-level data from hospitalizations from 21 geographically-dispersed participating states, which represents 49.3% of the total US population and 49.1% of all US hospitalizations.[13] Readmissions are identified from the deidentified unique patient linkage number assigned to each patient, which allows tracking of patients across hospitals within a state during a calendar year. For the current study, unplanned readmissions were defined as any inpatient episode in a hospital within 30 days of discharge after an index elective hospitalization where a patient underwent PCI.

Each patient in the NRD dataset has up to 15 International Disease Classification (ICD)-9 procedural codes for each admission to hospital. Patients with PCI were determined from the procedural codes 0066 (PTCA OR CORONARY ATHER), 3606 (INSERT CORON ART STENT), and 3607 (INSERT DRUG ELUTING CRNRY AR).[14] We excluded patients with an elective readmission (as staged PCI procedure are not considered unplanned readmissions), patients who died during the initial admission and those who were discharged in the month of December (these patients may not have had complete 30-day follow-up). We applied further exclusions, if patients had circulatory support or had an in-hospital complication such as complete heart block, stroke/transient ischemic attack, cardiogenic shock, acute kidney injury, major bleeding, vascular complication, or emergency coronary artery bypass graft (CABG) because this may justify a prolonged hospital stay.

The primary outcome was the rate of unplanned readmission within 30 days of hospitalization with PCI. We included patients, who underwent PCI with discharge dates in 2010 and 2014 with 30-day follow-up. The cost of (1) index admission and (2) readmissions (where relevant) for each patient was determined by multiplying the hospital charges with AHRQ's all-payer cost-to-charge ratios for each hospital. The total cost was defined by index admission and cost of first readmission.

The ICD-9 codes were used to define clinical variables including smoking status, dyslipidemia, coronary artery disease, previous myocardial infarction, previous PCI, previous CABG, previous stroke or TIA, atrial fibrillation, and dementia. The other co-morbidity variables in the analysis were available through the Elixhauser comorbidities,[15] which included alcohol misuse, chronic lung disease, heart failure, diabetes, valvular heart disease, peptic ulcer disease, hypertension, renal failure, obesity, cancer, fluid and electrolyte disorders, depression, peripheral vascular disease, hypothyroidism, liver disease, and anemia. The paralysis variable from the Elixhauser comorbidities was used as a surrogate for hemiplegia, and connective tissue disease and leukemia, where defined by CCS codes 210, 211, and 39, respectively. Combining these variables enabled us to compute the Charlson co-morbidity index.[14] The number of comorbidities was the sum of the comorbidities included in the analysis. Procedural ICD-9 codes were used to define multi-vessel disease, bifurcation disease, circulatory support, vasopressor use, intra-aortic balloon pump use, fractional flow reserve use, intravascular ultrasound, and drug-eluting stent use. Diagnostic ICD-9 codes were used to define in-hospital outcomes including complete heart block, transient ischemia attack or stroke, cardiogenic shock, cardiac arrest, acute kidney injury, major bleeding, blood transfusion, vascular complication, and emergency CABG. Additional data were collected on LOS in hospital, hospital bed size, hospital location, and hospital teaching status and discharge destination. The causes of readmission were determined by the first diagnosis based on Clinical Classification Software codes, which are presented in detail in Supplementary Table 1.

Statistical analysis was performed by using Stata 14.0 (College Station, TX). We report the overall and LOS stratified crude rates of elective inpatient PCI procedures as defined by the elective variable by the Healthcare Cost and Utilization Project. Descriptive statistics are presented according to LOS and readmission status or all included variables. The statistical differences between readmitted and nonreadmitted patients for continuous and categorical variables were compared by using the *t* test and chi-square test, respectively. Multiple logistic regressions were used to determine the independent predictors of each LOS group. A second multiple logistic regression was used to determine the odds of 30-day unplanned readmissions according to LOS group 1, 2, and ≥ 3 days compared with SDD. Candidate variables to be adjusted for in logistic regression models were age, gender, year, elective admission, weekend admission, diagnosis of acute myocardial infarction, primary expected payer, median household income, smoking, alcohol misuse, dyslipidemia, hypertension, diabetes mellitus, obesity, heart failure, coronary artery disease, previous myocardial infarction, previous PCI, previous CABG, previous valve disease, atrial fibrillation, previous TIA/stroke, peripheral vascular disease, pulmonary circulatory disorder, peptic ulcer disease, chronic lung disease, chronic kidney disease, liver disease, hypothyroidism, fluid and electrolyte disorders, anemia, cancer, depression, dementia, hospital bed size, hospital location, hospital teaching status, multivessel disease, bifurcation lesion, fractional flow reserve, intravascular ultrasound use, and drug-eluting stent. The mean cost of index admission for PCI and the costs associated with readmissions were computed and are shown graphically. The causes of readmission within 30 days are presented in figure and table format as (1) noncardiac and (2) cardiac.

Results

A total of 324,345 patients were included in the analysis (Supplementary Figure 1). Unplanned readmissions occurred in 5.8% (n = 18,781) participants. We observed an increase over 2010 to 2014 in same day discharge rate that was statistically significant (p trend < 0.001; Figure 1). The proportion of cases in which the LOS was 1 day decreased over time from 68.7% to 46.6%, whereas the proportion of cases that had 2 or ≥ 3 days admissions increased from 15.6% to 25.8% and 14.7% to 25.9%, respectively. The 30-day unplanned readmission rates were 4.75%, 4.67%, 6.44%, and 9.42% in the LOS groups 0, 1, 2, and ≥ 3 days, respectively (Figure 2).

The patient and institutional characteristics according to LOS are shown in Table 1. Patients with SDD were older (68.2 years compared with 66.8 years in 1 day, 65.3

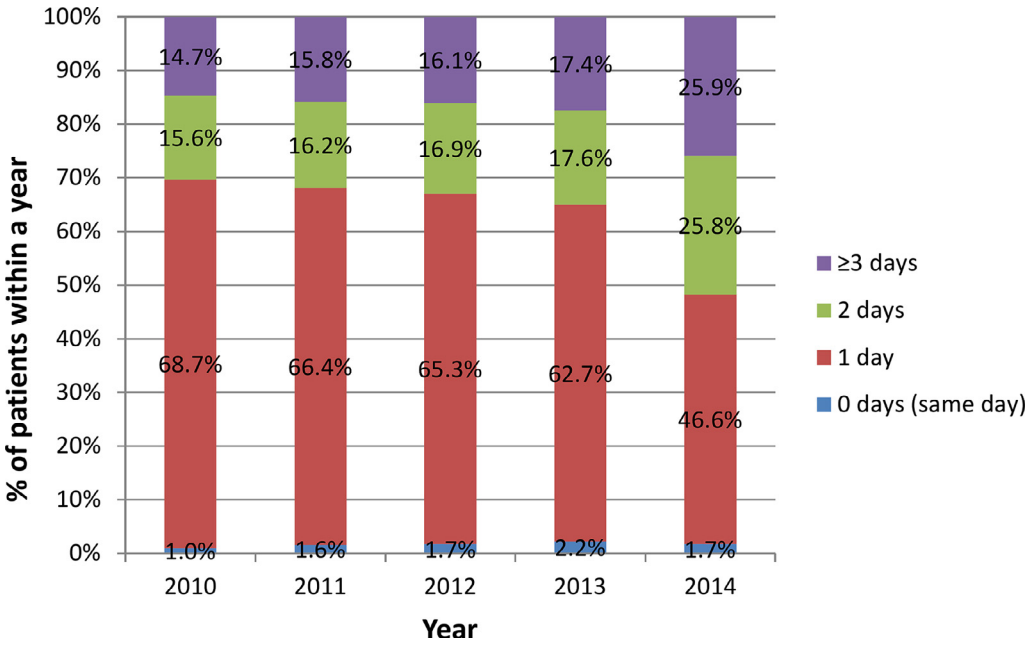

Figure 1. Elective inpatient PCI procedures in the Nationwide Readmission Database according to length of stay.

years in 2 days and 66.2 years in ≥3 days, p <0.001) and were more likely to receive Medicare (75.7% compared with 61.6% in 1 day, 56.5% in 2 days and 60.2% in ≥3 days, p <0.001), whereas patients who had private healthcare had the lowest SDD rates (17.6% compared with 29.2% for 1 day, 30.7% for 2 days and 25.6% for ≥3 days, p <0.001). Patients with the longest LOS (≥3 days LOS) had the highest comorbidities and worse risk factor profile, as evidenced by the highest proportion of smokers (36.5%), obesity (16.4%), diabetes (40.7%), atrial fibrillation (15.7%), peripheral vascular disease (15.5%), chronic lung disease (19.4%), renal failure (20.6%), and anemia (14.6%) (all had p <0.001). Patients with SDD had the highest percentage of patients with previous myocardial infarction (16.1%), previous PCI (26.1%) and previous CABG (12.6%). The cost of index admission was $14,516 for 0 days, $14,190 for 1 day, $17,444 for 2 days and $23,189 for ≥3 days.

The patient characteristics according to LOS and readmission status are shown in Table 2. In all LOS groups, patients who were female were more likely to be readmitted (p <0.001). Patients who had private healthcare also had lower rates of readmission in all LOS groups (10.8% vs 18.0% in 0 days, 21.0% vs 29.6% in 1 day, 21.7% vs 31.3% in 2 days, and 17.3% vs 26.5% in ≥3 days). Patients who experienced an unplanned 30-day readmission had a greater prevalence of individual comorbid conditions and global comorbid burden. For example, there were more patients with diabetes,

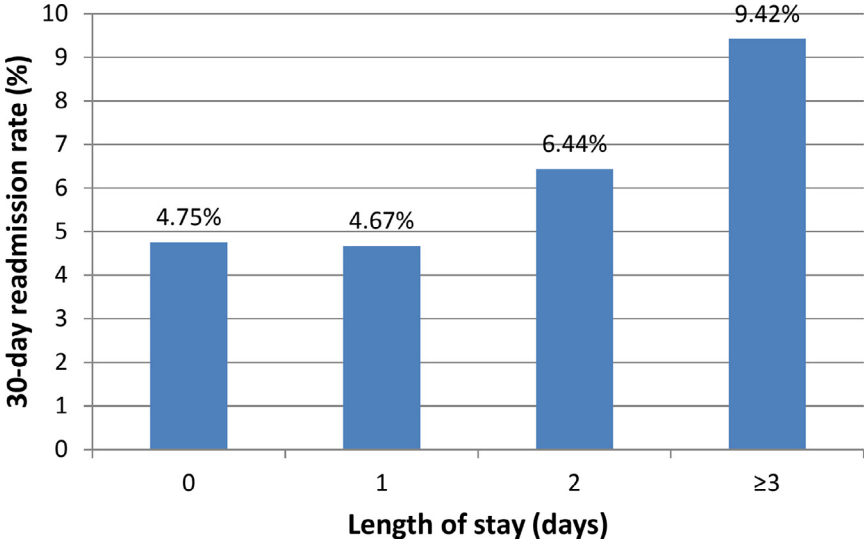

Figure 2. Rate of readmission according to length of stay.

Table 1
Patient characteristic according to length of stay

Variable	0 Days (n = 5,076)	1 Day (n = 207,391)		2 Days (n = 56,832)		≥ 3 Days (n = 55,046)	
	Mean ± SD/%	Mean ± SD/%	p Value	Mean ± SD/%	p Value	Mean ± SD/%	p Value
Age (year)	68.2 ± 10.5	66.8 ± 10.7	< 0.001	65.3±11.8	< 0.001	66.2 ± 11.9	< 0.001
Women	31.2%	30.4%	0.39	32.8%	0.14	35.31%	< 0.001
Year			< 0.001		< 0.001		< 0.001
2010	1.0%	68.7%		15.6%		14.7%	
2011	1.6%	66.4%		16.2%		15.8%	
2012	1.7%	65.3%		16.9%		16.1%	
2013	2.2%	62.7%		17.6%		17.4%	
2014	1.7%	46.6%		25.8%		25.9%	
Weekend	10.6%	1.4%	< 0.001	9.0%	0.012	13.8%	< 0.001
Primary expected payer			< 0.001		< 0.001		< 0.001
Medicare	75.7%	61.6%		56.5%		60.2%	
Medicaid	3.8%	5.7%		5.7%		6.3%	
Private	17.6%	29.2%		30.7%		25.6%	
Uninsured	1.4%	1.3%		3.8%		4.1%	
No charge	0.1%	0.2%		0.4%		0.5%	
Other	1.4%	2.1%		3.0%		3.2%	
Median household income (percentile)			< 0.001		0.93		< 0.001
0-25th	33.7%	28.3%		34.3%		38.3%	
26-50th	25.4%	24.3%		25.2%		25.2%	
51-75th	23.6%	24.4%		23.5%		21.7%	
76-100th	17.4%	23.0%		17.0%		14.8%	
Smoker	30.8%	30.9%	0.96	36.2%	< 0.001	36.5%	< 0.001
Alcohol misuse	1.1%	0.7%	0.054	1.4%	0.28	2.1%	0.002
Dyslipidemia (ICD-9 272.0-272.4)	74.1%	76.7%	0.006	74.1%	0.98	70.6%	< 0.001
Hypertension	75.0%	76.5%	0.11	74.5%	0.59	75.1%	0.87
Diabetes mellitus	35.9%	37.3%	0.17	36.2%	0.79	40.7%	< 0.001
Obesity (defined by AHRQ comorbidity measure)	12.7%	12.4%	0.63	13.9%	0.12	16.4%	< 0.001
Heart failure	0.2%	0.1%	< 0.001	0.2%	0.74	2.0%	< 0.001
Known coronary artery disease	98.6%	98.6%	0.96	96.6%	< 0.001	95.3%	< 0.001
Previous myocardial infarction	16.1%	14.9%	0.13	12.6%	< 0.001	13.4%	< 0.001
Previous percutaneous coronary intervention	26.1%	24.1%	0.04	19.7%	< 0.001	18.9%	< 0.001
Previous coronary artery bypass graft	12.6%	10.0%	< 0.001	8.6%	< 0.001	9.4%	< 0.001
Previous valve disease	0.09%	0.04%	0.21	0.09%	0.93	0.78%	< 0.001
Atrial fibrillation	9.3%	8.3%	0.11	9.6%	0.64	15.7%	< 0.001
Previous transient ischemic attack/stroke	5.6%	5.3%	0.54	5.8%	0.71	7.0%	0.015
Peripheral vascular disease	11.7%	11.3%	0.65	12.1%	0.53	15.5%	< 0.001
Pulmonary circulatory disorder	0.05%	0.02%	0.38	0.03%	0.75	0.4%	0.009
Peptic ulcer disease	0.05%	0.02%	0.28	0.02%	0.34	0.03%	0.68
Chronic lung disease	13.0%	11.8%	0.10	13.9%	0.25	19.4%	< 0.001
Renal failure	11.1%	9.5%	0.014	12.2%	0.15	20.6%	< 0.001
Liver disease	1.0%	0.7%	0.12	0.9%	0.60	1.7%	0.022
Hypothyroidism	7.1%	7.3%	0.76	8.0%	0.15	10.0%	< 0.001
Fluid and electrolyte disorders	2.7%	1.8%	0.003	5.1%	< 0.001	12.8%	< 0.001
Anemia	5.7%	4.1%	< 0.001	6.3%	0.23	14.6%	< 0.001
Cancer	1.5%	1.3%	0.30	1.4%	0.56	2.2%	0.035
Depression	4.1%	3.7%	0.39	5.0%	0.044	6.3%	< 0.001

(*continued*)

Table 1 (***Continued***)

Variable	0 Days (n = 5,076)	1 Day (n = 207,391)		2 Days (n = 56,832)		≥ 3 Days (n = 55,046)	
	Mean ± SD/%	Mean ± SD/%	p Value	Mean ± SD/%	p Value	Mean ± SD/%	p Value
Dementia	0.4%	0.5%	0.30	0.9%	0.011	1.4%	< 0.001
Charlson comorbidity index	1.1 ± 1.2	1.1 ± 1.2	0.033	1.1 ± 1.3	0.57	1.5±1.5	< 0.001
Mean number of comorbidities	4.6 ± 1.9	4.5 ± 1.8	0.019	4.6 ± 1.8	0.64	5.1±2.1	< 0.001
Bed size			< 0.001		< 0.001		< 0.001
Small	9.5%	9.6%		6.9%		5.5%	
Medium	21.3%	17.6%		21.9%		20.2%	
Large	69.2%	72.9%		71.2%		74.3%	
Location			0.35		0.084		0.056
Rural	0.1%	0.2%		0.3%		0.3%	
Urban	99.9%	99.8%		99.7%		99.7%	
Teaching status			< 0.001		0.15		0.050
Nonteaching	49.0%	42.1%		47.3%		46.8%	
Teaching status	51.0%	57.9%		52.7%		53.2%	
Multivessel disease	20.6%	20.5%	0.99	19.5%	0.24	19.2%	0.13
Bifurcation	3.8%	4.2%	0.42	3.2%	0.13	2.8%	0.009
Fractional flow reserve	4.5%	2.9%	< 0.001	2.2%	< 0.001	2.3%	< 0.001
Intravascular ultrasound	8.1%	9.2%	0.083	8.2%	0.85	8.1%	0.90
Drug eluting stent	80.4%	82.5%	0.009	78.2%	0.017	72.3%	< 0.001
Cost of first admission (all patients)	$14,516 ± 7,250	$14,190 ± 6,537	0.024	$17,444 ± 7,965	< 0.001	$23,189 ± 14,047	< 0.001
Readmission at 30-days	4.8%	4.7%	0.86	6.4%	0.002	9.4%	< 0.001
Cost of readmission (readmitted only)	$11,504 ± 11,789	$10,916 ± 16,279	0.072	$10,817 ± 13,041	0.61	$12,328 ± 18,548	0.66
Cost of first admission and readmission (all patients)	$15,063 ± 8,240	$14,693 ± 7,835	0.032	$18,136 ± 9,089	< 0.001	$24,336 ± 15,835	< 0.001
Cost of first admission and readmission (readmitted only)	$27,617 ± 16,650	$24,974 ± 18,186	0.15	$27,878 ± 15,894	0.87	$36,425 ± 24,662	< 0.001

AHRQ = Agency for Healthcare Research and Quality; ICD-9 = International Classification of Disease, Ninth Revision.

atrial fibrillation, peripheral vascular disease, chronic lung disease, renal failure, fluid and electrolyte disorders, and anemia readmitted across all LOS groups. Similarly, readmitted patients had higher Charlson co-morbidity index compared across all LOS categories (1.6 vs 1.1 in 0 days, p < 0.001, 1.4 vs 1.0 in 1 day, p < 0.001, 1.5 vs 1.1 in 2 days, p < 0.001, and 5.6 vs 1.5 in ≥ 3 days group, p < 0.001). The cost associated with the readmission was not significantly different when day 1, 2, and ≥ 3 days were compared with 0 days ($10,916, $10,817, and $12,328 for 1, 2, and ≥ 3 days vs $11,504 for 0 days, p = 0.072, 0.61, and 0.66, respectively). The average treatment cost for 30 days (average cost of index admission and readmissions within 30 days when they occur) for the LOS 0 days was $15,063, which was significantly greater than LOS 1 day ($14,963, p = 0.032), but significantly less than 2 days ($18,136, p < 0.001) and 3 days ($24,336, p < 0.001) (Figure 3).

Compared with SDD (LOS = 0 days), the odds of readmission for 1 day LOS was not statistically different (odds ratio [OR] 1.01, 95% confidence interval [CI] 0.77 to 1.32, p = 0.96), but there was a significant increase for 2 days (OR 1.41, 95% CI 1.07 to 1.87, p = 0.016), and ≥ 3 days (OR 1.70, 95% CI 1.28 to 2.24, p < 0.001) (Figure 4).

The independent predictors of readmissions within LOS groups are shown in Supplementary Table 2. Patients discharged on the same day were more likely to be readmitted, if they had atrial fibrillation (OR 2.58, 95% CI 1.23 to 5.43, p = 0.012), previous transient ischemic attack or stroke (OR 3.39, 95% CI 1.71 to 6.72, p = 0.001), and fluid and electrolyte disorders (OR 6.11, 95% CI 1.63 to 22.89, p = 0.007).

The causes of readmission are shown in Figure 5 and Table 3. Longer LOS was associated with reduced incidence of readmissions for noncardiac causes (LOS 0 days 60.8%, 1 day 62.8%, 2 days 57.9%, ≥ 3 days 58.2%). A decrease in nonspecific chest pain as a cause for readmission was observed with prolonged hospital stay (LOS 0 days 12.7%, 1 day 10.8%, 2 days 10.9%, and ≥ 3 days 7.5%). SDD had the highest rate of readmission for angina and atherosclerotic heart disease (17.6%) and acute myocardial infarction (9.8%). Prolonged LOS in hospital was associated with higher rates of readmission for heart failure (LOS 0 days 3.9%, 1 day 4.6%, 2 days 7.8%, and ≥ 3 days 10.7%).

Discussion

Our study provides several important findings. First, we observed that longer hospital stay is associated with a graded increase in the rate of unplanned readmission according to index LOS in elective PCI. Unlike previous studies which focus on LOS as a binary categorical variable

Table 2
Patient characteristic according to length of stay group and readmission status

Variable	0 Days (n = 5,076)			1 Day (n = 207,391)			2 Days (n = 56,832)			≥ 3 Days (n = 55,046)		
	Not readmitted	Readmitted	p Value	Not readmitted	Readmitted	p Value	Not readmitted	Readmitted	p Value	Not readmitted	Readmitted	p Value
Age (year)	68.2 ± 10.4	67.4 ± 11.6	0.42	66.8 ± 10.7	68.1 ± 11.4	< 0.001	65.2 ± 11.8	67.1 ± 12.3	< 0.001	66.0 ± 11.9	67.8 ± 11.9	< 0.001
Women	30.8%	40.2%	0.045	30.0%	37.4%	< 0.001	32.2%	41.3%	< 0.001	34.7%	40.8%	< 0.001
Year			0.53			0.47			0.33			0.82
2010	95.8%	4.2%		95.2%	4.8%		93.1%	6.9%		91.0%	9.0%	
2011	95.2%	4.8%		95.4%	4.7%		93.9%	6.2%		90.5%	9.5%	
2012	94.3%	5.7%		95.3%	4.7%		93.5%	6.5%		90.6%	9.4%	
2013	94.3%	5.1%		95.3%	4.7%		93.5%	6.5%		90.3%	9.7%	
2014	97.0%	3.0%		95.7%	4.3%		94.0%	6.0%		90.5%	9.5%	
Weekend	10.5%	11.8%	0.69	1.4%	1.7%	0.14	9.1%	7.0%	0.005	14.0%	12.1%	0.014
Primary expected payer			0.16			< 0.001			< 0.001			< 0.001
Medicare	75.6%	77.5%		61.2%	69.6%		55.8%	66.7%		59.2%	69.5%	
Medicaid	3.7%	5.9%		5.6%	6.6%		5.6%	6.5%		6.2%	7.3%	
Private	18.0%	10.8%		29.6%	21.0%		31.3%	21.7%		26.5%	17.3%	
Uninsured	1.3%	2.9%		1.3%	1.0%		3.9%	2.3%		4.2%	3.0%	
No charge	0.1%	0%		0.2%	0.2%		0.4%	0.5%		0.5%	0.4%	
Other	1.3%	2.9%		2.1%	1.6%		3.1%	2.3%		3.3%	2.5%	
Median household income (percentile)			0.57			0.010			0.40			0.32
0-25th	33.5%	36.4%		28.2%	30.3%		34.3%	35.1%		38.3%	37.5%	
26-50th	25.7%	20.2%		24.3%	23.8%		25.2%	26.2%		25.1%	26.4%	
51-75th	23.4%	27.3%		24.4%	24.4%		23.5%	23.3%		21.7%	22.3%	
76-100th	17.4%	16.2%		23.1%	21.4%		17.1%	15.5%		14.9%	13.8%	
Smoker	31.0%	27.5%	0.45	30.8%	31.0%	0.80	36.5%	32.4%	0.001	36.8%	34.2%	0.015
Alcohol misuse	1.1%	1.0%	0.93	0.7%	0.8%	0.48	1.3%	1.6%	0.49	2.1%	2.0%	0.89
Dyslipidemia	74.2%	72.6%	0.71	76.8%	74.6%	0.001	74.3%	70.9%	0.003	70.7%	68.9%	0.073
Hypertension	75.2%	71.6%	0.42	76.4%	77.9%	0.022	74.3%	76.4%	0.075	74.8%	77.9%	0.001
Diabetes mellitus	35.8%	38.2%	0.61	37.1%	42.7%	< 0.001	35.8%	42.3%	< 0.001	39.9%	47.8%	< 0.001
Obesity	12.7%	13.7%	0.76	12.3%	13.1%	0.13	14.0%	13.3%	0.47	16.3%	17.2%	0.27
Heart failure	0.1%	2.9%	< 0.001	0.05%	0.02%	0.47	0.2%	0.3%	0.26	1.9%	2.6%	0.035
Known coronary artery disease	98.7%	97.1%	0.17	98.6%	98.9%	0.14	96.5%	97.7%	0.012	95.2%	96.0%	0.072
Previous myocardial infarction	16.0%	18.6%	0.47	14.9%	15.5%	0.30	12.6%	12.8%	0.85	13.3%	13.8%	0.53
Previous percutaneous coronary intervention	26.1%	24.5%	0.72	24.2%	22.0%	0.001	19.6%	20.7%	0.29	18.8%	19.5%	0.42
Previous coronary artery bypass graft	12.7%	9.8%	0.39	9.9%	11.2%	0.050	8.4%	10.9%	0.001	9.2%	10.9%	0.012
Previous valve disease	0.05%	0.98%	0.003	0.04%	0.10%	0.050	0.09%	0.06%	0.75	0.7%	1.3%	0.005
Atrial fibrillation	8.8%	19.6%	< 0.001	8.1%	12.7%	< 0.001	9.2%	15.6%	< 0.001	15.2%	20.9%	< 0.001
Previous transient ischemic attack/stroke	5.4%	9.8%	0.058	5.2%	7.4%	< 0.001	5.6%	8.6%	< 0.001	6.8%	8.8%	0.001
Peripheral vascular disease	11.6%	13.7%	0.50	11.2%	14.5%	< 0.001	11.9%	15.2%	< 0.001	15.0%	20.3%	< 0.001

(*continued*)

Table 2 (***Continued***)

Variable	0 Days (n = 5,076)			1 Day (n = 207,391)			2 Days (n = 56,832)			≥ 3 Days (n = 55,046)		
	Not readmitted	Readmitted	p Value	Not readmitted	Readmitted	p Value	Not readmitted	Readmitted	p Value	Not readmitted	Readmitted	p Value
Pulmonary circulatory disorder	0%	1.0%	< 0.001	0.02%	0.05%	0.17	0.04%	0%	0.46	0.4%	0.6%	0.076
Peptic ulcer disease	0.05%	0%	0.82	0.02%	0%	0.41	0.02%	0%	0.60	0.03%	0.05%	0.66
Chronic lung disease	12.7%	17.7%	0.15	11.6%	16.1%	< 0.001	13.4%	19.8%	< 0.001	18.7%	26.1%	< 0.001
Renal failure	10.6%	20.6%	0.002	9.2%	16.6%	< 0.001	11.8%	17.9%	< 0.001	19.7%	29.6%	< 0.001
Liver disease	1.0%	1.0%	0.96	0.7%	1.1%	0.009	0.8%	2.1%	< 0.001	1.6%	2.1%	0.15
Hypothyroidism	7.2%	5.9%	0.62	7.2%	8.6%	0.001	7.8%	10.5%	< 0.001	9.9%	11.7%	0.007
Fluid and electrolyte disorders	2.6%	4.9%	0.16	1.8%	3.1%	< 0.001	5.0%	7.2%	< 0.001	12.3%	17.2%	< 0.001
Anemia	5.5%	9.8%	0.066	3.9%	7.9%	< 0.001	6.0%	10.7%	< 0.001	14.0%	20.9%	< 0.001
Cancer	1.4%	4.9%	0.005	1.3%	1.9%	< 0.001	1.3%	2.1%	0.017	2.2%	2.9%	0.022
Depression	4.0%	5.9%	0.34	3.6%	5.1%	< 0.001	4.9%	6.5%	0.006	6.1%	8.8%	< 0.001
Dementia	0.4%	0%	0.53	0.5%	0.7%	0.082	0.9%	1.7%	0.001	1.3%	1.8%	< 0.001
Charlson comorbidity index	1.1 ± 1.2	1.6±1.7	< 0.001	1.0±1.2	1.4±1.4	< 0.001	1.1±1.2	1.5±1.4	< 0.001	1.5±2.1	5.6±2.2	< 0.001
Mean number of comorbidities	4.6 ± 1.9	5.0±2.2	0.027	4.5±1.7	4.8±1.9	< 0.001	4.5±1.8	5.0±2.0	< 0.001	5.0±2.1	5.6±2.2	< 0.001
Bed size			0.11			0.040			0.97			0.054
Small	9.8%	3.9%		9.6%	8.8%		6.9%	6.8%		5.6%	4.9%	
Medium	21.4%	19.6%		17.6%	16.6%		21.9%	22.2%		20.0%	22.0%	
Large	68.8%	76.5%		72.8%	74.6%		71.2%	71.1%		74.4%	73.1%	
Location			0.75			0.61			0.76			0.80
Rural	0.1%	0%		0.2%	0.1%		0.3%	0.3%		0.3%	0.4%	
Urban	99.9%	100%		99.8%	99.9%		99.7%	99.7%		99.7%	99.6%	
Teaching status			0.31			0.58			0.64			0.33
Nonteaching	48.7%	53.9%		42.1%	42.5%		47.4%	46.8%		46.9%	45.8%	
Teaching status	51.3%	46.1%		57.9%	57.5%		52.6%	53.2%		53.1%	54.2%	
Multivessel disease	20.5%	22.6%	0.61	20.5%	21.0%	0.49	19.6%	17.4%	0.030	19.4%	17.7%	0.061
Bifurcation	3.9%	2.9%	0.64	4.2%	3.8%	0.23	3.2%	3.5%	0.53	19.4%	17.7%	0.34
Fractional flow reserve	4.6%	3.9%	0.77	2.8%	3.1%	0.38	2.2%	2.8%	0.090	2.3%	2.5%	0.62
Intravascular ultrasound	7.9%	10.8%	0.30	9.2%	9.3%	0.70	8.2%	7.9%	0.66	8.2%	7.9%	0.71
Drug eluting stent	80.9%	70.6%	0.011	82.8%	76.7%	< 0.001	78.4%	74.9%	0.001	72.8%	67.5%	< 0.001
Cost for first admission	$14,436 ± 7,022	$16,113 ± 10,774	0.024	$14,190 ± 6,541	$14,190 ± 6,465	0.99	$17,464 ± 7,994	$17,144 ± 7,508	0.13	$23,087 ± 14,042	$24,175 ± 14,066	< 0.001
Cost of readmission	–	$11,504 ± 11,789	–	–	$10,915 ± 16,279	–	–	$10,817 ± 13,041	–	–	$12,328 ± 18,548	–
30-day cost (first admission and readmission)	$14,436 ± 7,022	$27,617 ± 16,650	< 0.001	$14,190 ± 6,541	$24,974 ± 18,186	< 0.001	$17,465 ± 7,995	$27,879 ± 15,894	< 0.001	$23,087 ± 14,042	$36,425 ± 24,662	< 0.001

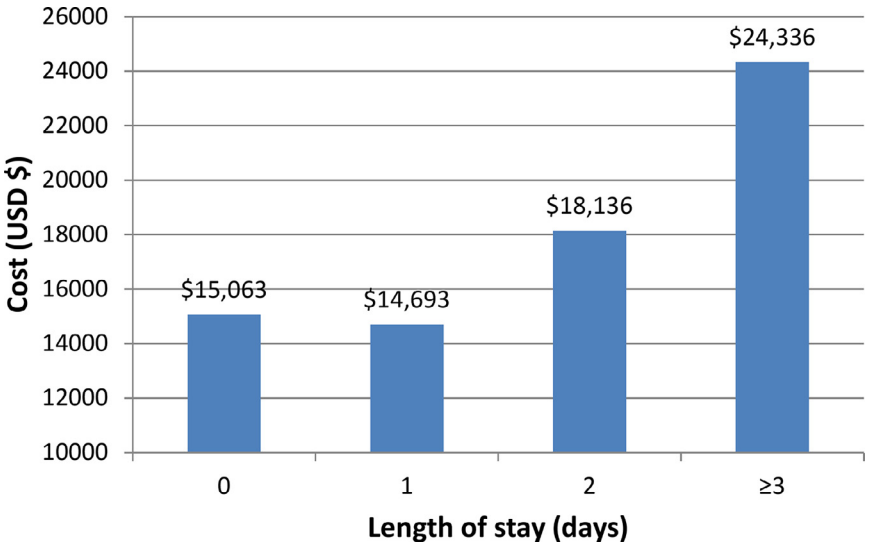

Figure 3. Total 30-day cost according to length of stay.

(SDD and non-SDD), our results provide further granularity through consideration of LOS in a graded manner. Second, the cost saved associated with reduced hospital stay persists for 30 days, with cost savings associated with SDD/shorter lengths of stay not offset by increased healthcare costs of readmission. Third, irrespective of LOS, readmission risk is most influenced by age, female gender, and comorbidities. Finally, the patterns and causes of readmissions depend on the LOS, that most likely relate to the differences in the risk profile of patients in each LOS group.

The major clinical implication of the current study is that there does not appear to be increased risk of readmissions with SDD and shorter LOS (SDD and overnight stay) in elective PCI. Previous studies have not studied the influence of LOS by considering 0, 1, 2, and ≥ 3 days, which incur different costs at index admission and these studies have not considered the cost of index PCI admission as well as the first unplanned readmission. This is important as total healthcare costs extend beyond direct causes of an index admission, but also the cost of the readmissions. Interestingly, whereas we observed that the total 30-day cost for SDD was slightly greater than for patients with an overnight stay, this was driven by the greater costs associated with the SDD index admission, as these patients were older and more comorbid than those admitted for overnight stay. Nevertheless, savings associated with shorter LOS are not offset by greater healthcare costs for 30 days due to increased readmissions in these groups.

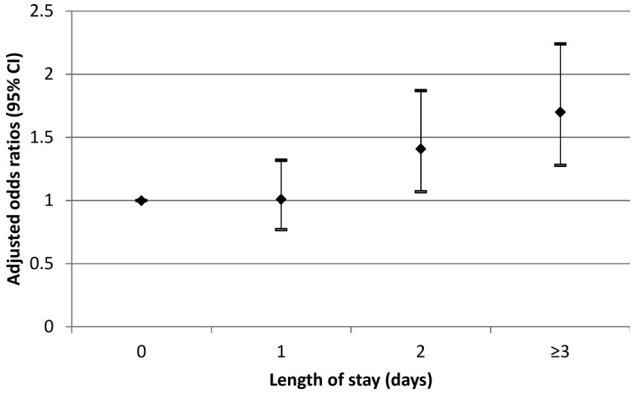

Figure 4. Adjusted odds of readmissions.

SDD and 30-day rehospitalizations after PCI has been explored in the Early Discharge After Transradial Stenting of Coronary Arteries (EASY) study.[9] Repeat hospitalization and unsolicited medical visits in this study occurred in 4.1% and 6.2%, respectively among SDD patients. The financial implications of SDD was explored in a follow-up analysis, suggest that SDD is associated with a 50% reduction in medical costs over 30 days, with no late catch up phenomenon exhibited in that study either, so for every 1,000 patients, there could be $1 million in savings.[10] We have extended the financial considerations applying it to a national setting and considered the cost in different LOS groups. These findings, together with those of the current study suggest that SDD is not associated with increased resource utilization or cost during the 30-day follow-up period.

Our study shows that longer lengths of stay (>1 day) were associated with increased odds of readmission. There are several explanations for this; first, we observed that patients with longer hospital stay are more likely to have significant comorbidities that are known to be independent predictors of readmissions.[14] Although, we attempted to adjust for differences in comorbid condition prevalence amongst the different LOS groups, our dataset does not capture the severity of each individual co-morbidity. We also observed a decrease in noncardiac readmissions with increasing LOS and one possible reason for this is that the longer admission results in better management of comorbidities, so there are fewer noncardiac readmissions, but this requires further investigation. Second, whereas we were able to exclude a variety of factors associated with higher risk of adverse outcomes such as use of circulatory

Table 3
Cause of readmission according to length of stay

Cause of readmission	0 days (n=5,388)	1 day (n=216,469)		2 days (n=61,439)		≥3 days (n=68,154)	
		%	p-value vs 0 days	%	p-value vs 0 days	%	p-value vs 0 days
Cardiac	39.2%	37.2%	0.68	42.1%	0.57	41.8%	0.60
Non-cardiac	60.8%	62.8%		57.9%		58.2%	

Cause of readmission (non-cardiac)	0 days	1 day	2 days	≥3 days
Non-specific chest pain	12.7%	10.8%	10.9%	7.5%
Infections	5.9%	6.0%	4.5%	6.3%
Gastrointestinal	4.9%	7.3%	6.6%	6.6%
Respiratory	3.9%	4.5%	4.0%	5.3%
Bleeding	3.9%	4.1%	3.1%	3.7%
Renal failure	3.9%	2.0%	1.7%	2.6%
Trauma	2.9%	2.0%	1.8%	0.8%
Genitourinary	2.0%	2.1%	1.6%	2.0%
Peripheral vascular disease	2.0%	2.7%	2.3%	2.6%
TIA/stroke	2.0%	2.6%	3.2%	2.6%
Endocrine/metabolic	2.0%	1.4%	1.0%	2.0%
Hematological/neoplasm	0.0%	2.0%	2.5%	1.8%
Rheumatological	0.0%	1.4%	0.8%	1.2%
Syncope	0.0%	1.2%	0.9%	1.1%
Neuropsychiatric	0.0%	0.9%	1.7%	0.7%
ENT problem	0.0%	0.9%	0.4%	0.6%
Opthalmological	0.0%	0.0%	0.2%	0.0%
Oral health problem	0.0%	0.1%	0.0%	0.1%
Obstetric or pregnancy problem	0.0%	0.0%	0.1%	0.0%
Dermatological	0.0%	0.0%	0.1%	0.0%
Poisoning	0.0%	0.0%	0.1%	0.4%
Other non-cardiac	14.7%	10.7%	10.6%	10.2%

Cause of readmission (cardiac)	0 days	1 day	2 days	≥3 days
Angina and atherosclerotic heart disease (excluding acute myocardial infarction)	17.6%	19.4%	18.0%	13.5%
Acute myocardial infarction	9.8%	6.4%	7.4%	7.0%
Arrhythmias	5.9%	5.1%	6.9%	7.6%
Heart failure	3.9%	4.6%	7.8%	10.7%
Valve disorders	1.0%	0.4%	0.2%	0.6%
Conduction disorders	0.0%	0.5%	0.5%	0.3%
Pericarditis	0.0%	0.2%	0.5%	0.6%
Other cardiac	1.0%	0.7%	0.8%	1.3%

support, cardiogenic shock, and in-hospital complications, there may still be unmeasured factors that warrant admission for observation such as patient frailty.[16]

It has also been reported that postprocedural complications were the strongest predictor of prolonged observation in a study of 1,015 patients, who underwent elective PCI.[17] In the current study, we excluded patients that had sustained PCI complications in their index event, because such patients by necessity would need to remain as inpatients for longer periods of time and would confound our results toward worse outcomes for the longer LOS groups. Important determinants of LOS in the current low risk elective cohort appeared to be comorbidities such as atrial fibrillation, diabetes, renal failure, and fluid and electrolyte disorders. Procedural variables such as access site, lesion complexity, contrast exposure, angiographic results, and method of hemostasis are not captured by this dataset and so cannot be included in our analyses.

We found that noncardiac readmissions are common after PCI. One reason for this may be related to inadequate management of pre-existing noncardiac comorbidities. We observed a greater prevalence of diabetes, chronic lung disease, renal failure, anemia, and cancer comparing patients who were readmitted to those who were not readmitted. It is not clear, whether any additional routine or specialist management of these noncardiac existing conditions took place during the index admission for PCI or plans for these conditions to be managed as an outpatient. Another contribution to noncardiac readmissions may be complications of the cardiac procedure. Antiplatelet therapy may cause bleeding and aspirin may exacerbate symptoms of dyspepsia. Contrast exposure may result in renal failure and patients who undergo procedures in hospitals may be at risk of hospital acquired infections. Finally, the most frequent cause of readmission was chest pain and patients who had a stent may have a lower threshold of returning to hospital because they are concerned about a recurrence of coronary disease.

A key limitation of the current study is that it likely under report day-case or same-day admission for PCI. SDD has been reported to be 0.9% in an analysis of uncomplicated elective PCI in the Nationwide Inpatient Sample[18]

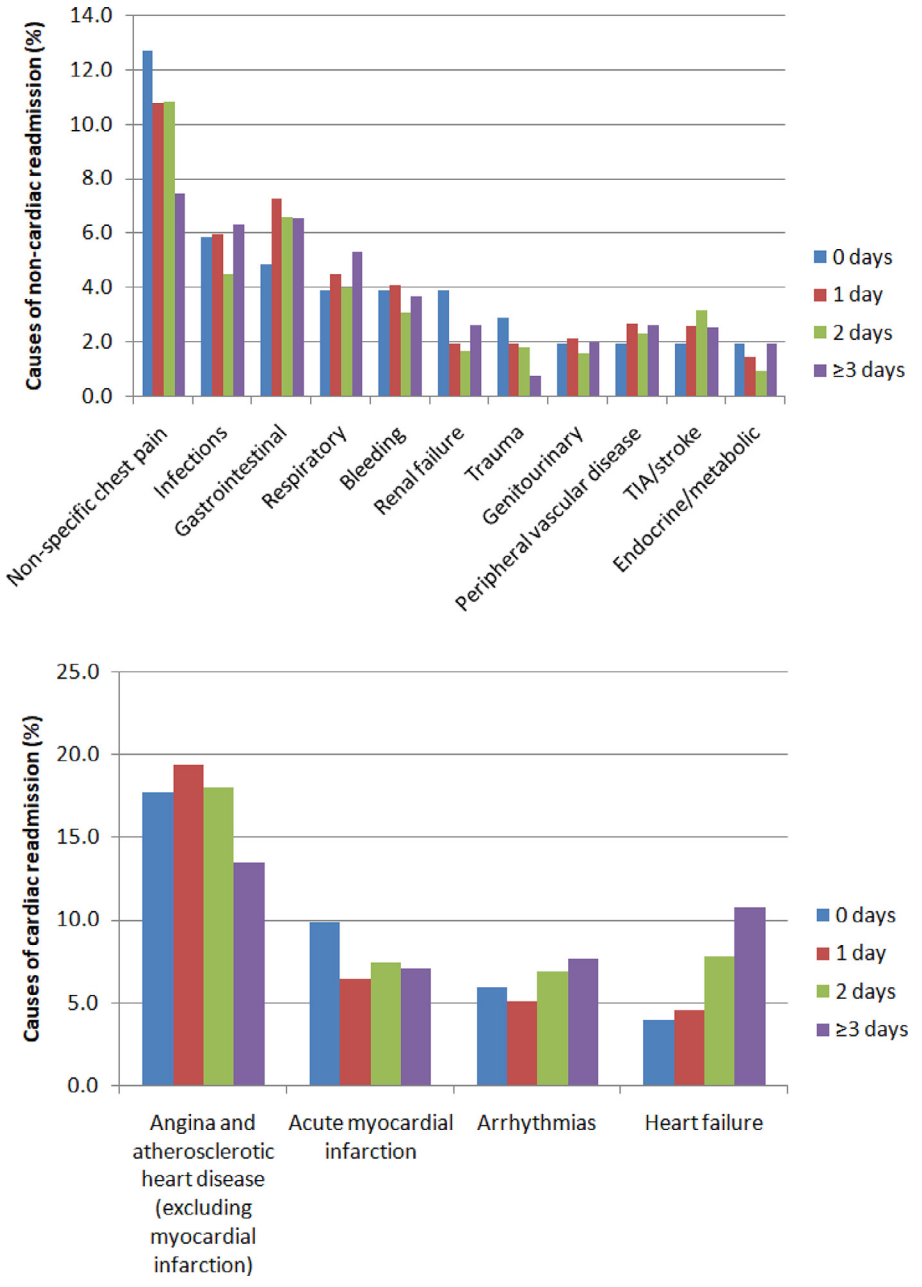

Figure 5. Cause of early readmissions after elective PCI.

and the NRD is provided by the same data source. Data from Medicare in 2004 to 2008, have been linked to the more complete PCI records of the CathPCI registry in the United States, but rates of SDD discharge are also low at 1.25%.[19] Low rates of SDD may reflect the increasing shift from inpatient to nonadmission PCI procedures which would serve to underestimate the proportion of patients underwent SDD PCI.[20] Second, the elective procedures captured in the current dataset may not be representative of the totality of elective procedures in the United States, although over 300,000 PCI procedures were included in this analysis that provides significant statistical power to explore the relations that we have studied. Third, we do not know the date of the PCI during the admission, and so 30-day readmission rates were calculated from the date of discharge rather than the date of the PCI procedure. This may over-estimate 30-day readmission rates, although the average LOS was short in the elective cohort (2 days) so even if we considered the date of admission as index PCI date, 30-day readmission rates only minimally decreased from 5.8% to 5.4% and there were no major changes in the rate of LOS or healthcare costs. Also, the current dataset lacks information about operator or center practice which may be a major determinant for LOS during the index PCI procedure. Furthermore, there is no possible linkage between years as the data is derived from 5 unique datasets corresponding to each year from 2010 to 2014. Finally, studies of readmissions may be affected by bias related to survivorship in that patients, who died after hospital discharge are not captured in the present analysis.

In the increasing cost-conscious and evidence based healthcare system, results from the current analysis suggest that SDD and shorter lengths of stay in elective patients are not associated with increased rates of unplanned readmission and that the savings achieved with shorter LOS are not offset by increased total healthcare cost for 30-days driven by unplanned readmissions. Longer LOS was associated with reduced incidence of readmissions for noncardiac causes such as noncardiac chest pain, but a greater rate of readmissions for heart failure.

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Disclosures

The authors have no conflicts of interest to declare.

Supplementary Materials

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.1016/j.amjcard.2018.09.028.

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