

# Incidence and mortality rates of acute ischemic stroke in hospitalized patients in the United States

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The American Heart Association recently reported that stroke is currently the 5<sup>th</sup> most common cause of death among Americans as one in every 19 deaths is from stroke [1]. While some studies have shown a decline in the incidence and rate of acute ischemic stroke (AIS) hospitalizations among adults in the United States [2], its impact over the healthcare system in the United States is still a major burden. Several racial/ethnic and gender disparities have also been reported among AIS patients over the years. A rise in the incidence among younger individuals, which could be linked with the use of multiple drugs predisposing to stroke such as cocaine [3, 4], has also raised serious concerns about the condition [2]. Thus, we conducted a retrospective study on the incidence and mortality of AIS hospitalizations and understand its economic impact in the United States.

Each year, the “Healthcare Cost and Utilization Project (HCUP), sponsored by the Agency for Healthcare Research and Quality (AHRQ) and their partners”, releases one of the largest public all-payer inpatient databases in the United States. The 2017 National (Nationwide) Inpatient Sample (NIS) database is the one of the most recent versions released by the HCUP [5]. It consists of more than 7 million unweighted records of admissions which, in its weighted form, is estimated to cover at > 97% of the US population from January 1<sup>st</sup> 2017 to December 31<sup>st</sup> 2017. Additional information about the database can be accessed from [www.hcup-us.ahrq.gov](http://www.hcup-us.ahrq.gov).

We used the methodology described by Ramirez *et al.* in past studies of AIS to conduct a retrospective observational study [2]. First, we filtered the database to include only admissions of patients aged 25 and over. Cases of AIS were identified using the International Classification of Diseases, 10th Revision, Clinical Modification codes I63.x [6, 7], provided by the HCUP, as primary discharge diagnostic codes. We compared the incidence of AIS in different groups based on sex, race, and primary payer forms. The mortality rates in each group were also compared. A *p*-value < 0.05 was considered statistically significant. We further used the 2017 census data (<https://www.census.gov>) to estimate the overall incidence

of AIS as well as the incidence in males and females. As per HCUP guidelines, all data were converted to weighted forms (DISCWT) and the study was waived from institutional review board (IRB) approval and ethical clearance. IBM SPSS Statistics version 24.0 (IBM Corporation, Armonk, NY) was used for all statistical analyses.

The 2017 NIS data consisted of 522,740 cases of AIS with 261,980 (50.1%) females and 260,755 (49.9%) males ( $p < 0.01$ ) (Table I). AIS had a higher prevalence per 100,000 admissions in males than females (2097 cases per 100,000 admissions in males and 1618 cases per 100,000 admissions in females). The overall rate per 100,000 Americans was 236 cases of AIS. 20,995 deaths were reported with an overall mortality rate of 3.1%. Females admitted with AIS had a higher mortality rate than males ( $p < 0.01$ ). 68.5% of all AIS cases were reported among Whites, who also had a higher mortality rate ( $p < 0.01$ ). Medicare was the most common form of primary payer form, covering 65.8% of all AIS hospitalizations ( $p < 0.01$ ).

The incidence of AIS was 243 per 100,000 Americans among males and 229 per 100,000 Americans among females. The mean length of stay was 4.91 days while the mean hospital charges were \$60,002.50. The total hospital charges for AIS patients in 2017 were \$31,252,598,673.

These results provide a fresh perspective of the impact and burden of AIS in the United States. Our study showed that the rate of AIS per 100,000 Americans increased in 2017. It rose from 204 in 2010 to 236 in 2017 [2]. The rise and presence of multiple risk factors over the years due to changes

in life-style has been a major factor contributing to the [8] higher incidence of AIS over the years [1]. Hales *et al.* found that there has been increasing prevalence of obesity among adults over the last two decades [9], while Mitchell *et al.* adjusted their data for age, sex, and ethnicity to conclude that obesity led to a higher stroke risk with an odds ratio of 1.57 (95% confidence interval, 1.28–1.94) [10]. The presence of hypertension (42%) and diabetes mellitus (17%) have also been seen among young patients with AIS [11, 12]. While an improvement in awareness of hypertension is now present among young adults, no drastic improvement in prevalence and incidence has been reported [13]. In their study of prediabetes, Andres *et al.* noted higher prevalence of prediabetes in young adults than adolescents. They also found a higher incidence in males and obese patients.

The incidence of AIS per 100,000 Americans in men (243) was lower in 2017 as compared to 2000–2005 (298, 294, 281, 267, 254, 247), 2008 (246), and 2010 (245) and lower in females as compared to 2000–2003 (272, 265, 255, 240). However, a rise in incidence in females was reported as compared to years 2004–2010 (228, 219, 214, 208, 219, 207, 212) [2]. Higher mortality was also observed among females compared to males in our study. Persky *et al.* hypothesized that since women live longer, they are more likely to end up with a less favorable outcome for stroke at an older age [14]. In their analysis, George *et al.* also added that women have certain risk factors that can predispose them to AIS. The use of birth control as well as migraine and pregnancy greatly increase

**Table I.** Incidence of acute ischemic stroke in the United States

Characteristic	Acute ischemic stroke (%)	Number of acute ischemic stroke cases per 100,000 admissions	P-value	Death during hospitalization (%)	Deaths per 100,000 stroke patients	P-value
Sex:						
Male	260755 (49.9)	2097	< 0.01	9700 (46.2)	3722	< 0.01
Female	261980 (50.1)	1618		11295 (53.8)	4313	
Race:						
White	346785 (68.5)	1833		14655 (73.2)	4228	
Black	87780 (17.3)	2143	< 0.01	2660 (13.3)	3032	< 0.01
Hispanic	41655 (8.2)	1440		1430 (7.1)	3432	
Rest	30125 (6.0)	1744		1270 (6.4)	4217	
Primary payer:						
Medicare	343670 (65.8)	2375		14730 (70.4)	4288	
Medicaid	47855 (9.2)	1017		1375 (6.6)	2875	
Private	97610 (18.7)	1310	< 0.01	3225 (15.4)	3306	< 0.01
Self-pay	20155 (3.9)	1870		645 (3.1)	3202	
No charge	1495 (0.3)	1600		30 (0.1)	2007	
Other	11175 (1.4)	1432		930 (4.4)	8326	

their risk by up to 9-fold as well as worsening their prognosis [12]. The hypercoagulable state during pregnancy can also be a risk factor for AIS in young women of reproductive age. Miller *et al.* reported a 0.2% incidence of pregnancy-associated stroke in premenopausal women admitted for any reason in New York [15]. The higher incidence of AIS among Blacks corresponds to several studies that attributed it to a higher prevalence of risk factors such as hypertension and diabetes which can predispose to stroke [2, 16]. The LOS decreased from 5.27 days in 2010 to 4.91 days in 2017, and an improvement in the mortality rate was also observed, as it dropped from 6.98% in 2000 to 5.21% in 2010 to 3.1% in our study in 2017 [2]. Lackland *et al.* previously linked the recent drop in stroke mortality rates to novel interventions applied among stroke patients and also to multiple changes in treatment protocols made by hospitals based on several scientific findings that helped lower risk factors for stroke such as hypertension [17]. The burden on Medicare rose in 2017 (65.8%) compared to 2010 (64.3%) [2]. However, since previous studies did not report hospital charges, we are unable to compare the financial burden of the disease.

The NIS data provided by the HCUP allow us to calculate the most recent estimates and incidences of multiple healthcare associated problems. The higher incidence in AIS hospitalization should encourage proper education among the population in recognizing the signs and symptoms of stroke and calling 911 [18]. Comparisons between different stroke protocols among hospitalized patients should also be encouraged across multiple hospitals in the United States. There are some limitations associated with the database, as it does not allow users to verify diagnoses and confirm severity. However, the database provides a large sample size and further research is encouraged.

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### Conflict of interest

The authors declare no conflict of interest.

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