In-Hospital Outcomes of ST-Segment Elevation Myocardial Infarction Complicated With Cardiogenic Shock at Safety-Net Hospitals in the United States (from the Nationwide Inpatient Sample)

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Safety-net hospitals (SNHs) are hospitals that serve a higher proportion of patients insured by Medicaid or uninsured and have been reported to have poor outcomes compared with non-SNHs. Procedural and clinical outcomes of ST-segment elevation myocardial infarction complicated by cardiogenic shock (STEMI-CS) at SNHs have not been well described. Nationwide Inpatient Sample from 2005 to 2011 was queried to identify STEMI-CS and age ≥18. SNHs were defined as hospitals with the highest number of inpatient stays that were paid by Medicaid or were uninsured (the top quartile). A total of 23,229 STEMI-CS of which 3,639 (15.7%) were treated at SNHs. Admissions to SNHs were younger (mean age 66.0 vs 67.2, $p < 0.001$), more likely men (64.0% vs 62.2%, $p = 0.04$), more frequently ethnic minorities (Black; 11.0% vs 6.0%, Hispanic 20.4% vs 5.8%, $p < 0.001$), and had higher Elixhauser ≥4 (25.8% vs 21.9%, respectively, $p < 0.001$). Percutaneous coronary interventions were less performed (60.4% vs 65.8%, $p < 0.001$) whereas administrations of thrombolysis (2.9% vs 2.1%, $p = 0.001$) were more frequent at SNHs. Coronary artery bypass and the use of mechanical circulatory support was similar. In-hospital mortality was significantly elevated at SNHs (36.6% vs 32.7%, adjusted odds ratio 1.24, 95% confidence interval 1.10 to 1.39) whereas new dialysis, stroke, and fatal arrhythmias were similar. The median length of stay was similar (6 vs 7 days, $p = 0.58$) but the median cost was higher (40,175 vs 38,012 US dollars, $p = 0.01$) at SNHs. SNHs had lower utilization of percutaneous coronary intervention and higher in-hospital mortality compared with non-SNHs in STEMI-CS. Further cause analysis is warranted to improve outcomes of STEMI-CS admitted at SNHs. **(Am J Cardiol 2019;124:485−490)**

Safety-net hospitals (SNHs) are defined as hospitals that serve high proportions of patients insured by Medicaid or uninsured.[1] SNHs accounted for approximately one-third of all hospital stays in the United States in 2014 and play vital roles in providing healthcare to vulnerable populations.[2] However, some studies have reported worse outcomes in SNHs.[3−8] When higher intensity of care is necessary, SNHs may have disadvantages due to limitations in resources and available services.[9] The outcomes of ST-segment elevation myocardial infarction (STEMI) has improved dramatically due to primary percutaneous coronary intervention (PCI) and advancements of adjunctive pharmacological therapies.[10−12] However, the mortality of STEMI complicated with cardiogenic shock (STEMI-CS) remains high, ranging from 30% to 50%.[13−17] The care of patients with STEMI-CS is complex as it requires intensive care unit stay, use of mechanical circulatory support (MCS), and prompt access to subspecialties. We sought to assess the patient demographics, procedural characteristics, and in-hospital outcomes of STEMI-CS between SNHs and non-SNHs.

Methods

The Nationwide Inpatient Sample (NIS) database, an administrative database that contains 20% sample of all the discharges in the United States produced by the Healthcare Cost and Utilization Project. We used the data from January 2005 to December 2011 and *International Classification of Diseases, Ninth Edition Clinical Modification* (ICD-9-CM) codes to identify the primary discharge diagnosis of STEMI (ICD-9-CM; 410.0x, 410.1x, 410.2x, 410.3x, 410.4x, 410.5x, 410.6x, and 410.8x) and diagnosis of CS (ICD-9-CM; 785.51) other than the primary diagnosis with age more than 18. We excluded those with a previous heart transplant (ICD-9-CM; V42.1) and left ventricular assist device or artificial heart (ICD-9-CM; V43.21). Additionally, elective

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admissions and those discharged the same day with alive status were excluded as it is unlikely to represent STEMI-CS admissions. Due to the change in NIS design after 2012 that precluded calculation of the safety-net burden of hospitals, we included data up to 2011. Burden of co-morbidity was expressed with the Elixhauser co-morbidity index. Elixhauser co-morbidity index was developed to predict in-hospital mortality and resource use by combining 29 different co-morbidities using the ICD-9-CM codes.[18] The variables used to determine the score in the NIS is presented in the supplement.

To be consistent with previous reports of *Healthcare Cost and Utilization Project*, we quantified safety-net burden for each hospital by calculating the percentage of total hospitalization (irrespective of diagnosis) with uninsured or Medicaid-insured patient for each calendar year. Hospitals within the top quartile were thereafter categorized as SNHs.[1,2] A brief explanation of Medicare and Medicaid is provided in the supplement.

The primary outcome was in-hospital mortality and secondary outcomes were acute kidney injury requiring dialysis, acute stroke, and ventricular fibrillation or cardiac arrest. Procedural outcomes were PCI, coronary artery bypass graft, administration of thrombolytic, use of temporal MCS (intra-aortic balloon pump, Impella, Tandem Heart), and left ventricular assist devices. Nonroutine discharge (discharge to home with healthcare, transfer to another acute care hospitals, or extended care facilities), length of hospital stay, and hospitalization cost were also assessed between SNHs and non-SNHs. Used ICD-9-CM codes are summarized in Supplemental Table 1.

Hospital-level trend weight provided by Agency for Healthcare Research and Quality was applied to generate national estimates including a measure of central tendencies, rates, and proportions. We compared baseline characteristics between SNHs and non-SNHs using a chi-square test for categorical variable and analysis of variance or Kruskal-Wallis test (as appropriate) for continuous variable. Subsequent analyses were conducted using hierarchical mixed effect models with a unique hospital identification number as random effects in the model to account for the nested sampling in NIS. The trend in hospitalization and in-hospital mortality was evaluated using multilevel mixed effect Poisson and logistic model, respectively. To compare clinical outcomes between SNHs and non-SNHs, we created 1:1 matched groups based on propensity score analysis and using the nearest neighbor matching with a caliper of 0.1. The propensity score was estimated using a logistic regression model with the patient- and hospital-level variables in Table 1 as independent variables and indicator for SNHs as the dependent variables. The success of matching was assessed based on the standardized differences in patient- and hospital-level covariates between the 2 groups. Binary outcomes were compared using mixed effect logistic model whereas the length of stay and inflation-adjusted hospitalization cost were compared using a linear mixed model. As a sensitivity analysis, we compared our estimates in the propensity analysis with that in a multivariable analysis adjusting for same covariates. All the analyses were performed using *Stata Statistical Software: Release 15*, College Station, Texas StataCorp LLC with the level of significance set at 0.05.

Results

A total of 23,229 unweighted (109,750 weighted) admissions of STEMI-CS of which 3,639 (15.7%) were admitted to SNHs. Patients admitted to SNHs were younger (mean 66.0 vs 67.2 years, $p < 0.001$), more likely men (64.0% vs 62.2%, $p = 0.04$), and ethnic minorities (Black; 11.0% vs 6.0%, Hispanic 20.4% vs 5.8%, $p < 0.001$), with higher prevalence of co-morbidities such as hypertension (51.4% vs 48.5%, $p = 0.001$), diabetes (33.1% vs 26.6%, $p < 0.001$), anemia (19.8% vs 16.9%, $p < 0.001$), coagulopathy (14.7% vs 11.4%, $p < 0.001$), renal failure (15.9% vs 13.8%, $p < 0.001$), liver disease (1.5% vs 1.0%, $p = 0.002$), and Elixhauser ≥4 (25.8% vs 21.9%, $p < 0.001$). Those admitted to SNHs were more frequently insured by Medicaid (12.1% vs 6.0%) or self-pay (9.2% vs 6.1%; $p < 0.001$). SNHs tended to be small bed size (5.8% vs 7.6%, $p < 0.001$) and were more frequently classified as urban teaching hospitals (63.4% vs 47.6%, $p < 0.001$; Table 1). PCIs were less performed during the weekend whereas the rate of weekend admissions was similar. There was a significantly increased number of admissions to SNHs during the study period (p trend = 0.001), whereas it remained stable at non-SNHs (p trend = 0.22). In-hospital mortality decreased significantly during the study period in both hospital settings (p trend <0.001 for both; Figures 1 and 2).

At SNHs, in the unadjusted model, PCI (60.4% vs 65.8%, $p < 0.001$) were less frequently performed whereas thrombolysis was more frequently administered (2.9% vs 2.1%, $p = 0.001$) compared with non-SNHs. Use of MCS (53.8% vs 55.5%, $p = 0.06$) and ventricular assist devices (0.59% vs 0.71%, $p = 0.38$) was similar between SNHs and non-SNHs (Figure 3). In multivariable adjusted models, in-hospital mortality was significantly higher (adjusted odd ratio [aOR] 1.24, 95% confidence interval [CI] 1.10 to 1.39, $p = 0.001$) in SNHs. Acute kidney injury requiring dialysis (aOR 1.27, 95% CI 0.99 to 1.62, $p = 0.09$), stroke (aOR 0.83, 95% CI 0.33 to 1.96, $p = 0.67$), and ventricular fibrillation/cardiac arrest (aOR 1.05, 95% CI 0.94 to 1.20, $p = 0.32$) were similar between SNHs and non-SNHs. Nonroutine home discharges (aOR 1.04, 95% CI 0.92 to 1.15, $p = 0.58$) and length of stay (median 6 vs 7 days, $p = 0.58$) did not significantly differ between the 2 hospitals but hospitalization cost was significantly elevated in SNHs (median 40,175 vs 38,012 US dollars, $p = 0.01$; Table 2). The results of sensitivity analyses are shown in Supplement Tables 2 and 3. The results were consistent with the primary analysis.

Discussion

We demonstrated that 15.7% of STEMI-CS admissions were at SNHs and those admitted to SNHs had a higher prevalence of comorbidities, more likely to be ethnic minorities, and socially disadvantaged. The admission rates to SNHs increased overtime whereas it did not change in non-SNHs during the study period. The rates of coronary angiogram and PCI were lower whereas thrombolysis was more frequently administered at SNHs. In-hospital mortality and hospitalization cost were increased at SNHs.

Table 1
Baseline patient co-morbidities and hospital characteristics between safety-net and nonsafety-net hospitals

	Total	Non-SNH	SNH	p Value
No. of patients (unweighted)	23,229	19,590	3,639	
No. of patients (weighted)	109,750	92,785	16,963	
Age, mean (SD) (Years)	67.01 (13.41)	67.19 (13.40)	66.03 (13.22)	<0.001
<65	43.92%	43.36%	46.94%	
65-79	35.29%	35.25%	35.53%	
≥80	20.79%	21.39%	17.53%	
Women	37.54%	37.82%	36.05%	0.04
White	81.67%	85.28%	62.73%	<0.001
Black	6.78%	5.98%	10.99%	
Hispanic	8.17%	5.84%	20.39%	
Asian	3.38%	2.90%	5.89%	
Peripheral vascular disease	9.36%	9.43%	9.01%	0.43
Hypertension	48.96%	48.50%	51.42%	0.001
Diabetes mellitus	27.58%	26.55%	33.11%	<0.001
Obese	8.20%	8.21%	8.11%	0.82
Anemia	17.31%	16.85%	19.79%	<0.001
Chronic pulmonary disease	20.07%	20.31%	18.77%	0.03
Renal failure	14.06%	13.72%	15.94%	<0.001
Liver disease	1.04%	0.95%	1.51%	0.002
Coagulopathy	11.91%	11.39%	14.67%	<0.001
Metastatic cancer	0.86%	0.86%	0.82%	0.81
Elixhauser score				<0.001
0-1	35.04%	35.65%	31.77%	
2-3	42.42%	42.42%	42.40%	
≥4	22.55%	21.93%	25.83%	
Anterior ST-segment elevation myocardial infarction	49.25%	49.48%	47.98%	0.10
Median household income (quartile)				<0.001
1st	25.86%	23.44%	39.01%	
2nd	26.51%	26.64%	25.85%	
3rd	25.01%	25.94%	19.99%	
4th	22.61%	23.98%	15.15%	
Expected payer				<0.001
Medicare	53.77%	54.35%	50.69%	
Medicaid	6.92%	5.97%	12.07%	
Private insurance	29.15%	30.12%	23.94%	
Self-pay	6.60%	6.13%	9.15%	
Hospital bed size				<0.001
Small	7.33%	7.62%	5.76%	
Medium	19.65%	19.33%	21.39%	
Large	73.02%	73.05%	72.85%	
Hospital location				<0.001
Rural	6.06%	6.14%	5.65%	
Urban nonteaching	43.84%	46.23%	30.95%	
Urban teaching	50.09%	47.63%	63.40%	
Hospital region				<0.001
Northeast	17.34%	18.18%	12.83%	
Midwest	23.37%	25.51%	11.82%	
South	37.19%	36.58%	40.45%	
West	22.10%	19.72%	34.90%	
Weekend admission	28.55%	28.59%	28.33%	0.75
Weekend PCI	19.07%	19.33%	17.67%	0.02
RN per 1000 inpatient days	4.4%	4.4%	4.5%	0.02
No MCS/LVAD	44.58%	44.33%	45.95%	0.07

SNH = safety-net hospital.
Anemia- ICD-9-CM codes: 280.1-281.9, 285.21-285.29, 285.9.
Obesity- ICD-9-CM codes: 278.0, 278.00, 278.01.
Definition of bedsize.
Rural: small 1 to 49, medium 50 to 99, and large ≥100.
Urban, nonteaching: small 1 to 99, medium 100 to 199, and large ≥200.
Urban, teaching: small 1 to 299, medium 300 to 499, large ≥500.

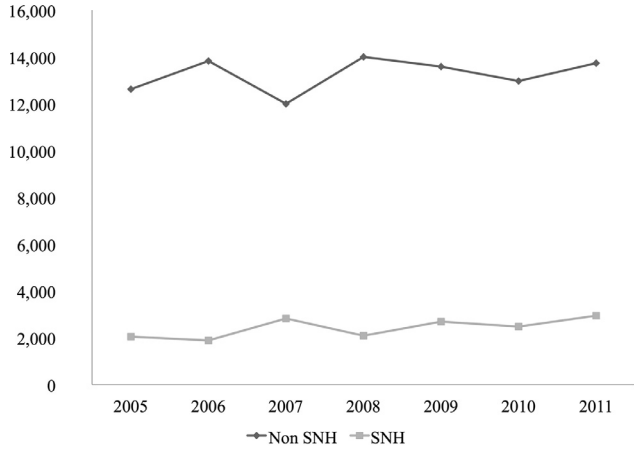

Figure 1. Trends in STEMI-CS admissions over the study period between SNHs and non-SNHs. SNH = safety-net hospital.

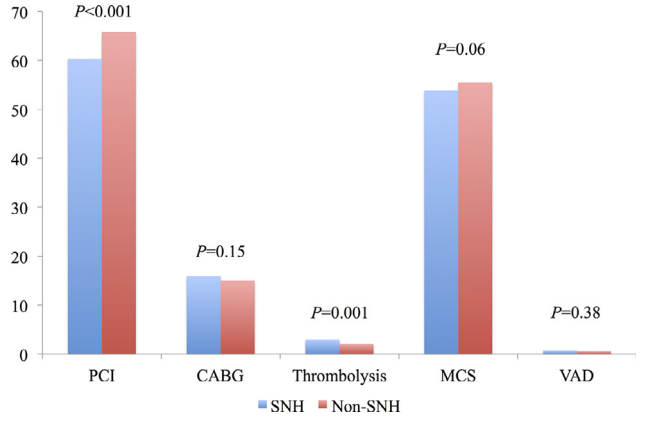

Figure 3. Incidence of in-hospital clinical events between SNHs and non-SNHs. CABG = coronary artery bypass graft, MCS = mechanical circulatory support, PCI = percutaneous coronary intervention, SNH = safety-net hospital; VAD = ventricular assist device.

Our study adds to the literature that outcomes of STEMI-CS admitted at SNHs were worse compared with outcomes at non-SNHs. The treatment strategies differed and are likely one of the reasons for higher mortality in SNHs as invasive revascularization is preferred over thrombolysis in STEMI-CS.[19] Timely PCI is the most effective treatment for STEMI-CS. Our results have suggested lower utilization of PCI but increased trend of admissions of STEMI-CS to SNHs. Therefore, to increase the rate of primary PCI at SNH could be a very effective measure to improve outcomes at SNHs. From the National Cardiovascular Disease Research analysis, PCI at SNHs had higher in-hospital mortality rate (1.9% vs 1.5%, $p < 0.001$), which remained significant in subgroup analysis of acute coronary syndromes.[20] This means that even when patients receive PCI for acute coronary syndromes, outcomes were worse at SNHs. This implicates that care at SNHs other than primary PCI rate had negative effects on outcomes such as fewer nursing staff and less availability of interventional cardiologists. SNHs had lower adherence to quality-of-care performance measures for acute myocardial infarction compared with non-SNHs and this is potentially another reason for higher mortality in SNHs.[21] Use of MCS was similar in both hospitals but MCS devices have failed to improve clinical outcomes in the treatment of CS.[22] Recently, early use of Impella CP device in acute myocardial infarction complicating CS was associated with better early and 1-year survival.[23] Therefore, expertise and experience with MCS may result in better outcomes in STEMI-CS.

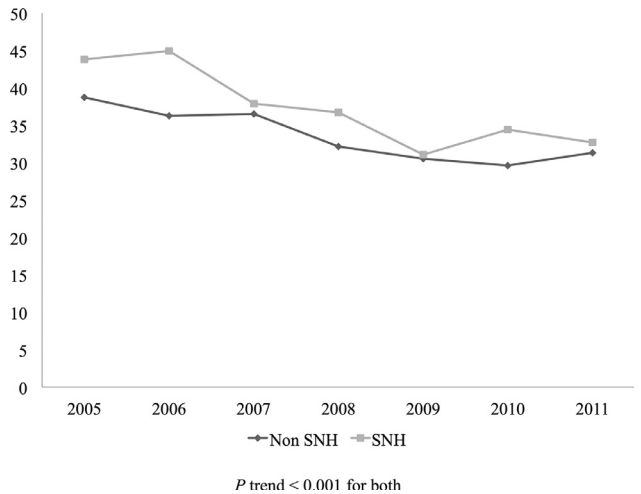

Figure 2. National trends in in-hospital mortality during the study period in SNHs and non-SNHs. SNH = safety-net hospital.

There was an increasing trend of STEMI-CS admitted to SNHs whereas it was similar at non-SNHs, implicating an important role of SNHs in care for STEMI-CS. SNHs had lower improvement in composite acute myocardial infarction performance compared with non-SNHs[24] but we demonstrated a substantial decrease in mortality in both SNHs and non-SNHs. There were no changes in inpatient care use after the insurance expansion program in Massachusetts compared with 3 other states that reform did not happen in both SNHs and non-SNHs, suggesting the continued important role of SNHs in the community.[25] The pre- and postdischarge care of safety-net providers were similar to that of nonsafety-net providers and is reassuring as STEMI-CS patients would be especially at high risk of readmission and benefit from close follow-up.[26,27]

The limitations of our study are the followings: first, the use of administrative databases is subject to incorrect coding resulting in under or overestimation of incidences of disease, co-morbidities, and outcomes. Second, because of the retrospective and observational design of this analysis, variables not adjusted for or not captured in the ICD-9-CM codes could affect our results. Third, the data were from 2005 to 2011 and whether study outside this period is similar to our analysis needs further study. Lastly, measures such as door-to-balloon time and timing of presentation that could affect revascularization strategy and survival were unknown.

SNHs had lower utilization of PCI and higher in-hospital mortality compared with non-SNH in STEMI-CS. Further cause analysis is warranted to improve outcomes of STEMI-CS admitted at SNHs.

Table 2
Clinical outcomes, length of stay, and hospitalization cost

	Non-SNH	SNH	aOR (95% CI)	p Value
Mortality	32.71%	36.64%	1.24 (1.10, 1.39)	0.001
Acute kidney injury requiring dialysis	3.15%	3.93%	1.27 (0.99, 1.62)	0.09
Stroke	0.35%	0.29%	0.83 (0.33, 1.96)	0.67
Ventricular fibrillation or cardiac arrest	29.48%	30.17%	1.05 (0.94, 1.20)	0.32
Non-routine home discharge	48.61%	49.45%	1.04 (0.92, 1.15)	0.58
Length of stay, median (Q1, Q3)	7 (3, 13)	6 (3, 13)	-	0.58
Cost, median (Q1, Q3)	38,012 (23,112, 67,271)	40,175 (22,431, 72,379)	-	0.01

aOR = adjusted odds ratio; CI = confidence interval; SNH = safety-net hospital.

Disclosures

The authors have no conflicts of interest to disclose.

Supplementary materials

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.amjcard.2019.05.037.

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