Open Access Emergency Medicine

Dovepress
open access to scientific and medical research

Open Access Full Text Article

ORIGINAL RESEARCH

Nationwide trends of clinical characteristics and economic burden of emergency department visits due to acute ischemic stroke

This article was published in the following Dove Press journal:
Open Access Emergency Medicine
19 September 2017
Number of times this article has been viewed

Mark Stuntz
Katsiaryna Busko
Shumaila Irshad
Taylor Paige
Veranika Razhkova
Tim Coan

Deerfield Institute, New York, NY, USA

Abstract: We aimed to provide estimates of the volume and associated charges of acute ischemic stroke (AIS) visits in the US, as well as to assess predictors of patient disposition following an emergency department (ED) visit for AIS. Our study was conducted using the 2010–2013 data from the Nationwide Emergency Department Sample. We identified adult visits with AIS as the primary diagnosis. A generalized linear model was used to calculate mean charges per visit after adjusting for covariates. Multinomial logistic regression was used to assess predictors of patient disposition following an ED visit for AIS. The national incidence did not appreciably change over time, increasing from 26.4 to 27.0 visits per 10,000 adults. Adjusted mean charges per event were highest in the West, increasing from $3,761 in 2010 to $4,575 in 2013. Multinomial logistic regression showed that older age was associated with increased likelihood of both hospital admission and mortality in the ED, while male sex was associated with lower odds of mortality in the ED. Despite improvements in primary and secondary prevention of cardiovascular disease, AIS remains a significant burden on the health care system with a high volume of ED visits and increasing charges for care.

Keywords: epidemiology, ischemic, stroke, patient disposition, hospital charges

Introduction

Stroke is a major burden in the US from both health and economic perspectives, with over 5,000,000 survivors and approximately 795,000 people experiencing a new or recurrent episode each year.[1,2] Stroke mortality remains high, despite recent reports of declining incidence among adults 65 years and older.[3–5] According to the National Center of Health Statistics (NCHS), stroke was the fifth leading cause of death in 2014.[6]

Approximately 87% of strokes in the US are acute ischemic strokes (AISs), where an interruption of blood flow to the brain results in central nervous system infarction accompanied by overt symptoms.[1,7] As a debilitating disease associated with significant morbidity and health care utilization, AIS has been the focus of numerous studies on inpatient hospitalization trends. According to recent published findings, there was an 18.4% decrease in the age-adjusted hospitalization rate of AIS from 2000 to 2010.[8] Furthermore, a trend toward a decrease in AIS hospital mortality has been reported,[3,8] potentially indicating an improvement in acute stroke care.

The mean lifetime cost of ischemic stroke per person, which includes inpatient care, rehabilitation, and follow-up care, is estimated at $140,048 in the US.[9] The American Heart Association projects the total cost of stroke, which encompasses both direct and indirect spending, to increase from $105.2 billion in 2012 to $240.7 billion by 2030.[10]

Correspondence: Mark Stuntz
Deerfield Institute, 780, Third Avenue, 37th Floor,
New York, NY 10017, USA
Tel +1 212 583 7268
Email mstuntz@deerfield.com

submit your manuscript | www.dovepress.com
Dovepress
http://dx.doi.org/10.2147/OAEM.S146654

Historically, studies examining stroke economic burden have primarily focused on in-hospital costs that follow after a patient gets admitted to a hospital,[11] while emergency department (ED) expenditure was predominantly overlooked. To our knowledge, there are no published studies examining ED charges or costs due to AIS, and the sole publication on the volume of ED visits for ischemic stroke is a NCHS data brief, showing a decrease in ED visits from 2001 to 2011.[12] However, this study was based on National Hospital Ambulatory Medical Care Survey data with a relatively small sample size, possibly providing inaccurate, extrapolated national estimates, particularly when stratified by relevant demographic characteristics.[13] In addition, no analyses were performed assessing charges or predictors of outcome following an ED visit for AIS.

Since early critical care is one of the drivers of AIS hospitalization costs that follow an ED visit, there is a need for a comprehensive analysis of recent ED trends to quantify the full economic burden of AIS. The aims of this study were to describe the recent trends in the volume and economic burden of ED visits for AIS from 2010 to 2013 in the US, as well as to assess patient, hospital, and clinical characteristics as predictors of patient disposition following an ED visit for AIS.

Methods

Data source

This study utilized the 2010–2013 discharge data from the Nationwide Emergency Department Sample (NEDS), provided by the Agency for Healthcare Research and Quality's Healthcare Cost and Utilization Project (HCUP).[14] The NEDS is the largest publicly available all-payer ED database in the US. Data for each year contain information from approximately 30 million ED visits, representing a 20% stratified sample of US hospital-based ED visits. Sampling weights are included for calculating national estimates.

Study population

Diagnosis information was identified using HCUP's Clinical Classifications Software (CCS), based on the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM), coding system. We classified AIS-related visits among adults 18 years and older using CCS codes 109 (acute cerebrovascular disease) or 110 (occlusion or stenosis of precerebral arteries) as the primary diagnosis. These codes have been shown to have a sensitivity of 84% in identifying AIS.[15]

We also identified specific procedures of interest performed in the ED. Infusion of tissue plasminogen activator (tPA) was examined using ICD-9-CM code 99.10 and Current Procedure Terminology (CPT) codes 37195, 37211, 37212, 37213, and 37214. Computed tomography (CT) scans of the head were also identified based on ICD-9-CM code 87.03 and CPT codes 70450, 70460, 70470, and 70496.

Data analysis

National and regional incidence rates of ED visits for AIS were calculated by dividing the annual weighted number of visits by the appropriate population on July 1 using estimates from the US Census Bureau's American FactFinder database,[16] and the results were expressed as ED visits per 10,000 adults. A generalized linear model was used to calculate mean hospital charges per ED visit for AIS by payer and hospital geographic region, after adjusting for covariates. Aggregate and mean ED charges for each year were adjusted to 2013 US dollars using the Medical Consumer Price-Hospital Services Index.

Multinomial multivariate logistic regression was used to assess predictors of patient disposition following an ED visit for AIS (hospital admission, transfer to another hospital, or mortality in ED), with treat-and-release cases used as the referent group.[17–19] Patient characteristics included as covariates in the model were age, sex, primary payer, income quartile for ZIP code of patient's residence, calendar year, procedures performed in the ED (CT scans of the head and infusion of tPA), and comorbid illness assessed using Elixhauser measurement system.[20] Hospital characteristics included as covariates were geographic region, teaching status and setting, and total ED visits.

All analyses were performed using SPSS Complex Samples module, version 23.0 (IBM Corp., Armonk, NY, USA). Complex sample data analysis was performed after adjusting for weights, cluster, and stratification of the sampling design to produce unbiased national estimates of population means and frequencies from the sample after taking into account weights for over- or under-sampling of specific groups.[21] The Taylor series linearization method was used to calculate standard errors.[22]

This study was approved by the Deerfield Institute Research Review Committee and complied with HIPAA (Health Insurance Portability and Accountability Act) guidelines, as it was conducted with de-identified data.

Results

Descriptive statistics

From 2010 to 2013, there were 2,497,622 (95% confidence interval [CI]: 2,403,514–2,591,731) total-weighted ED visits for AIS. Patient sociodemographic and hospital characteristics are presented in Table 1, segmented by year.

The mean age of patients visiting ED for AIS in 2013 was 69.8 years (95% CI: 69.5–70.0), 50.5% were male (95% CI: 50.1%–50.8%), 30.2% were in the lowest income quartile (95% CI: 28.5%–32.0%), and 41.6% presented at a hospital in the South region (95% CI: 39.2%–44.0%).

Incidence

The national incidence rate of ED visits for AIS increased from 26.4 (95% CI: 24.6–28.2) per 10,000 in 2010 to 27.0 (95% CI: 25.1–29.0) per 10,000 in 2013. After adjusting for population size in each geographic region, the South had the

Table 1 Characteristics and demographics of patients visiting ED with AIS as the primary diagnosis

Variable	2010 (95% CI)	2011 (95% CI)	2012 (95% CI)	2013 (95% CI)
Weighted AIS ED visits	620,947 (592,317–649,576)	617,386 (588,213–646,559)	603,103 (571,484–634,722)	656,186 (624,635–687,738)
Patient characteristics				
Mean age (years)	69.8 (69.5–70.1)	70.0 (69.8–70.3)	69.7 (69.4–70.0)	69.8 (69.5–70.0)
Age group (years)				
18–54	17.4% (16.9%–17.9%)	16.6% (16.1%–17.0%)	16.7% (16.2%–17.3%)	16.0% (15.6%–16.5%)
55–64	18.1% (17.7%–18.5%)	18.4% (18.0%–18.8%)	18.7% (18.3%–19.1%)	18.5% (18.1%–18.9%)
65–74	20.9% (20.7%–21.2%)	21.1% (20.9%–21.4%)	21.5% (21.3%–21.8%)	22.7% (22.4%–22.9%)
75–84	25.1% (24.7%–25.6%)	25.2% (24.8%–25.6%)	24.3% (23.9%–24.7%)	24.4% (24.1%–24.8%)
85+	18.5% (18.0%–19.0%)	18.7% (18.2%–19.2%)	18.7% (18.2%–19.2%)	18.4% (17.9%–18.8%)
Sex				
Female	48.6% (48.2%–48.9%)	48.7% (48.4%–49.0%)	49.2% (48.9%–49.5%)	49.5% (49.2%–49.9%)
Male	51.4% (51.1%–51.8%)	51.3% (51.0%–51.6%)	50.8% (50.5%–51.1%)	50.5% (50.1%–50.8%)
ED visit event				
Admitted to same hospital	80.7% (79.8%–81.6%)	80.2% (79.3%–81.2%)	79.0% (77.9%–80.0%)	78.8% (77.8%–79.7%)
Transferred to another hospital	11.7% (10.9%–12.5%)	11.6% (10.9%–12.4%)	12.1% (11.4%–12.9%)	12.2% (11.4%–12.9%)
Treated and released	7.1% (6.7%–7.6%)	7.7% (7.2%–8.2%)	8.5% (7.9%–9.2%)	8.7% (8.2%–9.2%)
Died in ED	0.3% (0.3%–0.4%)	0.3% (0.3%–0.4%)	0.3% (0.3%–0.3%)	0.3% (0.3%–0.4%)
Not admitted, unknown	0.2% (0.1%–0.3%)	0.1% (0.1%–0.2%)	0.1% (0.0%–0.1%)	0.1% (0.1%–0.2%)
Expected primary payer				
Medicare	63.2% (62.2%–64.2%)	64.1% (63.3%–65.0%)	63.9% (62.9%–64.9%)	64.3% (63.4%–65.3%)
Medicaid	7.7% (7.3%–8.2%)	7.6% (7.2%–8.0%)	7.8% (7.4%–8.4%)	7.4% (7.0%–7.9%)
Private, including HMO	20.0% (19.3%–20.7%)	19.8% (19.1%–20.5%)	19.0% (18.2%–19.8%)	19.0% (18.2%–19.8%)
Self-pay or no charge	6.7% (6.3%–7.2%)	6.1% (5.8%–6.4%)	6.6% (6.2%–7.1%)	6.7% (6.3%–7.2%)
Other	2.3% (2.1%–2.6%)	2.4% (2.2%–2.7%)	2.6% (2.3%–3.0%)	2.5% (2.2%–2.8%)
Income quartile for patient's ZIP code				
0–25th percentile	28.6% (26.5%–30.7%)	27.9% (26.3%–29.6%)	29.9% (28.2%–31.7%)	30.2% (28.5%–32.0%)
26th–50th percentile	27.3% (25.8%–28.8%)	25.5% (24.1%–27.0%)	25.3% (23.9%–26.7%)	26.9% (25.5%–28.3%)
51st–75th percentile	23.3% (21.9%–24.8%)	25.3% (24.0%–26.6%)	23.6% (22.2%–25.0%)	23.5% (22.2%–24.9%)
76th–100th percentile	20.8% (18.9%–22.8%)	21.3% (19.5%–23.1%)	21.2% (19.3%–23.3%)	19.4% (17.5%–21.4%)
Procedures performed in ED				
CT scan of head	14.7% (13.2%–16.3%)	14.6% (13.4%–15.9%)	16.2% (14.9%–17.6%)	16.5% (15.0%–18.1%)
tPA infusion	3.8% (3.5%–4.0%)	4.2% (3.9%–4.5%)	4.7% (4.4%–5.0%)	5.2% (4.9%–5.5%)
Hospital characteristics				
Hospital US geographic region				
Northeast	17.3% (15.7%–19.0%)	17.1% (15.6%–18.8%)	17.5% (15.8%–19.4%)	17.5% (15.7%–19.4%)
Midwest	23.2% (21.2%–25.2%)	23.6% (21.5%–25.9%)	22.7% (20.8%–24.8%)	22.1% (20.2%–24.1%)
South	40.6% (38.3%–42.9%)	39.4% (37.1%–41.7%)	41.2% (38.6%–43.9%)	41.6% (39.2%–44.0%)
West	18.9% (17.3%–20.7%)	19.9% (18.0%–21.9%)	18.5% (16.7%–20.5%)	18.8% (17.0%–20.8%)
Hospital teaching status				
Metropolitan teaching	44.3% (41.9%–46.6%)	42.1% (39.7%–44.5%)	44.9% (42.2%–47.7%)	45.9% (43.4%–48.4%)
Metropolitan nonteaching or nonmetro	55.7% (53.4%–58.1%)	57.9% (55.5%–60.3%)	55.1% (52.3%–57.8%)	54.1% (51.6%–56.6%)
Hospital ED visits				
<20,000	10.8% (9.6%–12.1%)	10.2% (9.0%–11.5%)	10.5% (9.2%–11.9%)	10.9% (9.5%–12.5%)
20,000–49,999	40.5% (36.6%–44.6%)	39.0% (35.2%–43.0%)	34.8% (31.2%–38.6%)	35.4% (31.8%–39.2%)
≥50,000	48.7% (44.5%–52.8%)	50.8% (46.7%–54.9%)	54.7% (50.6%–58.7%)	53.6% (49.6%–57.6%)

Abbreviations: AIS, acute ischemic stroke; CI, confidence interval; CT, computed tomography; ED, emergency department; HMO, Health Maintenance Organization; tPA, tissue plasminogen activator.

highest incidence rate throughout the study period, increasing from 29.0 (95% CI: 26.8–31.1) per 10,000 in 2010 to 30.2 (95% CI: 27.9–32.5) per 10,000 in 2013, while the West had the lowest incidence rate, increasing from 21.7 (95% CI: 19.6–23.9) per 10,000 in 2010 to 21.9 (95% CI: 19.5–24.3) per 10,000 in 2013 (Table 2). The Midwest was the only region to see a net decline in AIS incidence rates, from 28.3 (95% CI: 25.5–31.1) per 10,000 in 2010 to 28.0 (95% CI: 25.2–30.7) per 10,000 in 2013.

Age-specific incidence rates for each geographic region and year are shown in Figure 1. Patients in the age group of 85 years and older had the highest incidence rate across all four years of the study period. The incidence was highest among the patients in that age group in the South region where rates increased from 218.1 (95% CI: 193.0–243.2) per 10,000 in 2010 to 231.0 (95% CI: 202.3–259.7) per 10,000 in 2013.

Economic characteristics

Mean per-event charges are presented in Table 3. After controlling for covariates, ED visits for AIS among self-paying patients had the highest adjusted mean charges, increasing from \$3,260 (95% CI: \$3,059–\$3,461) in 2010 to \$3,931

Table 2 Annual incidence of ED visits for AIS by age group and hospital geographic region

	2010 (95% CI)	2011 (95% CI)	2012 (95% CI)	2013 (95% CI)
AIS ED visits (n)	620,947 (592,317–649,576)	617,386 (588,213–646,559)	603,103 (571,484–634,722)	656,186 (624,635–687,738)
Incidence rate by age group[a]				
18–54 years	6.8 (6.5–7.2)	6.5 (6.1–6.8)	6.4 (6.0–6.8)	6.6 (6.3–7.0)
55–64 years	30.5 (28.9–32.1)	29.8 (28.4–31.3)	29.3 (27.5–31.0)	30.9 (29.3–32.5)
65–74 years	59.5 (56.6–62.3)	58.0 (55.2–60.9)	54.2 (51.3–57.0)	59.0 (56.0–62.0)
75–84 years	119.4 (113.4–125.3)	118.1 (111.9–124.3)	110.5 (104.6–116.4)	119.3 (113.2–125.4)
85+ years	207.1 (196.5–217.7)	201.9 (190.7–213.0)	191.5 (181.1–201.9)	199.0 (188.4–209.6)
Overall	26.4 (24.6–28.2)	26.0 (24.2–27.8)	25.1 (23.2–27.0)	27.0 (25.1–29.0)
Incidence rate by hospital geographic region[a]				
Northeast	24.9 (22.3–27.5)	24.4 (22.0–26.9)	24.2 (21.6–26.9)	26.1 (23.1–29.2)
Midwest	28.3 (25.5–31.1)	28.5 (25.4–31.6)	26.6 (24.1–29.2)	28.0 (25.2–30.7)
South	29.0 (26.8–31.1)	27.6 (25.6–29.5)	27.8 (25.2–30.4)	30.2 (27.9–32.5)
West	21.7 (19.6–23.9)	22.3 (19.9–24.8)	20.0 (17.8–22.3)	21.9 (19.5–24.3)

Note: [a]Rate of ED visits per 10,000 population per year in the US.
Abbreviations: AIS, acute ischemic stroke; CI, confidence interval; ED, emergency department.

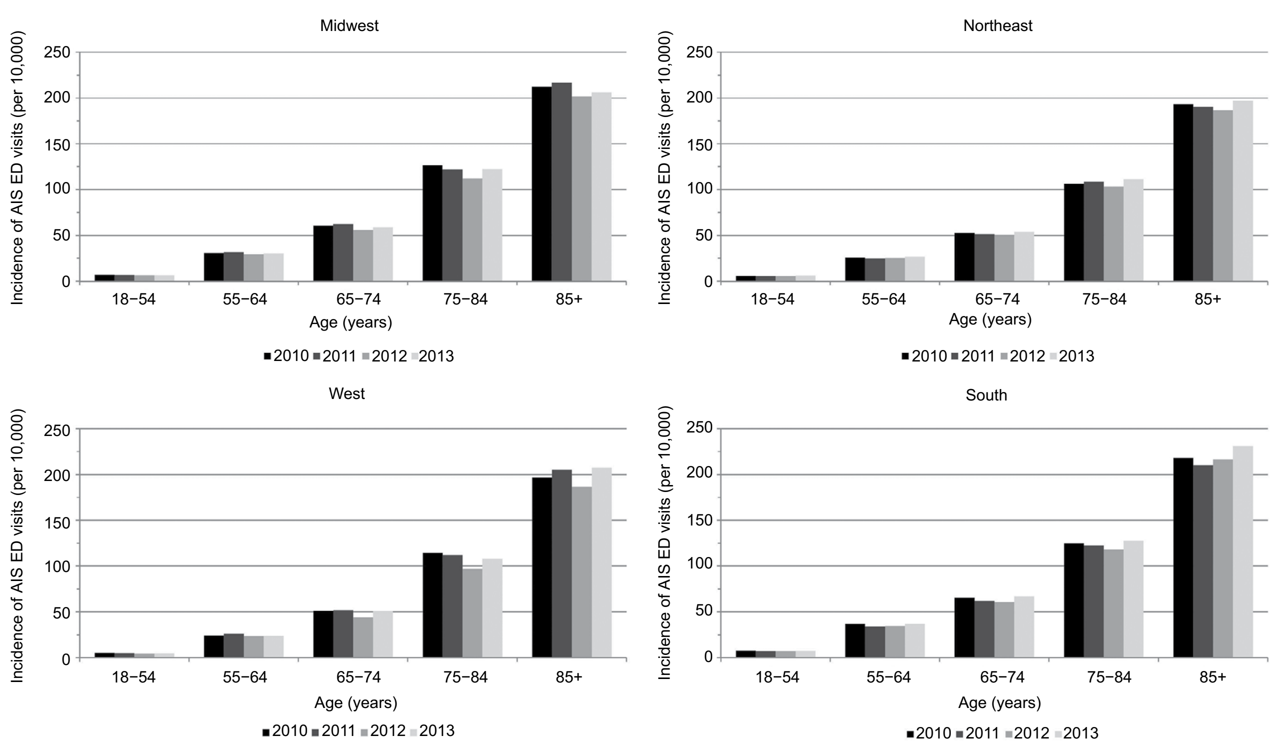

Figure 1 Age- and region-specific incidence of ED visits for AIS in the US.
Abbreviations: AIS, acute ischemic stroke; ED, emergency department.

Table 3 Adjusted mean charges billed per ED visit for AIS by expected primary payer, hospital geographic region, and year

	Adjusted mean ED charges[a] (95% CI)			
	2010	**2011**	**2012**	**2013**
Expected primary payer				
Medicare	$3,004 ($2,876–$3,131)	$3,158 ($3,029–$3,287)	$3,404 ($3,276–$3,531)	$3,803 ($3,637–$3,970)
Medicaid	$2,877 ($2,709–$3,044)	$3,253 ($3,018–$3,489)	$3,354 ($3,137–$3,570)	$3,437 ($3,240–$3,633)
Private, including HMO	$3,013 ($2,864–$3,162)	$3,237 ($3,073–$3,402)	$3,520 ($3,340–$3,700)	$3,771 ($3,596–$3,947)
Self-pay or no charge	$3,260 ($3,059–$3,461)	$3,466 ($3,248–$3,684)	$3,663 ($3,438–$3,887)	$3,931 ($3,675–$4,188)
Other	$2,996 ($2,771–$3,221)	$3,125 ($2,897–$3,354)	$3,523 ($3,270–$3,775)	$3,621 ($3,383–$3,858)
Hospital US geographic region				
Northeast	$2,813 ($2,535–$3,091)	$2,903 ($2,607–$3,198)	$3,072 ($2,736–$3,409)	$3,765 ($3,318–$4,213)
Midwest	$3,601 ($3,314–$3,888)	$3,654 ($3,372–$3,935)	$3,901 ($3,615–$4,187)	$4,456 ($4,071–$4,842)
South	$2,791 ($2,615–$2,968)	$3,008 ($2,824–$3,193)	$3,343 ($3,157–$3,528)	$3,459 ($3,270–$3,648)
West	$3,761 ($3,174–$4,349)	$4,274 ($3,794–$4,753)	$4,297 ($3,896–$4,698)	$4,575 ($4,054–$5,096)

Note: [a]Charges are reported in 2013 US dollars, rounded to nearest-whole dollar.
Abbreviations: AIS, acute ischemic stroke; CI, confidence interval; ED, emergency department; HMO, Health Maintenance Organization.

(95% CI: $3,675–$4,188) in 2013. Over the study period, compared with those covered by Medicare, Medicaid-covered patients had significantly lower adjusted mean charges (multivariate t=−2.81; p=0.005), while self-paying patients had significantly higher adjusted mean charges (multivariate t=4.14; p<0.001). Upon assessing regional differences, we found that ED visits for AIS in hospitals in the West had the highest adjusted mean charges per event, increasing from $3,761 (95% CI: $3,174–$4,349) in 2010 to $4,575 (95% CI: $4,054–$5,096) in 2013.

Predictors of disposition

Results of the multinomial logistic regression analysis of patient disposition following an ED visit for AIS are presented in Table 4. Numerous patient characteristics were associated with an increased likelihood of hospital admission, including increasing age, male sex, Medicaid insurance, and tPA infusion. Uninsured patients were associated with a significantly lower likelihood of hospital admission (odds ratio [OR]: 0.820; p<0.001) compared with Medicare patients, and overall, the odds of admission decreased with each year after 2010. Among hospital characteristics, metropolitan teaching status (OR: 1.535; p<0.001) and higher annual ED visit volume were associated with significantly higher odds of admission.

Patients treated at hospitals in the Midwest were more likely to be transferred to another hospital following an ED visit for AIS compared with patients treated in the Northeast (OR: 1.757; p<0.001).

Increasing age was significantly associated with increasing odds of mortality in the ED compared with patients 18–54 years of age ($OR_{55–64}$: 1.433 [p=0.002]; $OR_{65–74}$: 1.907 [p<0.001]; $OR_{75–84}$: 4.775 [p<0.001]; OR_{85+}: 5.735 [p<0.001]). Hospitals in the Midwest and those with higher annual ED visit volume were also associated with higher odds of mortality. Male sex was associated with significantly lower odds of mortality compared with female sex (OR: 0.752; p<0.001).

Discussion

To examine ED utilization and economic burden due to AIS, we analyzed a large nationally representative database. We found that AIS was the primary diagnosis in over 600,000 ED visits each year from 2010 to 2013, of which over 90% were either admitted or transferred to another hospital. Deaths in the ED remained consistently low across study years, and the proportion of patients treated and released increased slightly.

After adjusting for underlying population changes, the overall incidence of ED visits for AIS slightly increased from 2010 to 2013. Previous research has demonstrated that from 1973 to 2010, there was a substantial shift from the Northeast to the South in the concentration of counties with high mortality rates due to heart disease, which is reflected in the results of this study where the incidence of ED visits for AIS was highest in the South region.[23]

A comparison of adjusted mean charges showed that ED visits for AIS in hospitals in the West region had the highest per-event charges in 2013, $4,575, while those in the South had the lowest, $3,459.

Over 30% of the adult population self-reports taking low-dose aspirin daily for primary or secondary prevention of cardiovascular disease.[24] Despite this high prevalence, as well as other improvements in primary and secondary prevention of cardiovascular disease which have led to better-quality blood pressure and cholesterol treatment and control,[8,25,26] we

Table 4 Predictors of patient disposition following ED visit with primary diagnosis of AIS, 2010–2013

Variable	Admitted vs treated and released		Transferred vs treated and released		Died in ED vs treated and released	
	Adjusted odds ratio (95% CI)	***p*-value**	**Adjusted odds ratio (95% CI)**	***p*-value**	**Adjusted odds ratio (95% CI)**	***p*-value**
Patient characteristics						
Age group (years)						
18–54	Ref		Ref		Ref	
55–64	1.102 (1.054–1.152)	<0.001	0.882 (0.844–0.923)	<0.001	1.433 (1.145–1.794)	0.002
65–74	1.174 (1.104–1.249)	<0.001	0.908 (0.857–0.962)	0.001	1.907 (1.470–2.474)	<0.001
75–84	1.417 (1.324–1.515)	<0.001	0.883 (0.828–0.940)	<0.001	4.775 (3.682–6.193)	<0.001
85+	1.571 (1.454–1.696)	<0.001	0.605 (0.564–0.650)	<0.001	5.735 (4.417–7.448)	<0.001
Sex						
Female	Ref		Ref		Ref	
Male	1.088 (1.061–1.116)	<0.001	0.916 (0.891–0.940)	<0.001	0.752 (0.689–0.820)	<0.001
Primary payer						
Medicare	Ref		Ref		Ref	
Medicaid	1.199 (1.100–1.307)	<0.001	1.097 (1.005–1.198)	0.039	0.964 (0.732–1.269)	0.794
Private, including HMO	0.972 (0.919–1.029)	0.336	1.070 (1.014–1.129)	0.014	0.925 (0.755–1.135)	0.455
Self-pay/no charge	0.820 (0.759–0.885)	<0.001	1.171 (1.089–1.260)	<0.001	1.320 (1.028–1.696)	0.030
Other	0.967 (0.827–1.130)	0.671	0.870 (0.767–0.986)	0.029	0.837 (0.562–1.247)	0.383
Income quartile for ZIP code						
0–25th percentile	Ref		Ref		Ref	
26th–50th percentile	1.009 (0.933–1.092)	0.817	0.967 (0.900–1.038)	0.351	1.091 (0.949–1.254)	0.221
51st–75th percentile	1.008 (0.923–1.102)	0.852	0.853 (0.782–0.930)	<0.001	0.919 (0.784–1.077)	0.297
76th–100th percentile	1.091 (0.958–1.243)	0.190	0.878 (0.779–0.990)	0.034	1.084 (0.896–1.312)	0.404
Procedures performed in ED (Ref=no)						
CT scan of head	0.032 (0.026–0.039)	<0.001	1.564 (1.418–1.725)	<0.001	1.043 (0.921–1.182)	0.507
tPA infusion	15.399 (10.606–22.359)	<0.001	2.866 (1.968–4.173)	<0.001	0.482 (0.179–1.294)	0.147
Hospital characteristics						
Hospital US geographic region						
Northeast	Ref		Ref		Ref	
Midwest	0.353 (0.269–0.463)	<0.001	1.757 (1.413–2.183)	<0.001	1.698 (1.251–2.304)	<0.001
South	0.563 (0.443–0.715)	<0.001	1.108 (0.897–1.368)	0.343	1.398 (1.033–1.891)	0.030
West	0.351 (0.263–0.469)	<0.001	1.282 (1.015–1.619)	0.037	1.356 (1.004–1.830)	0.047
Hospital teaching status						
Metropolitan nonteaching or nonmetro	Ref		Ref		Ref	
Metropolitan teaching	1.535 (1.287–1.831)	<0.001	0.389 (0.320–0.472)	<0.001	1.236 (1.041–1.467)	0.016
Hospital ED visits						
<20,000	Ref		Ref		Ref	
20,000–49,999	2.357 (2.040–2.724)	<0.001	0.781 (0.696–0.875)	<0.001	1.420 (1.197–1.684)	<0.001
≥50,000	2.656 (2.187–3.226)	<0.001	0.419 (0.352–0.500)	<0.001	1.598 (1.311–1.947)	<0.001
Calendar year						
2010	Ref		Ref		Ref	
2011	0.863 (0.733–1.017)	0.079	0.929 (0.820–1.053)	0.251	0.951 (0.795–1.136)	0.579
2012	0.770 (0.654–0.907)	0.002	0.880 (0.775–0.998)	0.047	0.747 (0.632–0.882)	<0.001
2013	0.741 (0.634–0.867)	<0.001	0.880 (0.780–0.994)	0.039	0.812 (0.703–0.938)	0.005

Abbreviations: AIS, acute ischemic stroke; CI, confidence interval; CT, computed tomography; ED, emergency department; HMO, Health Maintenance Organization; tPA, tissue plasminogen activator.

found that ED visits for AIS did not markedly change from 2010 to 2013.

This study also examined predictors of patient disposition following an ED visit with a primary diagnosis of AIS. One interesting observation from this analysis is that since 2010, the odds of AIS patients being admitted decreased each year. Similarly, the odds of mortality in the ED have decreased since 2010, with 2012 and 2013 each being associated with significant reduction at the alpha level of 0.05 (OR_{2012}: 0.747 [p<0.001]; OR_{2013}: 0.812 [p=0.005]).

We found that increasing age was associated with increased likelihood of being admitted, as well as decreased likelihood of being transferred, and increased likelihood of death in the ED. We conclude that age, even after adjusting for confounders and comorbidities, is a significant predictor of worse outcomes for AIS patients in the ED. Males were more likely to be admitted and less likely to be transferred to another hospital or die in the ED compared with females. There could potentially be underlying pathophysiological reasons for these better outcomes, or it may be due to females being underdiagnosed or undertreated. Sex biases have previously been observed in selecting candidates for surgery among patients with abdominal aortic aneurysm,[27] and it is possible that such biases are also present among AIS patients. Patients covered by Medicaid were more likely to be admitted or transferred, but there was no significant difference in mortality OR compared with Medicare patients. Prior studies have shown that Medicaid patients are at a higher risk for worse outcomes in the hospital, potentially due to limited access to health care services, unmet health needs, and suboptimal management of chronic conditions.[28] Patients receiving tPA infusion were significantly more likely to be admitted or transferred than those not receiving tPA. This may be a reflection of the disease severity of the patient, because a more acute case would be more likely to be admitted or transferred to a different hospital, such as a stroke center with higher quality of care.

While this study provides valuable information around recent trends in ED utilization and economic burden due to AIS, there are some important limitations. The NEDS database is an administrative data set originally generated for billing purposes, which provides estimated charges to the payers but not the actual cost of services to the hospital or ED, and thus, it does not offer all the data necessary to perform a full assessment of ED economic burden due to AIS.[29] Similarly, data on imaging procedures may be underrepresented in the NEDS database due to billing factors, for example, a private radiology group providing service to a given hospital and thus generating a separate bill not captured in NEDS.[30]

Despite using four years of NEDS data, consisting of over 120 million ED records, this study could have benefited from examining additional years of data to draw more conclusions regarding trends or changes over time in ED visits for AIS.

An additional potential limitation is that NEDS does not contain any race or ethnicity variables. While previous studies have shown racial disparities in AIS hospitalization rates,[8] we were unable to replicate these analyses in the ED setting. Furthermore, there was a possibility of coding errors, including miscoding a transient ischemic attack as AIS.[31] From a clinical perspective, the small proportion of patients treated with tPA is unexpected because it is the only US Food and Drug Administration–approved intravenous thrombolytic for AIS.[32] This may point to the underutilization of tPA procedure codes in administrative database such as NEDS.

Despite these potential limitations, this study has some notable strengths. Using data from the largest publicly available all-payer ED database in the US, we produced national estimates of the volume of ED visits for AIS, as well as analyzed important predictors of patient disposition following an ED visit. This is also the first study to examine national trends in ED charges for the treatment of AIS. Mean charge estimates were adjusted for various demographic and clinical covariates so that appropriate comparisons could be made across insurance groups and hospital geographic regions. Future research could focus on similar analyses in the inpatient setting, which in conjunction with the results of the present study would provide a complete picture of the clinical and economic characteristics of AIS patients in the ED and hospital.

Acknowledgment

Financial support for this research was provided by Deerfield Management, a health care investment firm dedicated to advancing health care through investment, information, and philanthropy. The funder provided support in the form of salaries to the authors, but did not have any role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Disclosure

The authors report no conflicts of interest in this work.

References

1. Go AS, Mozaffarian D, Roger VL, et al. Heart disease and stroke statistics—2014 update: a report from the American Heart Association. *Circulation*. 2014;129:e28–e292.
2. Grysiewics RA, Thomas K, Pandey DK. Epidemiology of ischemic stroke and hemorrhagic stroke: incidence, prevalence, mortality, and risk factors. *Neurol Clin*. 2008;26:871–895.
3. Ovbiagele B. Nationwide trends in in-hospital mortality among patients with stroke. *Stroke*. 2010;41:1748–1754.
4. Fang J, Alderman MH, Keenan NL, Croft JB. Declining US stroke hospitalization since 1997: National Hospital Discharge Survey, 1988–2004. *Neuroepidemiology*. 2007;29:243–249.
5. Fang MC, Coca Perraillon M, Ghosh K, Cutler DM, Rosen AB. Trends in stroke rates, risk, and outcomes in the United States, 1988 to 2008. *Am J Med*. 2014;127:608–615.
6. Murphy SL, Kochanek MA, Xu J, Arias E. Mortality in the United States, 2014. NCHS data brief, no. 229. Hyattsville, MD: National Center for Health Statistics; 2015.
7. Sacco RL, Kasner SE, Broderick JP, Caplan LR, Connors JJ, Culebras A. An updated definition of stroke for the 21st century: a statement for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2013;44:2064–2089.

8. Ramirez L, Kim-Tenser MA, Sanossian N, et al. Trends in acute ischemic stroke hospitalizations in the United States. *J Am Heart Assoc*. 2016;5:e003233.
9. Johnson BH, Bonafede MM, Watson C. Short- and longer-term healthcare resource utilization and costs associated with acute ischemic stroke. *Clinicoecon Outcomes Res*. 2016;8:53–61.
10. Obviagele B, Goldstein LB, Hiqashida RT, Howard VJ, Johnston SC, Khavjou OA. Forecasting the future of stroke in the United States: a policy statement from the American Heart Association and American Stroke Association. *Stroke*. 2013;44:2361–2375.
11. Demaerschalk BM, Hwang HM, Leung G. US cost burden of ischemic stroke: a systematic literature review. *Am J Manag Care*. 2010;16:525–533.
12. Talwalkar A, Uddin S. Trends in emergency department visits for ischemic stroke and transient ischemic attack: United States, 2001-2011. NCHS data brief, no. 194. Hyattsville, MD: National Center for Health Statistics; 2015.
13. Taylor CA, Greenspan AI, Xu L, Kresnow MJ. Comparability of national estimates for traumatic brain injury-related medical encounters. *J Head Trauma Rehabil*. 2015;30:150–159.
14. Agency for Healthcare Research and Quality. Healthcare Cost and Utilization Project (HCUP). HCUP Nationwide Emergency Department Sample (NEDS). 2010, 2011, 2012, 2013. Rockville, MD: Agency for Healthcare Research and Quality.
15. Broderick J, Brott T, Kothari R, Miller R, Khoury J, Pancioli A, et al. The Greater Cincinnati/Northern Kentucky Stroke Study: preliminary first-ever and total incidence rates of stroke among blacks. *Stroke*. 1998;29:415–421.
16. U.S. Census Bureau, Population Division. American FactFinder. Annual Estimates of the Resident Population. Available from: http://factfinder2.census.gov. Accessed April 11, 2017.
17. Altyar A, Kordi L, Skrepnek G. Clinical and economic characteristics of emergency department visits due to acetaminophen toxicity in the USA. *BMJ Open*. 2015;5:e007368.
18. Skrepnek GH. Regression methods in the empiric analysis of health care data. *J Manag Care Pharm*. 2005;11:240–251.
19. Skrepnek GH, Ovney EL, Sahai A. Econometric approaches in evaluating costs and outcomes within pharmacoeconomic analyses. *Pharm Policy Law*. 2012;14:105–122.
20. Elixhauser A, Steiner C, Harris DR, Coffey RM. Comorbidity measures for use with administrative data. *Med Care*. 1998;36:8–27.
21. Saylor J, Friedmann E, Lee HJ. Navigating complex sample analysis using national survey data. *Nurs Res*. 2012;61:231–237.
22. Bieler GS, Brown GG, Williams RL, Brogan DJ. Estimating model-adjusted risks, risk differences, and risk ratios from complex survey data. *Am J Epidemiol*. 2010;171:618–623.
23. Casper M, Kramer MR, Quick H, Schieb LJ, Vaughan AS, Greer S. Changes in the geographic patterns of heart disease mortality in the United States: 1973 to 2010. *Circulation*. 2016;133:1171–1180.
24. Stuntz M, Bernstein B. Recent trends in the prevalence of low-dose aspirin use for primary and secondary prevention of cardiovascular disease in the United States, 2010–2015. *Prev Med Rep*. 2016;5:183–186.
25. Yoon SS, Ostchega Y, Louis T. Recent trends in the prevalence of high blood pressure and its treatment and control, 1999-2008. NCHS data brief, no. 48. Hyattsville, MD: National Center for Health Statistics; 2010.
26. Hyre AD, Muntner P, Menke A, Raggi P, He J. Trends in ATP-III-defined high blood cholesterol prevalence, awareness, treatment and control among US adults. *Ann Epidemiol*. 2007;17:548–555.
27. Starr JE, Halpern V. Abdominal aortic aneurysms in women. *J Vasc Surg*. 2013;57(4 Suppl):3S–10S.
28. Hasan O, Orav EJ, Hicks LS. Insurance status and hospital care for myocardial infarction, stroke, and pneumonia. *J Hosp Med*. 2010;5:452–459.
29. Mutter R, Stocks C. Using Healthcare Cost and Utilization Project (HCUP) data for emergency medicine research. *Ann Emerg Med*. 2014;64:458–460.
30. Johnson EK, Graham DA, Chow JS, Nelson CP. Nationwide emergency department imaging practices for pediatric urolithiasis: room for improvement. *J Urol*. 2014;192:200–206.
31. Kokotailo RA, Hill MD. Coding of stroke and stroke risk factors using International Classification of Diseases, revisions 9 and 10. *Stroke*. 2005;36:1776–1781.
32. Jauch EC, Saver JL, Adams HP Jr, et al. American Heart Association Stroke Council; Council on Cardiovascular Nursing; Council on Peripheral Vascular Disease; Council on Clinical Cardiology. Guidelines for the early management of patients with acute ischemic stroke: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2013;44:870–947.