Trends in Transient Ischemic Attack Hospitalizations in the United States

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Background—Transient ischemic attack (TIA) is a major predictor of subsequent stroke. No study has assessed nation-wide trends in hospitalization for TIA in the United States.

Methods and Results—Temporal trends in hospitalization for TIA (International Classification of Diseases, Ninth Revision code 435.0–435.9) from 2000 to 2010 were assessed among adults aged ≥25 years using the Nationwide Inpatient Sample. Age-, sex-, and race/ethnic-specific TIA hospitalization rates were calculated using the weighted number of hospitalizations as the numerator and the US population as the denominator. Age-adjusted rates were standardized to the 2000 US Census population. From 2000 to 2010, age-adjusted TIA hospitalization rates decreased from 118 to 83 per 100 000 (overall rate reduction, −29.7%). Age-specific TIA hospitalization rates increased for individuals aged 24 to 44 years (10–11 per 100 000), but decreased for individuals aged 45 to 64 (74 to 65 per 100 000), 65 to 84 (398 to 245 per 100 000), and ≥85 years (900 to 619 per 100 000). Blacks had the highest age-adjusted yearly hospitalization rates, followed by Hispanics and whites (124, 82, and 67 per 100 000 in 2010). Rates slightly increased for blacks, but decreased for Hispanics and whites. Compared to women, age-adjusted TIA hospitalization rates were lower and declined more steeply in men (132 to 89 per 100 000 versus 134 to 97 per 100 000).

Conclusions—Although overall TIA hospitalizations have decreased in the United States, the reduction has been more pronounced among older individuals, men, whites, and Hispanics. These findings highlight the need to target risk-factor control among women, blacks, and individuals aged <45 years. (J Am Heart Assoc. 2016;5:e004026 doi: 10.1161/JAHA.116.004026)

Key Words: hospitalization • Nationwide Inpatient Sample • transient ischemic attack • trends

Cerebrovascular diseases are among the leading causes of morbidity and mortality in the United States; however, recent studies have shown promising declines in prevalence and mortality. Although several studies have assessed recent temporal trends in hospitalizations for ischemic stroke, no study has assessed trends for transient ischemic attack (TIA). Several factors may influence temporal trends in TIA hospitalizations, including true changes in incidence, changes in the definition for TIA, alterations in management (inpatient vs outpatient), and improvements in stroke detection (where events previously classified as TIA are classified as strokes). The aims of this study were to assess trends in race/ethnic-, age-, and sex-specific rates of hospitalization for TIA between 2000 and 2010.

Methods

We analyzed data from the Nationwide Inpatient Sample (NIS), the largest publicly available all-payer inpatient care database in the United States. The NIS contains data from ≈8 million de-identified hospital stays a year and approximates a 20% stratified sample of nonfederal US hospitals. Most hospitals in the United States are nonfederal (97% in 2000 and 97.5% in 2010) and include government hospitals operated by the city, county, and state, as well as hospitals operated by for-profit and nonprofit organizations. The database sampling strategy allows for extrapolation from the sample to represent and be generalizable to all US hospitalizations nationwide, using sampling weights. The database is maintained by the

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An accompanying Table S1 is available at http://jaha.ahajournals.org/content/5/9/e004026/DC1/inline-supplementary-material-1.pdf

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Received June 5, 2016; accepted August 23, 2016.

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DOI: 10.1161/JAHA.116.004026
National Healthcare Cost Utilization Project (HCUP) of the Agency for Healthcare Research and Quality (AHRQ). Detailed information on the design of the NIS is available at www.hcup-us.ahrq.gov.

We followed the HCUP guideline for the data analysis (https://www.hcup-us.ahrq.gov/tech_assist/tutorials.jsp). The study qualified for institutional review board waiver. Discharge data were obtained from January 1, 2000 through December 31, 2010. TIA was defined by the International Classification of Diseases, Ninth revision primary discharge diagnosis codes for transient cerebral ischemia (435.0–435.9). The total number of TIA admissions for adults aged ≥25 years was estimated using SAS 9.4 PROC SURVEYMEANS (SAS Institute Inc., Cary, NC) by accounting for sampling weight to reflect the overall US population. Age-, sex-, and race/ethnic-specific TIA hospitalization rates were calculated using the weighted number of hospitalizations as the numerator and the US civilian population as the denominator. Yearly rate comparisons across years were standardized with the age distribution of the US population in 2000. For comparison across year and sex, all rates were standardized with the age distribution of the US female population in 2000, whereas for comparison across year and race, all rates are were standardized with the age distribution of the US white population in 2000. The average rate of change is the average of the percent change from the preceding year across all years after 2000.

Results

Overall, age-adjusted TIA hospitalization rates in the United States decreased from 118 to 83 per 100,000 population from 2000 through 2010 (absolute rate change, −29.7%; Table 1). The decline was greater from 2000 to 2005 (average rate change, −4.82%/year) versus 2006 to 2010 (−1.96%/year). The decline in TIA hospitalizations was driven by individuals aged ≥65 years. Age-specific TIA rates increased in individuals 25 to 44 years (10–11 per 100,000; +10%), but decreased for all other age groups: 45 to 64 (74–65 per 100,000; −12.2%); 65 to 84 (398–245 per 100,000; −38.4%) and ≥85 years (900–619 per 100,000; −31.2%; Figure 1).

Blacks had the highest age-adjusted yearly hospitalization rates, followed by Hispanics and whites (124, 82, and 67 per 100,000 in 2010; Figure 2). From 2000 to 2010, TIA hospitalization rates decreased for Hispanics (−31.1%) and whites (−24.7%), but slightly increased for blacks (+3.3%). Hospitalization rates slightly increased for whites from 2006 to 2010 (+3.1%). The difference in TIA rates between Hispanics and whites decreased 9% from 2000 to 2010, but increased 37% between blacks and whites.

Age-adjusted TIA hospitalization rates were lower in men and had a steeper decline compared to women (132 to 89 per 100,000 [−32.6%] in men vs 134 to 97 per 100,000 [−27.6%] in women; Figure 3).

The Charlson Comorbidity Index scores for individuals with TIA increased from 2000 to 2010 (≥3: 6.02–9.83%). In-hospital mortality decreased from 0.25% to 0.15% (Table 2 and Table S19).

Discussion

In this nationally representative sample, age-adjusted TIA hospitalization rates decreased 29.7% from 2000 to 2010 in

Table 1. Age-Adjusted Transient Ischemic Attack Hospitalization Rates Per 100,000

|            | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|------------|------|------|------|------|------|------|------|------|------|------|------|
| Overall    | 118  | 117  | 112  | 105  | 96   | 92   | 95   | 90   | 92   | 87   | 83   |
| Age categories, y |
| 25–44      | 10   | 10   | 10   | 11   | 10   | 11   | 12   | 11   | 12   | 12   | 11   |
| 45–64      | 74   | 71   | 72   | 71   | 66   | 63   | 68   | 66   | 69   | 65   | 65   |
| 65–84      | 398  | 393  | 372  | 345  | 311  | 291  | 299  | 277  | 282  | 263  | 245  |
| 85 and over| 900  | 933  | 864  | 785  | 729  | 716  | 710  | 664  | 672  | 617  | 619  |
| Race       |      |      |      |      |      |      |      |      |      |      |      |
| Hispanic   | 119  | 108  | 110  | 136  | 94   | 85   | 102  | 79   | 78   | 93   | 82   |
| White      | 89   | 84   | 76   | 70   | 64   | 64   | 65   | 59   | 70   | 67   | 67   |
| Black      | 120  | 117  | 123  | 118  | 117  | 90   | 110  | 110  | 109  | 112  | 124  |
| Sex        |      |      |      |      |      |      |      |      |      |      |      |
| Male       | 132  | 131  | 121  | 115  | 104  | 99   | 103  | 97   | 99   | 92   | 89   |
| Female     | 134  | 134  | 130  | 120  | 111  | 106  | 110  | 104  | 107  | 100  | 97   |
the United States, with a greater decline occurring in the first 5 years. Overall, blacks had the highest age-adjusted TIA hospitalization rates, followed by Hispanics and whites. Individuals aged >45 years, Hispanics, whites, and men saw the greatest declines, but rates increased for individuals aged <45 years and blacks. Comorbidity scores increased from 2000 to 2010, but in-hospital deaths decreased.

This study is the first to assess recent trends in TIA rates among a national sample of the US population. TIA incidence in the United States is estimated at 200 000 to 500 000 per year,10 and 14% to 78.7% are typically hospitalized.11–15 Data from the National Hospital Ambulatory Medical Care Survey (NHAMCS) demonstrated a stable 54% annual admission from 1992 to 2001.15 The HCUP showed a decline in TIA hospitalizations from 1997 to 2005.8 Recent data from the NHAMCS showed that the percentage of hospital admissions from emergency departments (EDs) for acute ischemic stroke (AIS) or TIA increased from 71% to 78%, whereas ED visits decreased 35% between 2001 and 2011.16

![Age Adjusted TIA Hospitalization Rates by Age Categories in US Population from 2000 to 2010](image1)

**Figure 1.** Age-category–specific TIA hospitalization rates per 100 000 in the United States from 2000 to 2010. TIA indicates transient ischemic attack.

![Age Adjusted TIA Hospitalization Rates by Race in US Population from 2000 to 2010](image2)

**Figure 2.** Race/ethnic differences in age-adjusted TIA hospitalization rates per 100 000 in the United States from 2000 to 2010. TIA indicates transient ischemic attack.
Cohort studies, such as Greater Cincinnati/Northern Kentucky Stroke Study (GCNKSS), Brain Attack Surveillance in Corpus Christi Project (BASIC), and Rochester, Minnesota, have shown that TIA incidence increases with age, is higher in men, and is higher in blacks compared to whites. Administrative data from NHAMCS showed that incidence rates increased with age, is higher in women, whites and non-Hispanics. Similarly, data regarding AIS epidemiology show increased incidence with age, male sex, and higher rates in blacks and Hispanics compared to whites. Trend analysis have shown an overall decline in age-adjusted AIS rates with increasing rates for the young.

Our finding of higher TIA hospitalization rates in older individuals corroborated previous studies; however, we uniquely showed an increase in TIA hospitalization rates from 2000 to 2010 in young adults and a decrease for individuals aged >45 years. We showed that TIA hospitalization rates were lower in men, consistent with a past ED diagnosis-based national database, though differing from 2 previous cohort studies. Our finding of steeper declines in men compared to women has not been previously described. TIA hospitalization rates were greatest in blacks throughout the decade, consistent with a previous cohort study, though differing from an ED diagnosis-based national database. This is the first study to show increasing TIA hospitalizations in blacks and decreasing rates in whites and Hispanics.

Figure 3. Sex differences in age-adjusted TIA hospitalization rates per 100,000 in the United States from 2000 to 2010. TIA indicates transient ischemic attack.

DOI: 10.1161/JAHA.116.004026
| Age, y | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|--------|------|------|------|------|------|------|------|------|------|------|------|
| 25–44, % | 3.88 | 4.15 | 4.53 | 4.63 | 4.85 | 5.1 | 5.27 | 5.17 | 4.91 | 5.1 | 5.1 |
| 45–64, % | 21.29 | 25.05 | 25.43 | 25.45 | 25.54 | 25.59 | 25.63 | 25.79 | 25.88 | 25.59 | 25.59 |
| 65–84, % | 56.08 | 51.22 | 52.59 | 52.39 | 52.23 | 49.51 | 49.23 | 49.49 | 49.21 | 49.21 | 49.21 |
| Over 85, % | 17.77 | 18.15 | 17.77 | 17.77 | 17.77 | 17.77 | 17.77 | 17.77 | 17.77 | 17.77 | 17.77 |
| Charlson index | <1, % | 80.62 | 80.47 | 80.11 | 79.32 | 78.12 | 77.93 | 77.74 | 77.55 | 77.37 | 77.2 |
| ≥1, % | 19.38 | 19.53 | 19.89 | 20.68 | 21.88 | 22.07 | 22.26 | 22.45 | 22.63 | 22.83 | 22.83 |
| Discharge status | Against medical advice, % | 0.73 | 0.49 | 0.42 | 0.42 | 0.42 | 0.42 | 0.42 | 0.42 | 0.42 | 0.42 |
| Died in hospital, % | 13.36 | 13.42 | 13.42 | 13.42 | 13.42 | 13.42 | 13.42 | 13.42 | 13.42 | 13.42 | 13.42 |
| Discharged alive, destination unknown, % | 7.97 | 8.17 | 8.17 | 8.17 | 8.17 | 8.17 | 8.17 | 8.17 | 8.17 | 8.17 | 8.17 |
| Home health care, % | 7.97 | 8.17 | 8.17 | 8.17 | 8.17 | 8.17 | 8.17 | 8.17 | 8.17 | 8.17 | 8.17 |
| Other, including SNF, intermediate care, another type of facility, % | 12.65 | 13.27 | 13.46 | 13.27 | 13.46 | 13.46 | 13.46 | 13.46 | 13.46 | 13.46 | 13.46 |
| Routine, % | 76.99 | 76.73 | 76.73 | 76.73 | 76.73 | 76.73 | 76.73 | 76.73 | 76.73 | 76.73 | 76.73 |
| Short-term hospital, % | 1.52 | 1.35 | 1.35 | 1.35 | 1.35 | 1.35 | 1.35 | 1.35 | 1.35 | 1.35 | 1.35 |

Sex

- Female, % | 59.22 | 59.5 | 60.19 | 59.42 | 59.2 | 59.42 | 59.2 | 59.42 | 59.2 | 59.42 | 59.2 |
- Male, % | 40.78 | 40.5 | 40.5 | 40.5 | 40.5 | 40.5 | 40.5 | 40.5 | 40.5 | 40.5 | 40.5 |

Hospital bed size

- Large, % | 5.83 | 6.09 | 6.49 | 6.15 | 6.34 | 6.34 | 6.34 | 6.34 | 6.34 | 6.34 | 6.34 |
- Medium, % | 28.24 | 27.22 | 26.14 | 26.14 | 26.14 | 26.14 | 26.14 | 26.14 | 26.14 | 26.14 | 26.14 |
- Small, % | 12.83 | 12.29 | 12.29 | 12.29 | 12.29 | 12.29 | 12.29 | 12.29 | 12.29 | 12.29 | 12.29 |
### Table 2. Continued

| Hospital region | 2000  | 2001  | 2002  | 2003  | 2004  | 2005  | 2006  | 2007  | 2008  | 2009  | 2010  |
|-----------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Midwest, %      | 21.38 | 23.5  | 22.75 | 22.15 | 24.19 | 22.12 | 22.75 | 22.35 | 22.57 | 20.46 | 21.3  |
| Northeast, %     | 23.11 | 20.79 | 21.6  | 22.27 | 20.53 | 21.97 | 22.02 | 20.6  | 21.13 | 22.14 | 23.42 |
| South, %        | 41.16 | 42.04 | 42.32 | 40.85 | 41.85 | 41.65 | 41.28 | 41.75 | 41.97 | 42.68 | 40.25 |
| West, %         | 14.35 | 13.67 | 13.33 | 14.73 | 13.43 | 14.26 | 13.94 | 15.3  | 14.33 | 14.72 | 15.02 |

| Length of stay | Mean days ±SE | 3.32 ±0.04 | 3.14 ±0.03 | 3.15 ±0.03 | 3.07 ±0.04 | 2.99 ±0.03 | 2.95 ±0.03 | 2.89 ±0.03 | 2.81 ±0.03 | 2.68 ±0.03 | 2.6 ±0.03 | 2.56 ±0.03 |

| Payment types | Medicaid, % | 4.06 | 4 | 4.26 | 5 | 4.63 | 4.74 | 5.13 | 5.03 | 5.29 | 6 | 6.43 |
|---------------|-------------|------|---|------|---|------|------|------|------|------|---|------|
|               | Medicare, % | 71.06 | 71.33 | 71.02 | 69.95 | 68.88 | 68.96 | 68 | 66.18 | 64.99 | 65.16 | 65.39 |
|               | No charge, % | 0.21 | 0.19 | 0.19 | 0.17 | 0.23 | 0.45 | 0.36 | 0.3 | 0.47 | 0.49 | 0.36 |
|               | Other pay, % | 1.49 | 1.55 | 1.38 | 1.63 | 1.64 | 1.59 | 1.78 | 2.16 | 2.16 | 1.89 | 2.2 |
|               | Private including HMO, % | 21.09 | 20.7 | 20.74 | 21 | 21.89 | 21.13 | 21.66 | 22.75 | 23.65 | 22.41 | 21.25 |
|               | Self pay, % | 2.09 | 2.23 | 2.41 | 2.26 | 2.73 | 3.14 | 3.06 | 3.58 | 3.44 | 4.06 | 4.37 |

| Race | Asian/Pacific, % | 1.28 | 1.46 | 1.62 | 1.93 | 1.86 | 1.55 | 1.53 | 1.96 | 1.69 | 1.69 | 1.81 |
|      | Black, %         | 11.01 | 11.24 | 12.88 | 12.95 | 14.46 | 11.75 | 13.62 | 14.93 | 13.32 | 13.88 | 15.55 |
|      | Hispanic, %      | 6.59 | 6.46 | 7.27 | 9.5 | 7.96 | 7.74 | 9.04 | 8.18 | 7.29 | 8.87 | 8.52 |
|      | Native American, % | 0.26 | 0.38 | 0.17 | 0.16 | 0.39 | 0.3 | 0.67 | 0.68 | 0.49 | 0.44 | 0.6 |
|      | Other Race, %    | 1.8 | 1.38 | 1.77 | 2.05 | 1.76 | 2.21 | 1.97 | 2.15 | 2.89 | 2.84 | 2.18 |
|      | White, %         | 79.06 | 79.08 | 76.28 | 73.41 | 73.57 | 76.46 | 73.17 | 72.09 | 74.33 | 72.28 | 71.34 |

| Rural/urban | Rural, % | 20 | 20.06 | 19.01 | 18.53 | 17.86 | 17.28 | 16.34 | 15.27 | 14 | 13.44 | 13.62 |
|            | Urban, % | 80 | 79.94 | 80.99 | 81.47 | 82.14 | 82.72 | 83.66 | 84.73 | 86 | 86.56 | 86.38 |

| Teaching/nonteaching | Nonteaching, % | 66.51 | 66.41 | 67.19 | 67.15 | 67.38 | 69.46 | 60.44 | 62.24 | 60.68 | 62.74 | 59.74 |
|                      | Teaching, %    | 33.49 | 33.59 | 32.81 | 32.85 | 32.62 | 30.54 | 39.56 | 37.76 | 39.32 | 37.26 | 40.26 |

AMA indicates against medical advice; HMO, Health Maintenance Organization; SNF, skilled nursing facility; TIA, transient ischemic attack.

* Hospital bed-size categories defined in Table S1.

DOI: 10.1161/JAHA.116.004026

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23% of patients were evaluated in a day or outpatient clinic setting.39 In addition, not all individuals with TIA symptoms seek medical attention when symptoms resolve.40 Public knowledge of stroke warning signs did not improve from 2000 to 2005 in a large US population survey.41 The likelihood that an individual will seek medical attention after TIA depends on factors such as health literacy, cultural beliefs, insurance status, and access to care, whereas the likelihood of diagnosing TIA depends upon hospital and provider factors. Therefore, although NIS is a national sample of US hospitals, individuals with poor access to care and the uninsured or uninsured were probably less likely to seek care if the symptoms resolved. Second, implementation of the new imaging-based definition of TIA27 may have been variable during the study period, and more-widespread use of MRI may have affected the proportion of individuals coded as TIA versus AIS. Third, given that this is an observational study, one cannot assume causality. Fourth, as with any administrative data set, there is the possibility of coding errors, including the miscoding of TIA as AIS or vice versa.52 Fifth, because of differences in race/ethnic categories in NIS versus the census data, TIA rates are underestimated in Hispanics. In the census, Hispanic ethnicity and race are separate measurements; therefore, populations reported under Hispanics include Hispanic white, Hispanic black, and Hispanic Asian. In NIS, race and ethnicity are combined; individuals are coded as Latino or other race. Despite these limitations, the study’s strengths include large sample size, nation-wide representation, and clinician-based TIA diagnosis. Further research is warranted to determine causes of disparate hospitalization rates, to better ascertain nationwide trends in incidence, and identify strategies to target subgroups who are most vulnerable.

Sources of Funding
This research was supported by the Roxanna Todd Hodges Foundation and Joachim Spilchial (Sanossian).

Disclosures
Towfighi, MD, is supported by 1U54NS081764-01 from the National Institute of Neurological Disorders and Stroke and 11SDG7590160 from the American Heart Association. The remaining authors have no disclosures to report.

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**Table S1. Hospital Bed Size Categories**

| Location and Teaching Status | Hospital Bedsize |
|-----------------------------|------------------|
|                             | Small | Medium | Large |
| **NORTHEAST REGION**        |       |        |       |
| Rural                       | 1-49  | 50-99  | 100+  |
| Urban, nonteaching          | 1-124 | 125-199| 200+  |
| Urban, teaching             | 1-249 | 250-424| 425+  |
| **MIDWEST REGION**          |       |        |       |
| Rural                       | 1-29  | 30-49  | 50+   |
| Urban, nonteaching          | 1-74  | 75-174 | 175+  |
| Urban, teaching             | 1-249 | 250-374| 375+  |
| **SOUTHERN REGION**         |       |        |       |
| Rural                       | 1-39  | 40-74  | 75+   |
| Urban, nonteaching          | 1-99  | 100-199| 200+  |
| Urban, teaching             | 1-249 | 250-449| 450+  |
| **WESTERN REGION**          |       |        |       |
| Rural                       | 1-24  | 25-44  | 45+   |
| Urban, nonteaching          | 1-99  | 100-174| 175+  |
| Urban, teaching             | 1-199 | 200-324| 325+  |

Note: Table S1. Hospital Bed Size and Categories. Reprinted from HCUP NIS Description of Data Elements, in Healthcare Cost and Utilization Project (HCUP), Retrieved August 26, 2016, from https://www.hcup-us.ahrq.gov/db/vars/hosp_bedsize/nisnote.jsp. Copyright 2008 by the Agency for Healthcare Research and Quality. Reprinted with permission.

**Supplemental Reference:**

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