

Prevalence of Cardiovascular Risk Factors and Strokes in Younger Adults

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IMPORTANCE While stroke mortality rates have decreased substantially in the past 2 decades, this trend has been primarily limited to older adults. Increasing trends in stroke incidence and hospitalizations have been noted among younger adults, but there has been concern that this reflected improved diagnosis through an increased use of imaging rather than representing a real increase.

OBJECTIVES To determine whether stroke hospitalization rates have continued to increase and to identify the prevalence of associated stroke risk factors among younger adults.

DESIGN, SETTING, AND PARTICIPANTS Hospitalization data from the National Inpatient Sample from 1995 through 2012 were used to analyze acute stroke hospitalization rates among adults aged 18 to 64 years. Hospitalization data from 2003 to 2012 were used to identify the prevalence of associated risk factors for acute stroke. Acute stroke hospitalizations were identified by the principal *International Classification of Diseases, Ninth Revision, Clinical Modification* code and associated risk factors were identified by secondary *International Classification of Diseases, Ninth Revision, Clinical Modification* codes for each hospitalization.

MAIN OUTCOMES AND MEASURES Trends in acute stroke hospitalization rates by stroke type, age, sex, and race/ethnicity, as well as the prevalence of associated risk factors by stroke type, age, and sex.

RESULTS The 2003-2004 set included 362 339 hospitalizations and the 2011-2012 set included 421 815 hospitalizations. The major findings in this study are as follows: first, acute ischemic stroke hospitalization rates increased significantly for both men and women and for certain race/ethnic groups among younger adults aged 18 to 54 years; they have almost doubled for men aged 18 to 34 and 35 to 44 years since 1995-1996, with a 41.5% increase among men aged 35 to 44 years from 2003-2004 to 2011-2012. Second, the prevalence of stroke risk factors among those hospitalized for acute ischemic stroke continued to increase from 2003-2004 through 2011-2012 for both men and women aged 18 to 64 years (range of absolute increase: hypertension, 4%-11%; lipid disorders, 12%-21%; diabetes, 4%-7%; tobacco use, 5%-16%; and obesity, 4%-9%). Third, the prevalence of having 3 to 5 risk factors increased from 2003-2004 through 2011-2012 (men: from 9% to 16% at 18-34 years, 19% to 35% at 35-44 years, 24% to 44% at 45-54 years, and 26% to 46% at 55-64 years; women: 6% to 13% at 18-34 years, 15% to 32% at 35-44 years, 25% to 44% at 45-54 years, and 27% to 48% at 55-65 years; *P* for trend < .001). Finally, hospitalization rates for intracerebral hemorrhage and subarachnoid hemorrhage remained stable, with the exception of declines among men and non-Hispanic black patients aged 45 to 54 with subarachnoid hemorrhage (13.2/10 000 to 10.3/10 000 hospitalizations and 15.8/10 000 to 11.5/10 000 hospitalizations, respectively).

CONCLUSIONS AND RELEVANCE The identification of increasing hospitalization rates for acute ischemic stroke in young adults coexistent with increasing prevalence of traditional stroke risk factors confirms the importance of focusing on prevention in younger adults.

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Stroke was the third leading cause of death in the United States from 1938 to 2007, and dropped to the fifth leading cause of death in 2013.¹ Yet, the relative rate of decline in mortality among those aged 65 years and older is approximately double the rate of decline among those aged 45 to 64 years.¹ The overall decline in stroke mortality over the past 50 years reflects the improved control of hypertension through efforts such as the National Heart, Lung, and Blood Institute's Joint National Commission guidelines on hypertension control, as well as increased treatment of atrial fibrillation with anticoagulants, increased use of aspirin for secondary prevention, improvements in stroke care through structured quality improvement programs, and the development of stroke systems of care that promote the use of evidence-based care.²

Against this backdrop of overall declining stroke mortality rates is suggestive evidence that acute stroke incidence rates among younger adults are increasing.³ In 2011, we reported that acute stroke hospitalization rates were increasing among young adults aged 15 to 44 years.⁴ Studies since then suggest that this increase is likely not due to increased use of imaging.^{3,5} Additionally, while rates of some traditional stroke risk factors have declined over the past decade in the overall adult population (tobacco smoking), many others have shown little change or have increased (overweight, obesity, diabetes, hypertension, and hypercholesterolemia).^{6,7} It is important to understand whether these risk factor patterns are similar among those experiencing an acute stroke. To identify whether previous trends in stroke hospitalization rates and the patterns of associated risk factors have continued, we examined the hospitalization rates for acute stroke by stroke type along with the prevalence of associated risk factors by sex and age group among younger adults (aged 18 to 64 years).

Methods

Data Sources and Study Sample

The National Inpatient Sample (NIS)⁸ is part of the Healthcare Cost and Utilization Project (HCUP),⁸ sponsored by the Agency for Healthcare Research and Quality. The NIS is a database of hospital inpatient stays derived from billing data submitted by hospitals to statewide data organizations across the United States. It is a stratified sample that represents discharges from approximately 20% of all community hospitals participating in HCUP; hospitals are selected based on 5 characteristics: rural/urban location, hospital size, region, teaching status, and ownership. There were 37 states that participated in 2003 and the number of states increased each year to 44 states in 2012.⁸ Because the data are publicly available and do not contain direct personal identifiers, this study was exempt from review by the institutional review board, per Agency for Healthcare Research and Quality guidelines.

International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes were used to identify hospitalizations for subarachnoid hemorrhage (430), intracerebral hemorrhage (431), and acute ischemic stroke (AIS) (433.01, 433.11, 433.21, 433.31, 433.81, 433.91, 434.01, 434.11,

Key Points

Questions Are stroke hospitalization rates for younger adults continuing to increase, and is the prevalence of associated risk factors increasing among those hospitalized for acute stroke?

Findings This analysis found that stroke hospitalization rates from 2003 to 2012 significantly increased for acute ischemic stroke hospitalization rates among men (41.5%) and women (30%) aged 35 to 44 years, with a near doubling of the prevalence of 3 or more of 5 common stroke risk factors among both men and women aged 18 to 64 years hospitalized for acute ischemic stroke.

Meaning Hospitalization rates for acute ischemic stroke in younger adults continued to increase since 1995-1996, coexistent with increasing prevalence of stroke risk factors.

434.91, and 436). For each hospitalization, only the principal diagnosis code was used to identify events, which were then assigned to 1 of 3 mutually exclusive categories: subarachnoid hemorrhage (SAH), intracerebral hemorrhage (ICH), and AIS.

The *ICD-9-CM* code 436 was included in ischemic stroke as recommended by HCUP when doing trend over time analysis across the time as coding instructions changed for this code. The use of this code underwent a change in fiscal year 2005, where coders were instructed to use code 434.91 rather than 436.

Statistical Methods

The unit of analysis was hospital discharge. In this analysis, hospital discharge records were included if the patient was 18 years or older at the time of the hospital admission. We combined NIS annual data to create 5 consecutive 2-year periods from 2003-2004 through 2011-2012. Four age groups were defined: 18 to 34 years, 35 to 44 years, 45 to 54 years, and 55 to 64 years. Separate stroke hospitalization rates for men and women were estimated for each stroke type and age group. Risk factor prevalence was estimated using secondary *ICD-9-CM* codes, taking into account changes in *ICD-9-CM* coding over time (eTable 1 in the Supplement). Common risk factors for stroke in this population were assessed for linear trends using orthogonal polynomial contrasts. We also looked at the combination of the following 5 traditional cardiovascular risk factors related to the stroke: hypertension, diabetes, lipid disorders, obesity, and tobacco use, which were identified as none, 1 to 2 risk factors, or 3 to 5 risk factors to address the burden of multiple stroke risk factors. Linear trends were not reported if the data were too sparse to report based on HCUP reporting guidelines. Further, trends in stroke hospitalizations for those aged 18 to 34, 35 to 44, 45 to 54, and 55 to 64 years by sex from 1995 to 2012 were assessed across 5 periods by using linear regression models.

National estimates were obtained by using individual discharge sampling weights. As a result of changes implemented in the redesign of 2012 NIS data, we used trend weights developed by the Agency for Healthcare Research and Quality to make estimates comparable for data prior to 2012. All statistical analyses were conducted using SAS version 9.3-

Table 1. Prevalence of Acute Ischemic Stroke as the Principal Diagnosis by Age, Sex, and Race/Ethnicity

Demographic	2003-2004		2011-2012		Relative Change, % ^a	P Value for Trend ^b
	Weighted No.	Rates/10 000 Hospitalizations (SE)	Weighted No.	Rates/10 000 Hospitalizations (SE)		
Age 18-34 y	8275	6.6 (0.2)	10 178	8.4 (0.3)	27.3	<.001
Male	3787	15.6 (0.7)	4634	18.0 (0.6)	15.4	.003
Female	4483	4.4 (0.2)	5539	5.8 (0.2)	31.8	<.001
Non-Hispanic white	3034	6.1 (0.3)	4974	8.2 (0.3)	34.4	<.001
Non-Hispanic black	1728	11.1 (0.7)	2354	11.9 (0.6)	7.2	.31
Hispanic	845	4.4 (0.5)	1300	6.2 (0.4)	40.9	.001
Other	460	6.4 (0.8)	775	7.9 (0.7)	23.4	.12
Age 35-44 y	25 350	35.1 (0.9)	28 287	47.6 (1.0)	35.6	<.001
Male	12 923	48.2 (1.3)	14 813	68.2 (1.6)	41.5	<.001
Female	12 417	27.5 (0.8)	13 463	35.8 (1.0)	30.2	<.001
Non-Hispanic white	10 052	30.5 (1.0)	13 551	42.1 (1.2)	38.0	<.001
Non-Hispanic black	5594	54.0 (2.7)	7633	72.4 (2.3)	34.1	<.001
Hispanic	1939	28.4 (1.6)	2995	37.3 (1.6)	31.3	<.001
Other	940	29.4 (2.5)	1985	44.5 (2.5)	51.4	<.001
Age 45-54 y	82 271	102.0 (1.7)	102 082	122.9 (1.6)	20.5	<.001
Male	46 275	120.1 (2.3)	59 472	144.1 (2.1)	20.0	<.001
Female	35 896	86.2 (1.7)	42 583	102.1 (1.6)	18.4	<.001
Non-Hispanic white	35 056	90.2 (2.0)	55 229	111.4 (1.7)	23.5	<.001
Non-Hispanic black	16 563	146.1 (5.1)	24 862	160.9 (3.5)	10.1	.003
Hispanic	5604	94.5 (3.7)	9005	112.5 (3.3)	19.0	<.001
Other	3260	117.5 (7.2)	6127	142.6 (5.3)	21.4	.007
Age 55-64 y	167 053	200.9 (0.9)	202 227	202.5 (0.6)	0.8	.44
Male	94 659	228.8 (3.4)	118 598	234.6 (2.7)	2.5	.10
Female	72 353	173.4 (2.7)	83 607	169.5 (2.0)	-2.2	.34
Non-Hispanic white	82 415	189.6 (3.5)	121 360	187.4 (2.4)	-1.2	.78
Non-Hispanic black	23 807	265.0 (6.4)	39 076	252.0 (4.3)	-4.9	.12
Hispanic	9740	181.8 (6.0)	15 147	199.7 (4.6)	9.8	.02
Other	6353	231.6 (11.6)	11 824	240.3 (6.7)	3.8	.29

^a Relative change = (2011/2012 - 2003/2004) / 2003/2004.

^b P value was obtained by using a linear regression model to assess the linear trends across the 5 periods.

callable SUDAAN (Research Triangle Institute) to account for the multistage, disproportionate stratified sampling design.

Results

Among acute ischemic stroke hospitalizations, rates increased from 2003-2004 through 2011-2012 for all race/ethnic groups; men; and women in age groups 18 to 34, 35 to 44, and 45 to 54 years, except among non-Hispanic black individuals and other race groups for ages 18 to 34 years. Among those aged 55 to 64 years, only Hispanic individuals showed a significant increase in AIS hospitalization rates (from 181.8/10 000 to 199.7/10 000; $P = .02$), but there was no change in stroke hospitalization rates in this age group by sex or among other non-Hispanic race groups (Table 1).

The hospitalization rate for men aged 18 to 34 years increased from 11.2 to 18.0 per 10 000 hospitalizations; for women aged 18 to 34 years, it increased from 3.8 to 5.8 per 10 000 hospitalizations; for men aged 35 to 44 years, it increased from 37.7 to 68.2 per 10 000 hospitalizations; and for

women aged 35 to 44, it increased from 24.8 to 35.8 per 10 000 hospitalizations from 1995-1996 through 2011-2012 (relative percentage increases were 74.8%, 65.7%, 91.0%, and 53.6%, respectively) (eFigure and eTable 2 in the Supplement).

Table 2 shows the prevalence of stroke-related risk factors among adults admitted for AIS by age and sex. Across all age groups and both sexes, increasing prevalence was seen in hypertension, lipid disorders, diabetes, tobacco use, obesity, and among multiple risk factors. The prevalence of 3 or more traditional risk factors (hypertension, diabetes, lipid disorders, obesity, and tobacco use) roughly doubled among all age groups for both men and women, while the prevalence of none of these risk factors decreased. Notably, during the study period of 2003-2004 through 2011-2012, hypertension increased from 34.0% to 41.3%, and lipid disorders increased from 14.6% to 29.1% among men aged 18 to 34 years. Smaller increases were seen among women aged 18 to 34 years, although in 2011-2012, 30.7% had hypertension, 21.7% had lipid disorders, 26.5% used tobacco, and 15.7% were obese. One in 7 men aged 18 to 34 years and 1 in 3 men aged 35 to 44 years had 3 to 5 traditional risk factors. There were small but

Table 2. Prevalence of Risk Factors Among Patients Hospitalized With Acute Ischemic Stroke by Age and Sex

Demographic	% (SE)							Risk Factors (HTN, Diabetes, LD, Obesity, and Tobacco Use)		
	HTN	LDs	Diabetes	Tobacco Use	Obesity	AFib	IHD	None	1-2 Risk Factors	3-5 Risk Factors
Male										
Age 18-34 y										
2003-04	34.0 (1.9)	14.6 (1.3)	15.3 (1.4)	23.1 (1.8)	6.8 (0.9)	2.1 (0.5)	6.4 (0.9)	42.0 (1.9)	48.9 (1.8)	9.1 (1.1)
2011-12	41.3 (1.7) ^a	29.1 (1.5) ^b	15.2 (1.1)	35.7 (1.6) ^b	13.3 (1.1) ^b	2.9 (0.5)	5.5 (0.7)	27.9 (1.6) ^b	55.9 (1.7) ^c	16.2 (1.2) ^b
Age 35-44 y										
2003-04	54.5 (1.1)	29.0 (0.9)	24.3 (0.8)	31.3 (1.2)	7.7 (0.5)	3.2 (0.4)	11.1 (0.6)	22.8 (0.8)	58.6 (0.9)	18.6 (0.8)
2011-12	65.9 (0.9) ^b	47.8 (1.0) ^b	30.3 (0.9) ^b	41.7 (1.0) ^b	15.2 (0.7) ^b	4.3 (0.4)	11.2 (0.6)	12.1 (0.6) ^b	52.9 (0.9) ^b	35.0 (0.9) ^b
Age 45-54 y										
2003-04	69.7 (0.5)	34.6 (0.6)	32.4 (0.5)	32.5 (0.8)	6.1 (0.3)	4.4 (0.2)	21.7 (0.5)	13.2 (0.4)	62.4 (0.6)	24.4 (0.5)
2011-12	76.3 (0.4) ^b	54.7 (0.5) ^b	37.9 (0.5) ^b	47.3 (0.6) ^b	11.7 (0.3) ^b	6.0 (0.2) ^b	20.5 (0.4) ^a	6.9 (0.3) ^b	48.9 (0.5) ^b	44.2 (0.5) ^b
Age 55-64 y										
2003-04	73.7 (0.4)	38.3 (0.5)	35.9 (0.4)	30.8 (0.8)	5.4 (0.2)	7.0 (0.2)	32.3 (0.5)	10.5 (0.3)	63.0 (0.4)	26.4 (0.5)
2011-12	81.1 (0.3) ^b	58.6 (0.4) ^b	41.0 (0.4) ^b	43.8 (0.4) ^b	9.7 (0.2) ^b	9.8 (0.2) ^b	29.5 (0.3) ^b	5.6 (0.2) ^b	47.9 (0.4) ^b	46.5 (0.4) ^b
Female										
Age 18-34 y										
2003-04	26.1 (1.5)	9.6 (1.0)	11.8 (1.2)	21.1 (1.5)	9.1 (1.0)	1.7 (0.4)	2.1 (0.5)	48.6 (1.7)	45.8 (1.6)	5.6 (0.8)
2011-12	30.7 (1.4) ^c	21.7 (1.3) ^b	15.5 (1.1) ^c	26.5 (1.4) ^a	15.7 (1.0) ^b	1.8 (0.4)	3.9 (0.6) ^b	38.5 (1.5) ^b	48.0 (1.6)	13.5 (1.0) ^b
Age 35-44 y										
2003-04	50.1 (1.2)	20.8 (0.9)	24.2 (0.9)	26.9 (1.0)	10.9 (0.7)	1.2 (0.2)	7.3 (0.5)	28.1 (1.1)	56.5 (1.1)	15.4 (0.8)
2011-12	57.3 (1.0) ^b	37.8 (1.0) ^b	31.4 (0.9) ^b	35.8 (1.0) ^b	21.0 (0.8) ^b	2.3 (0.3) ^a	7.2 (0.5)	18.6 (0.8) ^b	49.9 (0.9) ^b	31.6 (0.9) ^b
Age 45-54 y										
2003-04	69.8 (0.6)	32.4 (0.7)	35.2 (0.6)	27.4 (0.8)	9.9 (0.5)	3.0 (0.2)	15.1 (0.4)	13.8 (0.5)	61.1 (0.7)	25.0 (0.6)
2011-12	73.7 (0.6) ^b	50.9 (0.6) ^b	39.6 (0.6) ^b	43.5 (0.6) ^b	17.0 (0.5) ^b	3.9 (0.2) ^a	16.1 (0.4)	8.4 (0.4) ^b	47.9 (0.6) ^b	43.7 (0.6) ^b
Age 55-64 y										
2003-04	76.0 (0.4)	36.7 (0.5)	41.0 (0.5)	24.6 (0.7)	8.2 (0.3)	6.0 (0.2)	22.9 (0.4)	10.0 (0.3)	63.3 (0.5)	26.7 (0.5)
2011-12	81.1 (0.3) ^b	58.0 (0.4) ^b	46.2 (0.4) ^b	36.5 (0.5) ^b	15.6 (0.3) ^b	7.8 (0.2) ^b	22.4 (0.4)	5.8 (0.2) ^b	46.3 (0.4) ^b	47.9 (0.5) ^b

Abbreviations: AFib, atrial fibrillation; HTN, hypertension; IHD, ischemic heart disease; LD, lipid disorder.

^b $P < .001$ for trend.

^c $P < .05$ for trend.

^a $P < .01$ for trend.

significant increases in the prevalence of atrial fibrillation among the older 2 age groups for both men and women. Among those with AIS, the prevalence of ischemic heart disease declined among men aged 45 to 54 and 55 to 64 years, yet increased among women aged 18 to 34 years. There were no changes among the other sex/age groups (Table 2).

There were no changes in ICH hospitalization rates by age, race/ethnicity, or sex from 2003-2004 through 2011-2012 (Table 3). However, men had significantly higher hospitalization rates than women among all age groups. The relative difference between men and women decreased with increasing age group.

Among those with ICH, the prevalence of hypertension among men in 2011-2012 was 44.1% (aged 18-34 years), 73.8% (aged 35-44 years), and 81.4% (aged 45-54 and 55-64 years), and the prevalence of hypertension among men aged 18 to 34 and 35 to 44 years with ICH was higher than the prevalence among their counterparts with AIS. Rates of hypertension among women with ICH were comparable with those with AIS (Table 2 and Table 4). Tobacco use increased among all male

age groups and among women aged 18 to 34, 45 to 54, and 55 to 64 years. There was a significant trend toward increasing prevalence of having multiple stroke risk factors among men and women across all age groups among those hospitalized for ICH (Table 4).

From 2003-2004 through 2011-2012, hospitalization rates for SAH declined among all age groups, but significantly only among men aged 45 to 54 years (13.2/10 000 to 10.3/10 000; $P = .01$), non-Hispanic white individuals (14.5/10 000 to 11.9/10 000; $P = .045$), and non-Hispanic black individuals (15.8/10 000 to 11.5/10 000; $P = .006$). Rates of SAH among Hispanic individuals aged 45 to 54 and 55 to 64 years were significantly higher compared with non-Hispanic white and non-Hispanic black individuals. The hospitalization rate for men aged 18 to 35 years were 3 times the rate of women, but women had significantly higher hospitalization rates for SAH among those aged 45 to 54 and 55 to 64 years (Table 3).

Significant increases in the prevalence of stroke risk factors were seen among hospitalizations for SAH across all age groups of men for hypertension, obesity, and tobacco use and

Table 3. Prevalence of Subarachnoid and Intracerebral Hemorrhage as the Principal Diagnosis by Age, Sex, and Race/Ethnicity

Demographic	Subarachnoid Hemorrhagic Stroke						Intracerebral Hemorrhage Stroke					
	2003-2004		2011-2012		Relative Change, % ^b	P Value for Trend ^c	2003-2004		2011-2012		Relative Change, % ^b	P Value for Trend ^c
	Weighted No.	Rate (SE) ^a	Weighted No.	Rate (SE) ^a			Weighted No.	Rate (SE) ^a	Weighted No.	Rate (SE) ^a		
Age 18-34 y	3567	2.8 (0.2)	3411	2.8 (0.2)	0	>.99	2772	2.2 (0.2)	2888	2.4 (0.2)	9.1	.45
Male	1810	7.5 (0.6)	1646	6.4 (0.5)	-14.7	.10	1695	7.0 (0.5)	1621	6.3 (0.4)	-10.0	.18
Female	1742	1.7 (0.2)	1765	1.9 (0.1)	11.8	.45	1059	1.0 (0.1)	1251	1.3 (0.1)	30.0	.07
NHW	1313	2.6 (0.3)	1362	2.2 (0.2)	-15.4	.15	927	1.9 (0.2)	1139	1.9 (0.2)	0	.96
NHB	523	3.4 (0.4)	831	4.2 (0.4)	23.5	.29	486	3.1 (0.4)	593	3.0 (0.3)	-3.2	.65
Hispanic	490	2.5 (0.3)	629	3.0 (0.3)	20.0	.53	475	2.5 (0.3)	565	2.7 (0.4)	8.0	.53
Other	199	2.8 (0.3)	310	3.2 (0.5)	14.3	.41	175	2.4 (0.4)	323	3.3 (0.4)	37.5	.21
Age 35-44 y	7427	10.3 (0.7)	5282	8.9 (0.5)	-13.6	.08	6056	8.4 (0.4)	5169	8.7 (0.4)	3.6	.43
Male	2997	11.2 (0.9)	2123	9.8 (0.7)	-12.5	.17	3587	13.4 (0.8)	3152	14.5 (0.8)	8.2	.20
Female	4420	9.8 (0.7)	3159	8.4 (0.6)	-14.3	.09	2469	5.5 (0.3)	2017	5.4 (0.3)	-1.8	.95
NHW	2729	8.3 (0.7)	2455	7.6 (0.6)	-8.4	.44	2026	6.1 (0.4)	1783	5.5 (0.4)	-9.8	.43
NHB	1264	12.2 (1.1)	1044	9.9 (0.9)	-18.9	.08	1547	14.9 (1.2)	1423	13.5 (1.0)	-9.4	.52
Hispanic	758	11.1 (1.4)	758	9.4 (0.9)	-15.3	.28	610	8.9 (1.0)	843	10.5 (1.0)	18.0	.44
Other	330	10.3 (1.7)	588	13.2 (1.6)	28.2	.24	451	14.1 (1.8)	741	16.6 (1.6)	17.7	.18
Age 45-54 y	13 474	16.7 (1.2)	11 408	13.7 (0.7)	-18.0	.04	15 858	19.7 (0.9)	16 467	19.8 (0.7)	0.5	.83
Male	5095	13.2 (1.0)	4245	10.3 (0.6)	-22.0	.01	9606	24.9 (1.1)	9854	23.9 (1.0)	-4.0	.48
Female	8284	19.9 (1.5)	7151	17.1 (1.0)	-14.1	.15	6228	15.0 (0.9)	6613	15.9 (0.7)	6.0	.34
NHW	5644	14.5 (1.2)	5895	11.9 (0.7)	-17.9	.045	5146	13.2 (0.7)	6455	13.0 (0.6)	-1.5	.61
NHB	1793	15.8 (1.7)	1779	11.5 (0.9)	-27.2	.006	4231	37.3 (0.3)	4792	31.0 (1.6)	-16.9	.08
Hispanic	1139	19.2 (1.8)	1565	19.6 (1.6)	2.1	.81	1716	28.9 (0.3)	2223	27.8 (1.8)	-3.8	.63
Other	660	23.8 (1.4)	1171	27.3 (2.8)	14.7	.27	1027	37.0 (3.7)	1709	39.8 (2.8)	7.6	.47
Age 55-64 y	10 728	12.9 (0.9)	11 848	11.9 (0.6)	-7.8	.47	19 508	23.5 (0.8)	22 568	22.6 (0.7)	-3.8	.58
Male	3972	9.6 (0.7)	4484	8.9 (0.5)	-7.3	.47	11 250	27.2 (1.0)	13 421	26.5 (0.8)	-2.6	.79
Female	6755	16.2 (1.3)	7364	14.9 (0.8)	-8.0	.56	8258	19.8 (0.8)	9147	18.5 (0.7)	-6.6	.33
NHW	5129	11.8 (1.0)	6770	10.5 (0.6)	-11.0	.26	7809	18.0 (0.8)	11 141	17.2 (0.6)	-4.4	.30
NHB	1020	11.4 (1.1)	1577	10.2 (0.8)	-10.5	.48	3625	40.4 (2.4)	5547	35.8 (1.8)	-11.4	.23
Hispanic	920	17.2 (1.9)	1189	15.7 (1.6)	-8.7	.48	1753	32.7 (2.4)	2263	29.8 (2.0)	-8.9	.29
Other	549	20.0 (1.2)	1139	23.1 (2.4)	15.5	.16	1378	50.2 (4.3)	2055	41.8 (2.7)	-16.7	.11

Abbreviations: NHB, non-Hispanic black; NHW, non-Hispanic white.

^a Rates are per 10 000 hospitalizations.^b Relative change = (2011/2012 - 2003/2004) / 2003/2004.^c P value was obtained by using linear regression model to assess the linear trends across the 5 periods.

for lipid disorders and diabetes among men aged 35 to 44, 45 to 54, and 55 to 64 years. Among women with acute SAH hospitalizations, the prevalence of hypertension increased among all age groups, and the prevalence of diabetes, obesity, and lipid disorders increased among age groups 35 to 44, 45 to 54, and 55 to 64 years. Women aged 45 to 54 years had an increased prevalence of alcohol abuse and tobacco use. The presence of multiple risk factors (inclusive of hypertension, diabetes, lipid disorders, obesity, and tobacco use) shifted toward a greater number of risk factors among both men and women across all age groups (Table 5).

For most age groups and stroke types, there were trends of decreasing in-hospital death and increasing trends of transfer to skilled nursing units/rehabilitation facilities/long-term care facilities (eTable 3, eTable 4, and eTable 5 in the Supplement). While this data set lacks important socioeconomic data, we found that among all age groups and stroke types, between 56% and 60% of stroke hospitalizations occurred among

the lower 50th percentile of median household income of the patients' zip code, with no change over time.

Overall, AIS hospitalizations among those aged 18 to 64 years increased from an average of 141 474 per year in 2003-2004 to 171 386 per year in 2011-2012. Hospitalizations for SAH declined from an average of 17 598 per year in 2003-2004 to 15 974 per year in 2011-2012. There was little change in the number of hospitalizations for ICH (22 097/year in 2003-2004 vs 23 545/year in 2011-2012).

Discussion

The major findings in this study are as follows: first, AIS hospitalization rates increased for both men and women and for certain race/ethnic groups among younger adults aged 18 to 54, and they have almost doubled for men aged 18 to 34 and 35 to 44 years since 1995-1996, while rates for men and women

Table 4. Prevalence of Risk Factors Among Patients Hospitalized With Intracerebral Hemorrhage by Age and Sex

Demographic	% (SE)						Risk Factors (HTN, Diabetes, LD, Obesity, and Tobacco Use)		
	HTN	LDs	Diabetes	Tobacco Use	Obesity	AVM	None	1-2 Risk Factors	3-5 Risk Factors
Male									
Age 18-34 y									
2003-04	34.7 (2.6)	2.9 (0.9)	6.8 (1.4)	13.2 (1.7)	2.7 (0.8)	9.9 (1.6)	54.5 (2.7)	43.4 (2.6)	NR ^a
2011-12	44.1 (2.7) ^b	6.0 (1.2) ^b	10.3 (1.9) ^b	25.8 (2.4) ^c	7.1 (1.4) ^d	11.7 (1.9)	39.0 (2.6) ^c	53.5 (2.7) ^d	7.4 (1.5)
Age 35-44 y									
2003-04	64.5 (1.8)	9.8 (1.1)	15.4 (1.3)	16.2 (1.5)	4.3 (0.7)	4.1 (0.7)	27.0 (1.6)	65.8 (1.6)	7.3 (0.9)
2011-12	73.8 (1.7) ^c	14.3 (1.3) ^c	21.2 (1.6) ^c	22.2 (1.6) ^d	10.1 (1.3) ^c	4.2 (0.9)	16.1 (1.5) ^c	71.8 (1.8) ^d	12.1 (1.2) ^c
Age 45-54 y									
2003-04	73.2 (1.0)	10.8 (0.7)	20.4 (0.9)	18.5 (1.1)	4.7 (0.5)	1.0 (0.2)	18.6 (0.9)	71.8 (1.0)	9.6 (0.7)
2011-12	81.4 (1.0) ^c	23.3 (1.0) ^c	28.2 (0.9) ^c	26.9 (1.1) ^c	9.9 (0.7) ^c	2.4 (0.4) ^d	10.9 (0.8) ^c	67.7 (1.0) ^d	21.4 (0.9) ^c
Age 55-64 y									
2003-04	78.3 (0.9)	16.0 (0.8)	28.2 (1.0)	16.4 (0.9)	4.2 (0.4)	1.4 (0.2)	14.6 (0.7)	72.8 (1.0)	12.5 (0.8)
2011-12	81.4 (0.8) ^c	31.3 (0.9) ^c	35.0 (0.9) ^c	26.7 (0.9) ^c	7.9 (0.5) ^c	1.8 (0.3)	10.5 (0.6) ^c	63.8 (0.9) ^c	25.7 (0.8) ^c
Female									
Age 18-34 y									
2003-04	25.5 (2.9)	NR ^a	5.9 (1.5)	8.6 (1.8)	NR ^a	12.2 (2.3)	64.7 (3.1)	34.9 (3.1)	NR ^a
2011-12	28.1 (2.9)	NR ^a	8.0 (1.8)	23.9 (2.9) ^c	9.4 (1.9)	13.0 (2.1)	47.0 (3.6) ^c	50.2 (3.5) ^c	NR ^a
Age 35-44 y									
2003-04	52.9 (2.2)	6.9 (1.1)	10.1 (1.3)	16.2 (1.8)	7.1 (1.1)	4.7 (0.9)	35.8 (2.1)	58.0 (2.3)	6.2 (1.1)
2011-12	60.1 (2.6) ^b	11.6 (1.6) ^d	22.2 (2.1) ^c	16.0 (1.9)	15.2 (1.8) ^c	6.2 (1.3)	29.3 (2.3) ^d	55.8 (2.5)	14.9 (1.9) ^c
Age 45-54 y									
2003-04	71.0 (1.5)	9.1 (0.9)	21.7 (1.1)	14.3 (1.1)	7.4 (0.8)	2.5 (0.5)	21.0 (1.3)	71.6 (1.4)	7.4 (0.7)
2011-12	76.7 (1.2) ^c	18.7 (1.1) ^c	29.3 (1.2) ^c	25.2 (1.4) ^c	13.5 (1.0) ^c	3.2 (0.5)	13.9 (1.0) ^c	66.3 (1.3) ^c	19.9 (1.2) ^c
Age 55-64 y									
2003-04	73.7 (1.1)	15.6 (0.9)	27.3 (1.1)	13.1 (1.0)	6.1 (0.6)	1.8 (0.3)	18.3 (0.9)	70.9 (1.0)	10.8 (0.8)
2011-12	81.0 (1.1) ^c	29.7 (1.2) ^c	33.8 (1.1) ^c	20.8 (1.1) ^c	12.5 (0.8) ^c	1.5 (0.3)	10.8 (0.8) ^c	65.4 (1.2) ^d	23.8 (1.2) ^c

Abbreviations: AVM, arteriovenous malformation; HTN, hypertension; LD, lipid disorder; NR, not reported.

^c P value for trend < .001.

^d P value for trend < .01.

^a Not reportable based on the estimates with a relative SE greater than 0.30.

^b P value for trend < .05.

aged 55 to 64 have not changed from 2003-2004. Second, the hospitalization rates for ICH did not change from 2003-2004 to 2011-2012 among those aged 18 to 64 years, while the only change in hospitalization rates for SAH was a decrease among men and non-Hispanic individuals aged 45 to 54 years. Third, the prevalence rates of multiple risk factors associated with people experiencing AIS and ICH hospitalizations have continued to increase for both men and women of all age groups studied over the most recent decade of available data, and they are consistent with increases seen from 1995-1996 and 2007-2008. Finally, the prevalence of having multiple traditional stroke risk factors among young adults experiencing an AIS has doubled over the decade from 2003-2004 through 2011-2012.

The increasing trends in AIS hospitalization rates among the 3 younger age groups (18-34 years: 27.3% increase; 35-44 years: 35.6% increase; and 45-54 years: 20.5% increase) are consistent with other studies,^{3,9} as well as earlier hospitalization trends.⁴ They are also associated with high and increasing

trends in the prevalence of having multiple traditional cardiovascular risk factors.⁹⁻¹² This is also consistent with a clinical study reported 25 years ago, which found that among young adults aged 15 to 45 years, AIS was due to atherosclerotic disease in one-third of patients.¹³ Both small- and large-vessel disease have been identified as an increasing cause of AIS beginning at age 30 years.¹⁴ It is unclear why hospitalization rates among non-Hispanic black individuals aged 18 to 34 years remained stable; however, Kissela et al³ noted a nonsignificant increase in incident stroke rates among black individuals aged 20 to 44 years from 1993 to 2005 and yet a significant increase among white individuals. The young adult population experiencing AIS has rates of traditional stroke risk factors that are also nearly double that of their peers in the general population or greater.⁷ Approximately 12% of the general population aged 45 to 64 years has diabetes,⁷ yet approximately 40% of those hospitalized with an AIS had diabetes. Tobacco use is high among men of all age groups experiencing an AIS, at rates nearly double the national rate among adults. In com-

Table 5. Prevalence of Risk Factors Among Patients Hospitalized With Subarachnoid Hemorrhage by Age and Sex

Demographic	HTN	LDs	Diabetes	Tobacco Use	Obesity	Other Drug Abuse	Risk Factors (HTN, Diabetes, LD, Obesity, and Tobacco Use)		
							None	1-2 Risk Factors	3-5 Risk Factors
Male									
Age 18-34 y									
2003-04	20.0 (2.0)	NR ^a	NR ^a	17.9 (2.2)	2.7 (0.8)	14.3 (1.8)	65.6 (2.4)	33.1 (2.4)	NR ^a
2011-12	32.8 (2.6) ^b	4.3 (1.1)	7.5 (1.5)	33.9 (2.7) ^b	5.9 (1.2) ^c	17.7 (2.1)	41.0 (2.7) ^b	55.7 (2.8) ^b	3.3 (1.0)
Age 35-44 y									
2003-04	35.5 (1.8)	6.2 (0.9)	5.8 (0.8)	25.7 (2.1)	1.9 (0.5)	6.6 (1.0)	44.3 (2.2)	53.3 (2.1)	2.4 (0.6)
2011-12	48.0 (2.5) ^b	13.9 (1.7) ^b	18.9 (2.2) ^b	35.4 (2.6) ^c	6.7 (1.2) ^b	7.7 (1.3)	28.6 (2.4) ^b	58.5 (2.3) ^d	12.9 (1.7) ^b
Age 45-54 y									
2003-04	48.1 (1.7)	8.2 (0.9)	10.3 (0.9)	25.4 (1.7)	3.5 (0.6)	5.9 (0.8)	36.8 (1.8)	57.9 (1.6)	5.3 (0.6)
2011-12	60.1 (1.8) ^b	16.5 (1.3) ^b	19.2 (1.5) ^b	35.3 (1.8) ^b	6.5 (0.9) ^c	7.9 (1.0)	23.4 (1.5) ^b	62.8 (1.6) ^d	13.8 (1.2) ^b
Age 55-64 y									
2003-04	56.3 (1.8)	16.5 (1.4)	14.8 (1.2)	21.5 (1.6)	3.0 (0.6)	1.7 (0.4)	29.6 (1.7)	61.5 (1.8)	9.0 (1.1)
2011-12	68.5 (1.6) ^b	29.8 (1.6) ^b	25.5 (1.5) ^b	33.9 (1.6) ^b	5.8 (0.8) ^c	2.8 (0.5)	15.2 (1.3) ^b	65.5 (1.7)	19.3 (1.3) ^b
Female									
Age 18-34 y									
2003-04	22.4 (2.4)	NR ^a	NR ^a	14.5 (1.9)	NR ^a	11.0 (2.1)	67.2 (2.8)	32.1 (2.7)	NR ^a
2011-12	31.4 (2.5) ^c	3.2 (0.9)	12.4 (1.9)	26.2 (2.3) ^b	8.8 (1.5)	10.6 (1.7)	45.9 (2.8) ^b	48.9 (2.8) ^b	5.2 (1.2)
Age 35-44 y									
2003-04	39.6 (1.5)	2.6 (0.5)	4.0 (0.7)	26.9 (1.7)	3.7 (0.6)	7.4 (0.9)	42.4 (1.6)	56.2 (1.6)	1.4 (0.4)
2011-12	50.4 (1.9) ^b	6.4 (1.0) ^b	13.7 (1.5) ^b	28.4 (1.8)	9.6 (1.5) ^b	7.1 (1.0)	32.2 (1.8) ^b	59.0 (1.9) ^d	8.8 (1.2) ^b
Age 45-54 y									
2003-04	44.8 (1.5)	6.3 (0.6)	8.1 (0.7)	22.5 (1.4)	3.9 (0.5)	4.5 (0.5)	39.4 (1.6)	57.0 (1.5)	3.6 (0.5)
2011-12	56.5 (1.5) ^b	14.2 (1.0) ^b	18.0 (1.2) ^b	35.5 (1.5) ^b	8.9 (0.8) ^b	6.0 (0.7)	22.8 (1.2) ^b	63.9 (1.2) ^b	13.2 (0.9) ^b
Age 55-64 y									
2003-04	54.1 (1.7)	12.2 (1.0)	11.8 (1.0)	20.3 (1.5)	2.8 (0.5)	1.3 (0.3)	33.2 (1.7)	60.1 (1.5)	6.7 (0.7)
2011-12	64.1 (1.4) ^b	24.7 (1.2) ^b	22.6 (1.3) ^b	29.6 (1.3) ^b	6.9 (0.7) ^b	1.9 (0.3)	19.6 (1.1) ^b	64.0 (1.2) ^d	16.4 (1.2) ^b

Abbreviations: HTN, hypertension; LD, lipid disorder; NR, not reported.

^c P value for trend <.01.^a Not reportable based on the estimates with a relative SE greater than 0.30.^d P value for trend <.05.^b P value for trend <.001.

parison with European studies on stroke in young adults, we found similar rates of lipid disorders, atrial fibrillation, and tobacco use, but much higher rates of hypertension, diabetes, and ischemic heart disease.¹⁴ We found a lower prevalence of obesity than other traditional risk factors and yet obesity has been identified as a major risk factor for stroke in young adults.¹⁵⁻¹⁷ This could be due to underreporting in an administrative data set. The shift to an increasing number of multiple traditional risk factors for stroke and the extremely high and increasing prevalence of hypertension among those hospitalized with all stroke types is of particular concern, as the hypertension control rate among men aged 18 to 39 years is only 27.9%.¹⁸

One in 3 acute stroke hospitalizations for all stroke, AIS, and ICH occurs among those aged 18 to 64 years, while 60% of SAH hospitalizations occur among adults aged 18 to 64 years, when adults are in their prime years for productive careers and busy family lives.¹⁹ Most age, race/ethnic, and sex groups had nonsignificant decreasing trends in hospitalization rates for SAH, with only modest, although significant, decreases among men aged 45 to 54 years. Hypertension, tobacco use, and al-

cohol use are among the most important risk factors for SAH.²⁰ We saw significant increases in hypertension, tobacco use, and drug abuse only among men and women aged 55 to 64 years and among women aged 45 to 54 years, but no significant increase in alcohol abuse among those with SAH. With increasing prevalence of key risk factors for SAH, the trend toward stable or decreasing hospitalizations for SAH are difficult to explain. There are improved diagnostic modalities for other cerebral conditions that could be leading to increased incidental findings of aneurysms from imaging for other reasons. Management and prophylactic treatment prior to rupture when indicated could in part explain decreases in hospitalizations for SAH.²¹

Nearly 40% of ICH hospitalizations occur in those aged 18 to 64 years.¹⁹ Because intracerebral hemorrhage can result in significant morbidity and mortality, the relatively high prevalence of unhealthy lifestyle behaviors among men aged 18 to 34 years (drug abuse: 14.3%; tobacco use: 25.8%; and hypertension: 44.1% among men and 28.1% among women aged 18-34 years), suggests that many of these strokes are likely preventable, although we are not able to determine the cause of

stroke in this study. The findings that Hispanic and non-Hispanic black individuals have ICH hospitalization rates 1.5 to 2 times the rates for white individuals is not inconsistent with the findings from Walsh et al,²² which found an increased risk for ICH among Hispanic and non-Hispanic black individuals with treated or untreated hypertension among younger age groups compared with white individuals. They concluded that untreated hypertension confers a greater ICH risk in black and Hispanic relative to white individuals.

These findings of increasing AIS hospitalization rates among those aged 18 to 54 years and no change among those aged 55 to 64 years reveals an inflection point in stroke hospitalization rates when compared with findings of decreasing AIS hospitalization rates among those aged 65 to 74 and 75 to 84 years, and a nonsignificant decline among those 85 years and older.^{23,24} We identified no change in the hospitalization rate for ICH among those aged 18 to 64 years, while others have seen decreasing rates among those with ICH aged 65 to 74, 75 to 84, and 85 years and older.²³ It is possible that these findings represent better hypertension control over time among elderly people compared with younger adults. We only noted a decrease in SAH hospitalization rates among those aged 45 to 54 years, while others also noted no change in rates among the 3 oldest age groups.²³

Strengths and Limitations

This study has several strengths in that the data are nationally representative of hospitalizations in the United States and provide the ability to report trends over time. The reported comorbidities and risk factors were documented in the medical record using ICD-9-CM codes. However, there are some limitations. First, a person who experiences more than 1 hospitalization for an acute stroke during a 2-year analytic period would be represented for each acute stroke hospitalization event. Second, while one can identify the prevalence of multiple comorbidities, we are unable to characterize stroke severity nor the cause of the stroke. Third, while we

cannot rule out any influence of increased use of advanced imaging over time, Kissela et al³ found high rates of the use of computed tomography (87%) and magnetic resonance imaging (60%-70%) among younger adults by 2005, and the impact of magnetic resonance imaging findings does not appear to influence stroke incidence,⁵ making it unlikely that the trends in stroke hospitalizations among younger adults are due solely to increased imaging and hence increased detection. Finally, we are unable to account for several important risk factors such as family history or the use of estrogen-based medications.

Conclusions

The young adult population is experiencing an increase in a serious yet largely preventable disease. We note the trend of increasing AIS among Hispanic individuals (a small but relative increase of 41% among those aged 18-34 years) of all age groups as a particularly important demographic to assure access to adequate stroke prevention. The significant increases in ischemic stroke hospitalizations and associated traditional stroke risk factors from 2003-2012, which is consistent with rates from 1995-1996 and 2007-2008 among those experiencing an acute stroke⁴ should serve as a call to action to focus on improving the health of younger adults. Preventing and controlling stroke risk factors among young working-age adults can save lives, reduce disability, decrease societal health care costs, and improve the quality of life for hundreds of thousands of Americans and their families. Identifying the high and rising prevalence of stroke risk factors among younger adults presenting with acute stroke should prompt a sense of urgency among younger adults, public health practitioners, clinicians, and policy makers to engage adolescents and their families, as well as younger adults, to identify and treat stroke risk factors and promote opportunities that allow for healthy lifestyles to prevent the tragedy of stroke at such early ages.

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