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## Hospital-Based Stroke Diagnoses Among the Oldest Old in the United States 1997 to 2006

Bruce Ovbiagele, MD, MSc

**Background and Purpose**—Continued surveillance of stroke trends among the very elderly is needed to determine how best to mitigate the likely rise with time in the proportion of strokes in this relatively understudied age group. This study assessed recent time trends in the proportion of hospitalized patients with stroke who are very elderly.

**Methods**—Data were obtained from all US states that contributed to the Nationwide Inpatient Sample. Patients with stroke diagnoses were identified by the International Classification of Diseases, 9th Revision procedure codes. Percentage of stroke diagnoses among persons aged  $\geq 80$  years was evaluated.

**Results**—Between 1997 and 2006, the absolute number of US hospital-based stroke diagnoses lessened (from 680 666 to 609 381). Of all patients with stroke, very elderly men constituted 25.2% in 1997 versus 25.1% in 2006 ( $P=0.83$ ), whereas very elderly women were 39.5% in 1997 versus 39.9% in 2006 ( $P=0.55$ ). Very elderly persons comprised similar percentages of primary acute ischemic stroke in 1997 versus 2006, but their proportion of primary acute intracerebral hemorrhages rose from 29.4% in 1997 to 32.2% in 2006 ( $P=0.005$ ) and of primary acute subarachnoid hemorrhages from 12.5% in 1997 to 14.5% in 2006 ( $P=0.039$ ).

**Conclusion**—Across the last decade, the overall percentage of persons in the United States hospitalized with stroke, who were very elderly, remained unchanged, but the proportion of persons with primary acute hemorrhagic strokes who were very elderly increased. (*Stroke*. 2010;41:1820-1822.)

**Key Words:** acute cerebral ischemia ■ acute stroke ■ elderly ■ epidemiology trends ■ hospitalization ■ incidence ■ oldest old ■ outcomes ■ sex-specific stroke diagnosis ■ United States population

Due to a major shift in age structure toward very elderly populations ( $\geq 80$  years) and the fact that stroke incidence is generally highest in the very elderly, it is expected that there will correspondingly be an increasingly higher proportion of strokes in this age group.<sup>1</sup> Awareness of recent trends in stroke incidence among the very elderly, especially by sex, could be helpful for planning purposes by healthcare policymakers at all levels as the inevitable graying of society continues. This study aimed to assess US trends in the percentage of stroke hospitalizations among men and women aged  $\geq 80$  years between 1997 and 2006.

### Methods

Data were obtained from the Nationwide Inpatient Sample (NIS), which approximates a stratified 20% sample of all non-Federal, short-term, general, and specialty hospitals serving adults in the United States. Detailed information on the design of the NIS is available at [www.hcup-us.ahrq.gov](http://www.hcup-us.ahrq.gov). From 1997 to 2006, NIS captured discharge-level information on several million discharges each year. A unique hospital identifier allows for linkage of discharge data to an NIS data set with hospital characteristics.

All patients with a diagnosis of stroke were included whether they were alive or dead at the time of discharge. To analyze percentages

of hospital-based stroke diagnoses, all discharges with International Classification of Diseases, 9th Revision, Clinical Modification codes 430.xx to 438.xx included in any of the diagnoses were identified. For patients with  $>1$  reported code, only the first reported code was included to avoid double-counting patients with multiple reported codes. The primary analysis assumed that using both primary and secondary codes identified all hospital strokes, but secondary analyses looked specifically at primary stroke diagnosis alone and primary acute stroke diagnoses by type alone. To adjust for likely overascertainment of stroke due to using both primary and secondary diagnoses, the procedure proposed by Williams et al was used.<sup>2</sup> By this procedure, the estimated number of strokes by International Classification of Diseases, 9th Revision, Clinical Modification code 430 to 438 was obtained by multiplying number of discharges with each International Classification of Diseases, 9th Revision, Clinical Modification code by its estimated positive predictive value for stroke derived by pooling data from previously published studies.<sup>2</sup> For example, pooled positive predictive value estimate for code 434 was 573 of 701 (82%).<sup>2</sup> Weighted estimate for total number of strokes with code 434 was obtained by multiplying the weighted total number of strokes with this code by its pooled positive predictive value estimate (0.82). As such, the sample number of strokes with code 434 in the NIS data set was 846 791, the corresponding weighted number of strokes after applying the NIS survey weights was 4 141 216, and the corresponding corrected number of strokes

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**Table 1. Descriptive Summary of Persons Aged  $\geq 80$  Years With a Hospital-Based Stroke Diagnosis in the United States: 1997 Versus 2006**

Variable	Description	Year 1997				Year 2006			
		Sample Frequency	Weighted Frequency	Weighted Percent	SE	Sample Frequency	Weighted Frequency	Weighted Percent	SE
Sex	Male	49 787	77 553	34.47	0.27	50 720	70 423	34.94	0.26
	Female	86 547	147 443	65.53	0.27	83 585	131 155	65.06	0.26
Race	White	96 140	157 215	87.06	0.76	82 153	123 531	82.06	1.03
	Black	8544	13 304	7.37	0.52	9238	11 999	7.97	0.59
	Hispanic	4549	6316	3.50	0.54	6300	8360	5.55	0.67
	Other	2428	3749	2.08	0.22	4712	6656	4.42	0.51
Primary payer	Medicare	125 314	204 652	91.12	0.48	126 151	187 843	93.30	0.34
	Medicaid	1375	2388	1.06	0.11	1331	1966	0.98	0.09
	Private	8251	15 332	6.83	0.45	5397	9226	4.58	0.32
	Other	1242	2223	0.99	0.13	1265	2289	1.14	0.13
Hospital region	Northeast	28 650	46 017	20.45	0.83	26 866	41 968	20.82	1.20
	Midwest	32 459	55 185	24.53	0.83	33 600	51 246	25.42	1.04
	South	50 818	84 323	37.47	1.02	49 369	72 697	36.06	1.25
	West	24 417	39 489	17.55	0.83	24 478	35 684	17.70	0.83
Hospital location	Rural	27 734	47 955	21.35	0.68	21 665	35 862	17.83	0.72
	Urban	108 373	176 670	78.65	0.68	112 308	165 228	82.17	0.72
Teaching status	Nonteaching	101 085	164 988	73.45	1.03	81 949	121 440	60.39	1.40
	Teaching	35 022	59 636	26.55	1.03	52 024	79 650	39.61	1.40
Admission source	Emergency	80 007	141 443	65.02	0.88	89 330	147 743	73.52	0.94
	Another health facility	16 138	26 228	12.06		11 761	12 695	6.32	0.34
	Routine	35 214	49 881	22.93	0.80	32 713	40 519	20.16	0.86
	Quarter 1	Median	Quarter 3		Quarter 1	Median	Quarter 3		
Age, years	82	84.2	88		82	84.7	89		

was  $4\,141\,216 \times 0.82 = 3\,395\,797$ . Total number of stroke hospitalizations was obtained by summing across codes.

Weighted percentages of stroke hospitalizations among men and women in the sample were computed. Race was not adjusted for given the large amount of missing data on this variable ranging from 21% to 28% for years 1998 to 2006 and 9% for year 1997. We tested for significant trends in hospitalization percentage over years using linear logistic regression at the same time as adjusting for necessary survey design variables. To test for curvilinear trends, we included year as a continuous variable together with the quadratic term to the regression models. Probability values for assessing sex differences in hospitalizations across the study period were computed using contrasts (Z-tests) under the regression model. All data analyses were conducted using SAS (Version 9.1; SAS Institute Inc, Cary, NC). Statistical hypotheses were tested using  $P < 0.05$  as the level of statistical significance.

## Results

Across the 10-year study period, the proportion of persons aged  $\geq 80$  years in the US population rose very modestly (Supplemental Figure I; available at <http://stroke.ahajournals.org>). Supplemental Table I confirmed a subtle shift in the age distribution among the oldest old toward older ages.

Over the study period, actual number of total hospital-based stroke diagnoses decreased from 680 666 to 609 381 (10.5%). Table 1 displays descriptive summary statistics (for simplicity, only results for years 1997 and 2006 are shown). These results are generally comparable across variables, but

there was a 5 percentage point drop in those persons categorized as being of white race, a substantial increase in the proportion of teaching hospitals, and a 6-point percentage reduction in admission sources other than the emergency room. Supplemental Table II shows stroke rates in the oldest old age groups: rates increased in persons aged 85 to 89 years relative to persons aged 80 to 84 years and declined at some point beyond age 90 to 94 years in both men and women.

Table 2 shows percent of stroke diagnoses in men and women aged  $\geq 80$  years by study year. Percentage of stroke diagnoses among very elderly men was 25.2% in 1997 versus 25.1% in 2006 ( $P = 0.827$ ), whereas stroke diagnoses among very elderly women was 39.5% in 1997 versus 39.9% in 2006 ( $P = 0.553$ ). There was no difference in the rate of change in stroke diagnoses between the sexes (probability value for comparing change [slope] = 0.55). Primary stroke (Table 3) diagnoses showed similar patterns as the result for the overall hospital-based stroke diagnoses, but primary acute stroke by type indicated that although ischemic stroke rates remained flat, hemorrhagic stroke rates increased (Supplemental Table III). The very elderly percentage of primary acute intracerebral hemorrhages rose from 29.4% in 1997 to 32.2% in 2006 ( $P = 0.005$ ), whereas their proportion of primary acute subarachnoid hemorrhage rose from 12.5% in 1997 to 14.5% in 2006 ( $P = 0.039$ ).

**Table 2. Percentage of Overall Hospital-Based Stroke Diagnoses in Persons Aged  $\geq 80$  Years in the United States: 1997 to 2006**

Year	Males			Females		
	Weighted Total No.	Percent Aged $\geq 80$ Years	SE	Weighted Total No.	Percent Aged $\geq 80$ Years	SE
1997	307 429	25.23%	0.37%	373 1237	39.50%	0.42%
1998	299 594	25.36%	0.35%	371 032	39.79%	0.38%
1999	284 368	25.60%	0.35%	356 845	40.02%	0.42%
2000	276 653	25.40%	0.34%	352 684	39.87%	0.41%
2001	277 946	26.17%	0.36%	350 798	40.52%	0.41%
2002	275 213	26.28%	0.36%	345 748	40.12%	0.39%
2003	272 844	25.46%	0.38%	337 062	39.70%	0.43%
2004	270 531	24.87%	0.40%	327 517	39.34%	0.46%
2005	270 225	26.32%	0.40%	322 842	40.85%	0.43%
2006	280 438	25.11%	0.38%	328 943	39.87%	0.46%

### Discussion

This study found that over the last decade, the percentage of strokes in the oldest old in society remained roughly the same. The reasons for the lack of any corresponding rise in the proportion of strokes along with the increasingly older population are not immediately clear. However, there are some conceivable explanations. First, it could well be that the evolving

**Table 3. Percentage of Hospital-Based Primary Stroke Diagnoses in Persons Aged  $\geq 80$  Years in the United States: 1997 to 2006**

Year	Males			Females		
	Weighted Total No.	Percent Aged $\geq 80$ Years	SE	Weighted Total No.	Percent Aged $\geq 80$ Years	SE
1997	223 980	25.0%	0.4%	276 543	39.8%	0.4%
1998	224 342	24.9%	0.4%	280 413	39.8%	0.4%
1999	211 617	25.2%	0.4%	268 165	40.0%	0.4%
2000	208 949	24.8%	0.3%	270 022	39.7%	0.4%
2001	209 896	25.5%	0.4%	266 820	40.4%	0.4%
2002	205 467	25.6%	0.4%	260 085	40.1%	0.4%
2003	205 616	24.8%	0.4%	254 445	39.6%	0.5%
2004	202 715	24.2%	0.4%	246 685	39.3%	0.5%
2005	198 523	25.6%	0.4%	239 151	41.0%	0.5%
2006	204 464	24.4%	0.4%	241 639	40.1%	0.5%

trend toward an older society may have been possibly outweighed by a greater relative impact of preventive care among the very elderly thereby lowering the number of these individuals admitted to the hospital with stroke. This explanation, although tempting, is generally not borne out by the underdiagnosis and undertreatment generally seen among the very elderly with or at risk for stroke.<sup>1</sup> Second, educational campaigns in the recent decade to raise awareness about stroke warning signs and availability of stroke treatment<sup>3</sup> may have prompted relatively younger individuals to be taken to hospitals more frequently than the very elderly, the latter of whom frequently receive less aggressive care.<sup>1</sup> Third, it is possible that over the study period there may have been a boost in nonhospital strokes among the very elderly that were not captured by this study. The substantial increase in the proportion of strokes diagnosed at teaching hospitals, and percentage reduction in admission sources other than the emergency room, may lend some support to the 2 latter speculative points.

Of note, an analysis of acute stroke by type revealed that although rates of acute ischemic stroke diagnosis among the oldest old also remained flat, rates of intracerebral hemorrhage and subarachnoid hemorrhage showed a pattern of modest increase. This slight rise in acute hemorrhagic stroke rates coincided with the observed modest aging among the very elderly and is certainly a trend to watch in the years to come.

The study was limited by possible inaccurate reporting of International Classification of Diseases codes and lack of information on the rate of nonhospital strokes. However, it was strengthened by its nationwide scope, incidence data, hospital-diagnosed strokes, and inclusion of analysis of both primary and secondary stroke diagnoses (which minimized the false-negative rate) and primary stroke diagnoses only.

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### Disclosures

None.

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