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Clinical paper

Regional trends in In-hospital Cardiac Arrest following sepsis-related admissions and subsequent mortality

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Abstract

Background: Previous studies have reported regional variation in either the incidence or outcomes of sepsis or In-hospital Cardiac Arrest (IHCA) discretely; however, regional variations in the incidence and outcomes of sepsis-associated IHCA (SA-IHCA) have never been studied.

Methods: From the National Inpatient Sample (NIS), discharges with sepsis and sepsis-associated IHCA were identified in 4 geographic regions (Northeast, Midwest, South, West) from 2007 to 2014 using applicable ICD-9-CM codes. We assessed the regional incidence and trends in SA-IHCA and subsequent inpatient outcomes.

Results: Out of 8,058,091 sepsis-related admissions, 187,163 (2.3%) were associated with IHCA with a rising trend in the incidence from 2007- to 2014 (2.0% to 2.6%, $p_{trend} < 0.001$). The overall incidence of SA-IHCA was highest in South (2.6%) with the highest mortality in West (74.4%) ($p < 0.001$). The incidence of SA-IHCA increased in the South (2.4%–3.0%) and Midwest (1.6%–2.4%) from 2007 to 2014. Mortality has not significantly increased or decreased across all regions. Compared with the West, survivors in the Northeast, Midwest, and the South were less likely to be discharged home and were more likely to be transferred to other facilities. In the SA-IHCA cohort, the mean length of stay for SA-IHCA was highest in Northeast (10.9 days) and lowest in Midwest (8.6 days) ($p < 0.001$). Hospital charges were highest in the West ($234,278) and lowest in the Midwest ($125,725) ($p < 0.001$).

Conclusion: This nationwide analysis demonstrates that the highest incidence of SA-IHCA is in the Southern region of the US whereas the associated in-hospital mortality was highest in the West. The incidence of SA-IHCA is rising in the Midwest and South from 2007 to 2014. Despite significant advances in the treatment of sepsis and IHCA, there has been no significant improvement in the incidence of SA-IHCA and subsequent survival in any US geographic region from 2007 to 2014.

Keywords: Sepsis, Septicemia, Septic shock, In-hospital Cardiac Arrest (IHCA), Trends, Regional/geographic variation, Mortality

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Introduction

In the United States, nearly 200,000 hospitalized adult patients suffer from an In-hospital Cardiac Arrest (IHCA) each year. Among these patients with IHCA, the survival rate has been estimated at around 20%.[1–3] The prevalence of IHCA among adult hospitalizations has been measured from 13 to 27% in previous studies.[4–6] Sepsis is the leading cause of death in critically ill patients.[7] Sepsis-induced vasodilation, hypovolemia, myocardial dysfunction, hypoxemia, acidosis, and metabolic derangements are possible contributors to the development of IHCA and can also disrupt the successful return of spontaneous circulation (ROSC) in these patients.[8] It has been well established that patients with sepsis-associated IHCA (SA-IHCA) demonstrate worse outcomes as compared to patients with IHCA without sepsis.[5,6]

While prior studies have evaluated regional variations in the outcomes of patients with IHCA and OHCA (out of hospital cardiac arrest),[9,10] regional variations in the outcomes of SA-IHCA have not been examined. It is important to understand the regional patterns of disease to identify differences in patient characteristics, health behaviors, healthcare resource utilization rates, and hospital outcomes.[9,11] Identifying the spatial pattern of the incidence of SA-IHCA and associated outcomes may provide insight into factors that portend a poor prognosis and may help to identify healthcare disparities in the management of sepsis or IHCA. [12] In this study, our objective is to assess regional trends in the incidence and in-hospital outcomes of encounters with SA-IHCA utilizing a nationally representative inpatient database from 2007 to 2014. We also explore regional differences in resource utilization rates, patient and hospital-level demographic characteristics, and medical comorbid conditions in encounters with SA-IHCA during this period.

Methods

Our study cohort was acquired from the National Inpatient Sample (NIS) databases (2007–2014), one of the largest all-payer inpatient healthcare datasets in the United States. The NIS is a part of the Healthcare Cost and Utilization Project (HCUP), financed by the Agency for Healthcare Research and Quality (AHRQ). Each year of the NIS dataset comprises more than 7 million unweighted and almost 35 million weighted hospital stays. Weighted discharge data represents 97% US population and is sampled from 20% of inpatient stays of all nonfederal US community hospitals (rehabilitation and long-term acute care hospitals are excluded). Institutional review board permission was not required to publish this de-identified data, which is publicly available.[13]

We identified a primary discharge diagnosis of sepsis by using the applicable clinical classifications software (CCS) code. CCS codes incorporate multiple associated International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9 CM) codes into smaller, more clinically meaningful classes.[14] The selected ICD-9 codes were utilized in previously published studies.[9] We then identified IHCA from any of the secondary discharge diagnoses using the ICD-9 CM codes 427.5 [cardiac arrest], 427.1 [ventricular tachycardia], 427.41 [ventricular fibrillation] or 427.42 [ventricular flutter]) or procedure codes for cardiopulmonary resuscitation (ICD-9-CM codes 99.60, 99.63) detailed elsewhere.[15]

We compared the demographics, hospital-related characteristics, and medical comorbidities in SA-IHCA hospital encounters among 4 geographic regions (the Northeast, Midwest, South, and West). The primary outcomes were the incidence and trends in SA-IHCA and subsequent in-hospital mortality across all 4 regions. The secondary outcomes explored differences in encounter characteristics (demographic and medical comorbid conditions in the patient, and healthcare resource utilization rates (as measured by discharge disposition, mean length of stay in days, and hospitalization charges) associated with hospital encounters with SA-IHCA across all 4 geographic regions.

SPSS version 22 (IBM Corp, Armonk, NY, USA) was used for all statistical analyses and maps were prepared using ArcGIS Release version 10.3. Continuous and categorical variables were analyzed by Student's t-test and Pearson's chi-square test, respectively. Continuous and categorical variables were displayed as mean ± standard deviation (SD) and percentages, respectively. A two-tailed p-value ≤ 0.05 was taken as statistically significant. Trends were analyzed by the Mann-Kendall trend test and/or linear-by-linear association test.

Results

A total of 8,058,091 sepsis-related admissions from 2007 to 2014 were included in the final analysis. Of these, 187,163 (2.3%) admissions were associated with IHCA with a rising trends in incidence from 2007 to 2014 (2.0% to 2.6%, $p_{trend} < 0.001$). The overall incidence of IHCA among all sepsis-related admissions was highest in the South (2.6%) followed by West (2.4%), Midwest (2.1%) and Northeast (2.0%) ($p < 0.001$) (Fig. 1a). Fig. 1b displays the in-hospital mortality following

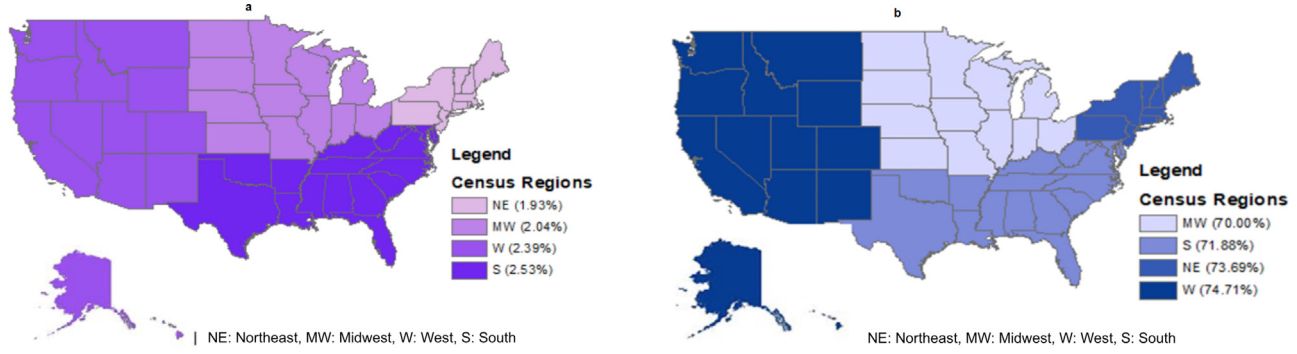


Fig. 1 – Regional variation in sepsis-associated in-hospital cardiac arrest and inpatient mortality.
(a) Regional variation in sepsis-associated in-hospital cardiac arrest.
(b) Regional variation in inpatient mortality following sepsis-associated in-hospital cardiac arrest.

SA-IHCA, which was highest in the West (74.4%) followed by Northeast (73.2%) ($p < 0.001$).

Fig. 2 shows regional trends in SA-IHCA and associated inpatient mortality, respectively. The incidence of SA-IHCA increased in the South (2.2%–3.0%; $p = 0.006$) and the Midwest (1.6% to 2.4%; $p = 0.005$) from 2007 to 2014 (Fig. 2a). There was no significant change in inpatient mortality following SA-IHCA from 2007 to 2014 (Fig. 2b).

From 2007 to 2014, we identified 187,163 SA-IHCA stratified by hospital geographic region; Northeast, Midwest, South, and West. 78,712 (42.1%) patients were hospitalized in the South, 42,446 (22.7%) in the West, 36,393 (19.4%) in the Midwest, and 29,612 (15.8%) in the Northeast. Patients in the Northeast region had a mean age of 69.8 ± 15.3 years, which was higher than the mean age of the overall cohort (67.4 ± 15.6 years). A male predominance was seen across all 4 regions. In comparison to the overall cohort, the Midwest region had a higher proportion of whites (69.5% vs. 62.3%), and the South had a higher proportion of African Americans (25.5% vs. 20.1%). As compared to other geographic regions, the West had the greatest proportion of encounters with Hispanic (19.6% vs. 10.2%) and Asian or Pacific Islander (10.0% vs. 3.4%) patients. The proportion of Medicare beneficiaries was lowest in the Western region (61.7% vs. 66.3%) as compared to the overall cohort, whereas the proportion of Medicaid beneficiaries was the highest in the West (15.8% vs. 11.9%). In the South, 44.4% of encounters had a median household income in the lowest quartile, as compared to only 20.7% in the West. Encounters in the Northeast were associated with the highest proportion of median household incomes in the first quartile (31.3%). The greatest proportion of hospital encounters were non-elective admissions to large urban teaching hospitals, except for the West, where there the greatest proportion of encounters with SA-IHCA were in large urban non-teaching hospitals (59.5% vs. 37.2%). The p value for all of these interactions is <0.001 (Table 1).

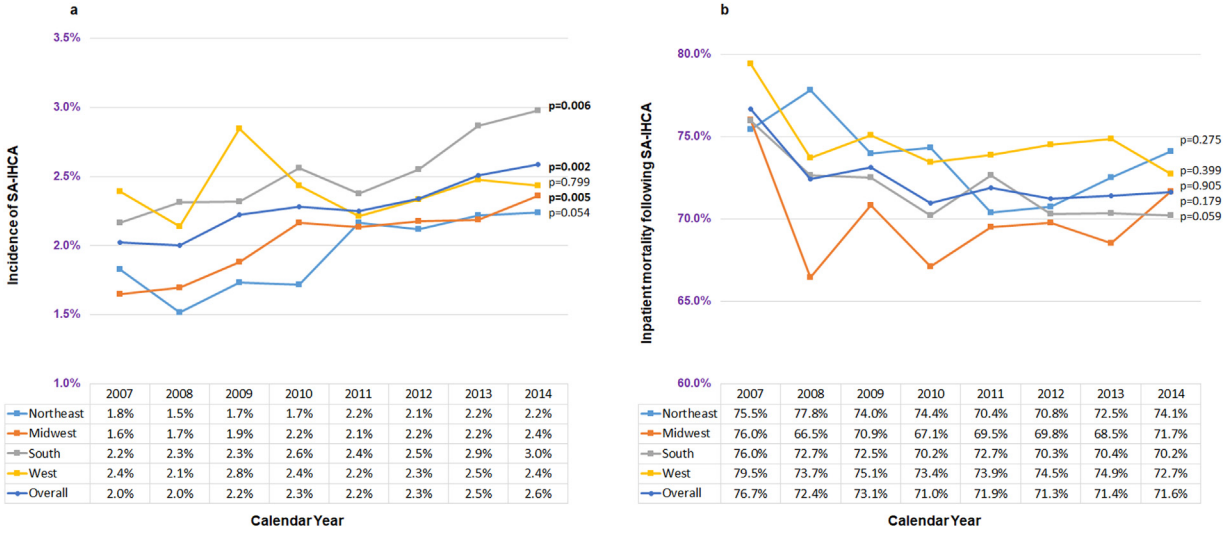
With respect to medical comorbid conditions, the highest prevalence of smoking, obesity, fluid/electrolyte disorders, and cardiopulmonary disease was observed in the Midwest, where there was the lowest prevalence of septic shock. Patients in the West had the highest prevalence of end-organ dysfunction associated with sepsis as compared to other regions. The prevalence of alcohol and drug abuse was also notably higher in the West than in other regions.

Overall in-hospital mortality was 72.1% for the study cohort, with the highest and lowest rates of mortality observed in the West (74.4%) and Midwest (69.9%), respectively. The use of therapeutic hypothermia for hospital encounters with SA-IHCA was lowest in the South and highest in the West (0.5% vs.1.2%, respectively). Compared with the West, survivors of SA-IHCA in the Northeast, Midwest, and South were less likely to have a routine discharge disposition (e.g. discharge home or to another short-term hospital). The mean length of stay was highest in the Northeast (10.9 days) and lowest in the Midwest (8.6 days). Total hospital charges incurred per admission for SA-IHCA were highest in the West ($234,278) and the lowest in the Midwest ($125,725). All p-values were <0.001 (Table 2).

Discussion

The present study demonstrates substantial geographic variation in the incidence and outcomes of hospital encounters with SA-IHCA. To the best of our knowledge, this is the first study to investigate regional trends in the incidence and outcomes of hospital encounters with SA-IHCA using a nationally representative sample. We found the highest incidence of encounters with SA-IHCA in the South and the highest associated in-hospital mortality in the West. We observed an upward trend in the incidence of encounters with SA-IHCA in the Midwest and South. Despite advances in the identification and treatment of sepsis and in-hospital cardiac arrest, the overall mortality of patients in the United States with SA-IHCA did not improve from 2007 through 2014.

Most of the hospital encounters with SA-IHCA were for white patients in every region. The Western region had the highest proportion of encounters with Hispanic, Asian or Pacific Islander, and Native American patients. Encounters in the South were by and far associated with the lowest median household income. We also found that the greatest number of encounters for SA-IHCA were at non-teaching facilities in the West as compared to other geographic regions, where encounters were most commonly at teaching facilities. With respect to resource utilization, the Midwest had the lowest cost of



	2007	2008	2009	2010	2011	2012	2013	2014
Northeast	1.8%	1.5%	1.7%	1.7%	2.2%	2.1%	2.2%	2.2%
Midwest	1.6%	1.7%	1.9%	2.2%	2.1%	2.2%	2.2%	2.4%
South	2.2%	2.3%	2.3%	2.6%	2.4%	2.5%	2.9%	3.0%
West	2.4%	2.1%	2.8%	2.4%	2.2%	2.3%	2.5%	2.4%
Overall	2.0%	2.0%	2.2%	2.3%	2.2%	2.3%	2.5%	2.6%

	2007	2008	2009	2010	2011	2012	2013	2014
Northeast	75.5%	77.8%	74.0%	74.4%	70.4%	70.8%	72.5%	74.1%
Midwest	76.0%	66.5%	70.9%	67.1%	69.5%	69.8%	68.5%	71.7%
South	76.0%	72.7%	72.5%	70.2%	72.7%	70.3%	70.4%	70.2%
West	79.5%	73.7%	75.1%	73.4%	73.9%	74.5%	74.9%	72.7%
Overall	76.7%	72.4%	73.1%	71.0%	71.9%	71.3%	71.4%	71.6%

Fig. 2 – Regional trends in sepsis-associated in-hospital cardiac arrest and inpatient mortality.
(a) Regional trends in sepsis-associated in-hospital cardiac arrest.
(b) Regional trends in inpatient mortality following sepsis-associated in-hospital cardiac arrest.

Table 1 – Baseline characteristics of in-hospital cardiac arrest secondary to sepsis-related admissions stratified by hospital region.

Variable	Northeast (n = 29,612)	Midwest (n = 36,393)	South (n = 78,712)	West (n = 42,446)	Overall (n = 187,163)	P[a]
Age (years) at admission						
Mean age ± SD	69.8 ± 15.3	67.3 ± 15.3	66.7 ± 15.5	67.3 ± 15.9	67.4 ± 15.6	<0.001
18–44	6.4%	7.9%	8.6%	8.6%	8.1%	
45–64	27.8%	32.5%	33.2%	32.1%	31.9%	
≥65	65.8%	59.6%	58.2%	59.3%	59.9%	
Sex						<0.001
Male	51.8%	51.8%	51.4%	53.5%	52.0%	
Female	48.2%	48.2%	48.6%	46.5%	48.0%	
Race						<0.001
White	67.2%	69.5%	60.9%	56.4%	62.3%	
African American	18.0%	23.1%	25.5%	9.8%	20.1%	
Hispanic	6.6%	2.6%	9.4%	19.6%	10.2%	
Asian or Pacific Islander	2.3%	1.1%	1.1%	10.0%	3.4%	
Native American	0.2%	0.5%	0.6%	1.3%	0.7%	
Other	5.7%	3.1%	2.5%	2.9%	3.2%	
Primary expected payer						<0.001
Medicare[b]	69.7%	67.8%	66.8%	61.7%	66.3%	
Medicaid[c]	10.9%	11.2%	10.4%	15.8%	11.9%	
Private including HMO[d]	15.4%	15.9%	14.5%	15.0%	15.0%	
Self-pay	2.6%	3.0%	5.4%	4.4%	4.3%	
No charge	0.1%	0.2%	0.5%	0.2%	0.3%	
Others	1.3%	1.8%	2.4%	2.9%	2.2%	
Median household income						<0.001
0–25th	23.4%	32.5%	44.4%	20.7%	33.4%	
26–50th	21.5%	30.4%	25.9%	25.6%	26.0%	
51–75th	23.8%	24.2%	17.5%	28.6%	22.3%	
76-100th	31.3%	12.9%	12.2%	25.1%	18.2%	
Type of admission						<0.001
Non-elective	98.2%	95.4%	94.8%	97.4%	96.1%	
Elective	1.8%	4.6%	5.2%	2.6%	3.9%	
Bed size of hospital						<0.001
Small	16.0%	11.9%	10.5%	10.5%	11.6%	
Medium	31.2%	22.2%	27.7%	24.9%	26.5%	
Large	52.8%	65.9%	61.8%	64.6%	61.8%	
Location/teaching status of hospital						<0.001
Rural	5.2%	8.9%	11.4%	3.3%	8.1%	
Urban – non teaching	28.9%	31.1%	40.1%	59.5%	41.0%	
Urban – teaching	65.9%	59.9%	48.4%	37.2%	50.9%	

p-Values <0.05 indicates statistical significance. "Medicare" and "Medicaid", both are types of health coverage funded by federal US government that provides health coverage for US people who are 65+ or under 65 with disability and US people with very low income, respectively.
Abbreviations: [d]HMO = Health Maintenance Organization.

hospital care with the shortest length of hospital stay but had the highest rate of transfer to skilled nursing facilities (SNF), intermediate care facilities (ICF) or other facilities.

Previous studies have demonstrated a disproportionately large number of hospitalizations in the South for either sepsis or IHCA, though regional differences in the rate of SA-IHCA had not been previously characterized.[9,16] Although reasons for such regional variations are not clearly understood, possible explanations could be variations in patient demographics, comorbid conditions, and differences in hospital characteristics.[9,17] A recent study has shown substantial regional variation in behavioral cardiovascular risks including smoking, poor diet and physical activity, as well as differences in the rates of diagnostic cardiac catheterization and revascularization.[18]

The rate of non-routine discharge disposition (e.g. to SNF, ICF, and other facilities) was highest in whites and Medicare enrollees from smaller, urban teaching hospitals in the Midwest and Northwest, consistent with the findings of prior studies.[19] A possible reason for the higher rate of non-routine disposition at discharge in these regions may be that the patient population had a greater severity of illness, as evidenced by a higher rate of non-elective admissions, multi-organ dysfunction associated with sepsis or septic shock, and a higher prevalence of cardiopulmonary comorbid conditions. Numerous studies have reported increased sepsis-related mortality with chronic alcoholism and opioid use,[20,21] and among heroin users due to subcutaneous, intradermal and intramuscular injection site infections in the Western US.[22] Interestingly, encounters with SA-IHCA in the Western region of the US had higher rates of comorbid alcohol and

Table 2 – Comorbidities and outcomes in in-hospital cardiac arrest secondary to sepsis-related admissions stratified by hospital region.

Comorbidities	Northeast (N = 29,612)	Midwest (N = 36,393)	South (N = 78,712)	West (N = 42,446)	Overall (N = 187,163)	*p*
Alcohol abuse	4.5%	6.3%	5.8%	8.3%	6.3%	<0.001
Smoking	11.1%	19.3%	16.2%	17.2%	16.2%	<0.001
Deficiency anemias	19.1%	30.5%	28.1%	33.1%	28.3%	<0.001
Chronic blood loss anemia	0.8%	1.5%	1.4%	1.5%	1.3%	<0.001
Congestive heart failure	31.4%	35.0%	31.6%	31.8%	32.3%	<0.001
Chronic pulmonary disease	23.0%	29.2%	25.5%	24.4%	25.6%	<0.001
Coagulopathy	18.7%	22.7%	22.2%	26.0%	22.6%	<0.001
Depression	5.3%	9.0%	6.6%	6.8%	6.9%	<0.001
Diabetes, uncomplicated	22.1%	27.0%	26.4%	25.4%	25.6%	<0.001
Diabetes with chronic complications	6.7%	9.4%	8.7%	11.5%	9.2%	<0.001
Drug abuse	2.5%	2.7%	2.9%	5.6%	3.4%	<0.001
Hypertension	46.7%	57.6%	54.9%	54.1%	53.9%	<0.001
Liver disease	6.4%	6.4%	7.4%	10.4%	7.7%	<0.001
Fluid and electrolyte disorders	64.9%	73.4%	71.4%	71.4%	70.8%	<0.001
Obesity	7.7%	13.4%	11.4%	11.1%	11.1%	<0.001
Peripheral vascular disorders	9.2%	12.4%	12.0%	12.3%	11.7%	<0.001
Pulmonary circulation disorders	6.9%	9.4%	8.2%	8.4%	8.3%	<0.001
Renal failure	26.5%	32.9%	31.3%	32.1%	31.0%	<0.001
Valvular heart disease	8.2%	8.8%	7.9%	8.6%	8.3%	<0.001
Dyslipidemia	16.8%	22.8%	19.0%	20.0%	19.6%	<0.001
Previous MI PCI CABG	8.9%	11.0%	9.8%	11.1%	10.2%	<0.001
Acute myocardial infarction	16.0%	14.2%	15.4%	13.9%	14.9%	<0.001
Atrial fibrillation	24.5%	27.4%	22.7%	24.4%	24.3%	<0.001
VF/VT	19.7%	20.5%	19.5%	19.6%	19.7%	0.001
Sepsis without organ dysfunction	16.2%	18.4%	18.3%	14.6%	17.2%	<0.001
Sepsis with acute/multiple organ dysfunction	69.2%	66.8%	67.7%	77.8%	70.0%	<0.001
Septic shock	61.5%	56.9%	57.3%	62.0%	58.9%	<0.001
Intubation/mechanical ventilation	82.3%	82.2%	83.1%	83.0%	82.8%	<0.001
Prior history of sudden cardiac arrest	0.3%	0.5%	0.4%	0.4%	0.4%	<0.001
Outcomes						
All-cause In-hospital mortality	73.2%	69.9%	71.4%	74.4%	72.1%	<0.001
Therapeutic hypothermia	1.1%	1.0%	0.5%	1.2%	0.9%	<0.001
Extracorporeal membrane oxygenation	0.3%	0.2%	0.1%	0.1%	0.2%	<0.001
Disposition of patient						<0.001
Routine	2.4%	3.5%	4.1%	4.7%	3.8%	
Transfer to short-term Hospital	3.0%	2.7%	2.8%	3.8%	3.0%	
Other transfers (SNF, ICF, Another facility)	17.7%	20.2%	17.7%	13.4%	17.2%	
Home health care	3.5%	3.2%	3.7%	3.2%	3.4%	
Length of stay (days) *Mean ± SD*	10.9 ± 18.3	8.6 ± 11.6	9.1 ± 14.4	9.3 ± 15.1	9.4 ± 14.8	<0.001
Total hospital charges (mean)	$203,041	$125,725	$151,793	$234,278	$179,421	<0.001

p-Values <0.05 indicates statistical significance. HMO = Health Maintenance Organization, MI = myocardial infarction, PCI = percutaneous coronary intervention, CABG = coronary artery bypass grafting, VF = ventricular fibrillation, VT = ventricular tachycardia, SNF = skilled nursing facility, ICF = intermediate care facility.

drug use disorders, possibly accounting in part for the higher in-hospital mortality observed in the West. Other possibilities to account for the higher mortality rate observed in the West include differences in hospital characteristics, which were less likely to be teaching facilities. Also of interest was a higher rate of therapeutic hypothermia used in the West as compared to other regions, the use of which may potentially be harmful in patients with sepsis.[23,24] Among a number of other potential contributing factors, the lower mortality observed in the Midwest as compared to other regions may in part be attributable to its high smoking prevalence, as smoking may be a protective factor in patients who experience IHCA – the so called "smoker's paradox".[25] However, this phenomenon is not well-established and remains contentious.[26]

Another interesting observation was the regional variation in resource utilization in SA-IHCA. We found that both all-cause mortality and total cost of care were highest in the West and lowest in the Midwest region, while the disposition of patients as transfer to other facilities (SNF, ICF, and others) was highest in the Midwest and lowest in the West region. While the average cost of in-hospital care is known to be highest in the Western US and lowest in the Midwest, the staggering difference in cost for encounters with SA-IHCA observed in the present study is worth noting ($234,278 vs $125,725).[9,27] The increase in non-routine discharge disposition may be in part related to the lower mortality observed in the Midwest, as patients surviving IHCA can be surmised to require greater care at discharge.

Interestingly, previous studies have shown the greatest incidence of sepsis and sepsis-related mortality in the Southern US,[11,28] with the highest primary-IHCA related mortality in the Northeast.[9] These studies also pointed out possible differences in cardiovascular risk factors, including medical comorbidities, lifestyle, diet, socioeconomic status, genetics, and medication adherence that could account for the findings. In our study, the higher mortality among hospitalizations for SA-IHCA in the West could be attributable to its higher proportion of minority populations, who are known to have a generally poorer prognosis with a higher rate of multiple organ dysfunction with sepsis.[17,29] Variations in sepsis treatment protocols, availability of nursing and other ACLS/BLS trained staff, and other regional differences in hospital-specific standards and protocols may also account for some of the observed differences in patient outcomes.[2,30–33]

The observations in the present study draw attention to prevailing regional discrepancies in the current state of severe sepsis care, resuscitation practice, and cardiac emergency protocols in the United States. The 2018 CMS Medicare data on hospital compare showed that only 51% of patients received appropriate care for severe sepsis and septic shock, with substantial variations in hospital protocols and priorities across US regions.[34] The Surviving Sepsis Campaign consensus guidelines outline the optimal clinical approaches, treatment protocols, and antibiotic usage in sepsis.[35] However, how the care should be organized and implemented in the clinical setup is missing. Furthermore, state laws regarding AEDs and their use in hospitals vary across the US,[36] though some research suggests that the use of AEDs in hospitals may result in decreased survival rates from cardiac arrest.[37] In addition, regional variation in evidence-based practices, physicians' behavior, and cardiologists' propensity to test and treat partly influence noticed variation in the cardiac arrest outcomes across the states.[38,39] Identifying the multitude of factors that account for the regional differences in the incidence and outcomes of SA-IHCA can allow for focused interventions by policymakers and healthcare providers to help reduce these observed disparities.

Our study also has several limitations. First, given the administrative nature of the NIS, the accuracy and consistency of collected data is highly dependent on the expertise of medical coders and the data management capabilities of individual hospitals. Second, there are discrepancies in applying ICD-9-CM code for a diagnosis of IHCA and it is not possible to prove a direct causal relationship between sepsis and IHCA due to the nature of NIS data.[1,9,15] Third, increased clinical and political awareness with campaigns like Surviving Sepsis (SSC) could impact the overall estimation of sepsis.[40] Fourth, overestimation of IHCA incidence is possible due to inconsistent coding of CPR or use of defibrillators. Fifth, NIS data does not collect data on patient and family preference on end of life care, Do-not-Resuscitate (DNR) status or timing of DNR. It is possible that patients with DNR orders for whom no treatments are attempted may also be coded under in-hospital cardiac arrest, which could be varied by the systemic difference in regional and hospital use of DNR order.[41]

Conclusion

Using a population-based nationwide cohort, we observed the highest incidence of SA-IHCA in South with the highest subsequent in-hospital mortality in West. The incidence of SA-IHCA is rising in the Midwest and South. Despite significant improvements in healthcare access and delivery, the incidence and mortality associated with SA-IHCA did not improve in the US from 2007 through 2014. Future research should assess the factors affecting sepsis-associated IHCA and the observed regional disparities in outcome.

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Conflict of interest

The authors report no relationships that could be construed as a conflict of interest.

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