Trend of Stroke Hospitalization, United States, 1988–1997

Jing Fang, MD; Michael H. Alderman, MD

Background and Purpose—Age-adjusted stroke mortality in the United States has declined in recent decades. However, the course of stroke incidence is less certain. To address this issue, we determined trends of stroke hospitalization and in-hospital case fatality during 1988–1997.

Methods—Stroke hospitalization was estimated from National Hospital Discharge Survey as numerator and Current Population Survey as denominator. Hospitalization rates were determined and stratified by patient characteristics. Average length of hospital stay was also determined. In-hospital mortality was specified by sex, age, and other patient characteristics. The change in these rates over 10 years and average annual percent changes were calculated.

Results—During 1988–1997, age-adjusted stroke hospitalization rate increased 18.6% (from 560 to 664/100 000; P=0.043), while total hospitalization increased from 592 811 to 821 760. This increase was limited to persons aged ≥65 years. Patients in the South had the highest stroke hospitalization rates, and those in the West had the lowest. Overall, 58% of strokes were classified as ischemic, 13% as hemorrhagic, and 29% as other. Over these 10 years, stroke patients having coincident diabetes, hypertension, and congestive heart failure increased 17.4% (P=0.17), 34% (P=0.05), and 31% (P=0.091), respectively. The average length of hospital stay fell from 11.1 to 6.2 days (44.1%; P=0.012). As a result, despite an increase in hospitalizations for stroke, the total person-days in hospital actually decreased by 22% (P=0.06).

Conclusions—The declining age-adjusted stroke mortality in the United States has not been accompanied by a fall in hospitalization over recent years. Thus far, however, decrease in length of stay has more than offset increased admission. At the same time, the sharp drop in hospital case fatality rates suggests that continuing decline in stroke mortality may be due, in large part, to improved survival after acute stroke. (Stroke. 2001;32:2221-2226.)

Key Words: health care surveys ■ hospitalization ■ hospital mortality ■ length of stay

Stroke is a major health problem. Not only is it the third leading cause of death in the United States, after heart disease and cancer,1 but many stroke survivors are permanently disabled. US stroke mortality has declined dramatically in recent decades.2,3 This may be a consequence of declining incidence, declining case fatality rate, or both. Few studies have used consistent methods for the country as a whole, or for sufficiently long periods of time, to accurately determine national trends in both incidence and case fatality. There have been no nationwide studies of stroke morbidity in the United States over the past decade.

Evidence from regional studies suggests that, since 1980, the incidence of stroke may no longer be declining and may even be increasing.4–9 At the same time, studies around the world suggest that case fatality rates are declining.10–13

To estimate the most recent hospitalization and in-hospital case fatality rates for stroke in the United States and to test the hypothesis of whether the decline of stroke mortality has mirrored the reduction of stroke incidence in the United States, we report rates of hospitalization for stroke and in-hospital mortality by sex, age, and region in the United States during 1988–1997 based on the National Hospital Discharge Survey (NHDS).

Subjects and Methods

Data Source

Data were obtained from the NHDS, conducted by the National Center for Health Statistics.14–16 Since 1965 this survey has obtained a nationally representative sample of discharge records from non-federal short-stay hospitals in the United States. The NHDS covers discharges from noninstitutional hospitals, not including federal, military, and Veterans Administration hospitals. Only short-stay hospitals (those with an average length of stay for all patients of <30 days) and those with a general specialty are included in the survey. These hospitals must also have ≥6 beds staffed for patient use. During 1988–1997, each year there were approximately 6200 to 6400 hospitals in the NHDS universe and approximately 513 to 542 hospitals in the NHDS sample. Each year approximately 200 000 patients’ records are abstracted and weighted to represent all such hospital discharges nationwide.

Information collected from hospital records included date of birth and sex of patient, admission and discharge dates, discharge status, up to 7 discharge diagnoses, up to 4 procedures performed during

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hospitalization, length of hospital stay, and region of residence. We have not provided estimates for racial and ethnic groups in this analysis because such classifications of NHDS data were incomplete and became increasingly so during this period. Underreporting of race or ethnicity increased from 10% in the 1985 survey to almost 20% in 1992.17

We defined patients with stroke by the principal diagnostic code of the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) of 431 to 434 and 436 to 438. Among these patients, we also defined the comorbidity status for stroke by other ICD-9 codes (second to seventh diagnostic codes). These conditions included diabetes (ICD 250), hypertension (ICD 401 to 405), coronary heart disease (ICD 410 to 414), and congestive heart failure (ICD 428). We then categorized stroke into hemorrhagic stroke (ICD-9-CM 431 to 432) and ischemic stroke (ICD-9-CM 433 to 434 and 437.0 to 437.2). The detailed methods of design, data collection, ICD coding, and quality control have been reported.18

The patients of this study consisted of the sampled populations aged ≥55 years hospitalized during 1988–1997.

For computation of discharge rates, population estimates were taken from the census data. Current Population Survey (CPS). This survey is administered monthly each year by the US Bureau of the Census to account for entire US population.19 Each month’s survey has a different emphasis. The March survey used here contains the survey during 1988–1997. Age-adjusted rates for hemorrhagic and ischemic stroke were then estimated separately. Other comorbidity conditions, including congestive heart failure, diabetes, hypertension, and coronary heart disease, were determined from diagnostic codes other than the first one and were estimated as percentage of total stroke hospitalization. Hospitalization was further categorized by geographic region into Northeast, Midwest, South, and West. The definition for each region was the same as used by the Census Bureau20 and was applied for both hospital discharge data and CPS data. Age-adjusted stroke hospitalization rates for each region were computed. Average length of hospital stay and person-days in hospital were determined in each year. In-hospital case fatality rate was determined by the percentage of patients who died at discharge among all those hospitalized for stroke. This rate was estimated by age, sex, region, type of stroke, and morbidity status. Percent changes in case fatality rates were determined from 1988 to 1997. Average annual percent changes of the rates were estimated by the percent changes of rates for each year. One-sample t test was performed to test the difference from 0 for the average of changes for all study periods.

Age-adjusted stroke mortality rates during 1988–1997 were obtained from the National Center for Health Statistics.

Results

Overall, during these 10 years, the actual number of stroke hospitalizations increased from 592 811 in 1988 to 821 760 in 1997 (38.6%). At the same time, age-adjusted stroke mortality reported by the National Center for Health Statistics fell from 29.9 to 25.9 per 100 000 population (13.4%).

Stroke Hospitalization Rates

Overall, the age-adjusted stroke hospitalization rate increased from 560 per 100 000 population in 1988 to 664 in 1997 (18.6%; P = 0.043). The average annual percent change was 2.15 (95% CI, 0.13 to 4.37; P = 0.05).

Figure 1. Stroke hospitalization by age and sex: NHDS data, 1988–1997.

Stroke hospitalization rates were 2650, 1085, and 180 per 100 000 population for those aged ≥75 years, 65 to 74 years, and <65 years, respectively. Men had higher stroke hospitalization rates than did women up to age 74 years. There was no significant sex-related difference for persons aged >75 years (Figure 1). During this time, stroke hospitalization rates did not change for men and women aged 35 to 64 years but increased for older men and women. This increase was greater for men than for women (Figure 1).

By region of the United States, stroke hospitalization rates were lowest in the West and generally highest in the South. Although the stroke hospitalization rate in the West was generally 20% lower than other regions, the increase in the West was comparable to other parts of the country (Figure 2).

Length of Hospital Stay

The average length of hospital stay fell by 44.1% from 11.1 to 6.2 days from 1988 to 1997, with an average annual percent decrease of 6.1% (P = 0.012). Therefore, although the actual number of patients hospitalized for stroke increased during this period, the total person-days in hospital decreased by 22% (P = 0.06) (Figure 3).

Type of Stroke

In 10 years, age-adjusted hospitalization rate for hemorrhagic stroke was 76.5 per 100 000 population in 1988 and 88.9 in 1997, increasing 16.2%. Average annual percent changes were 1.7 (P = 0.57). Age-adjusted hospitalization rates for ischemic stroke were 296.2 in 1988 and 400.5 in 1997.
increasing 35%. Average annual percent changes were 3.6 ($P=0.03$) (Figure 4).

**Comorbidity**

The comorbidity of diabetes among stroke patients increased by 17.4% from 19.3% to 22.6% ($P=0.17$), and that of hypertension increased by 33.6% from 39.3% to 52.5% ($P=0.05$) (Figure 5) during this period. However, while the percentage of patients with coronary heart disease remained constant over the 10 years (19.3% in 1988 and 19.4% in 1997), the percentage of patients with congestive heart failure, although small, increased by 31% from 6.4% to 8.4% ($P=0.091$) during this time (Figure 5).

**Hospital Discharge Status and Case Fatality Rate**

During these 10 years, in-hospital death among stroke patients decreased steadily from 12.7% to 7.6% (40%; $P=0.04$). Discharge home was the outcome for most patients, and this fraction fell insignificantly from 57.6% to 53.9% ($P=0.34$). By approximately an equal amount, transfer to short- and long-term care facilities increased by 23% (from 6.5% to 8.0%; $P=0.16$) and 22% (from 16.2% to 19.7%; $P=0.18$), respectively (Figure 6).

Stratification by age, sex, region, and type of stroke revealed an almost across-the-board decline in case fatality rates in 10 years (Table). Patients with hemorrhagic stroke had substantially higher in-hospital mortality than did patients with ischemic stroke. Older patients ($\geq$75 years), men, and those hospitalized in the Northeast had higher in-hospital case fatality rates than did younger patients, women, and those hospitalized in other regions. During these 10 years, the decline of in-hospital case fatality rate varied substantially by patient characteristics. Specifically, in-hospital case fatality showed no consistent decline among patients aged <65 years, those with hemorrhagic stroke, and those living in the Midwest. On the other hand, patients aged $\geq$65 years and those who sustained an ischemic stroke had a much more favorable outcome (Table).

**Discussion**

These findings give national context to recent suggestions that US stroke incidence may be increasing. Moreover, during these past 10 years, although both the total number and rates of stroke hospitalization increased, a dramatic fall in length of hospital stay has produced an actual decline in total stroke hospital days. At the same time, it is likely that the sharp drop observed in hospital case fatality rate, particularly in persons aged $\geq$65 years, has made an important contribution to the overall decline in national age-adjusted stroke mortality.

Worldwide experience suggests inconsistent patterns of incidence over the past several decades. In Sweden, for example, although mortality has fallen, it has not been possible to detect a parallel decline in stroke incidence. In fact, a significant rise in the incidence of acute stroke has also been seen among Swedish women during 1975–1978 and 1983–1986 compared with 1975–1978.9 In the United States, a study in Rochester, Minn, revealed an increase in stroke incidence. Age-adjusted incidence of acute stroke was 17% higher during 1980–1984 compared with 1975–1979, and this increase persisted during 1985–1989.6 Reviews of NHDS for 1979–1983 and 1970–1987 both reported a rise in the hospitalization for stroke.7,8 By contrast, reductions in case fatality have been more consistent across regions and cul-

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**Figure 3.** Stroke hospital admission and total stroke person-days, United States, 1988–1997.

**Figure 4.** Stroke hospitalization rate by type of stroke, 1988–1997.

**Figure 5.** Changes in percentage of stroke patients with other comorbidity. CHD indicates coronary heart disease; CHF, congestive heart failure; and HT, hypertension.

**Figure 6.** Hospital discharge status, 1988–1997.

<table>
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<tr>
<th>Age, y</th>
<th>Average Case-fatality Rate, %</th>
<th>% Change*</th>
<th>AAPC†</th>
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</table>

*Percent change in case fatality rates from 1988 to 1997; minus indicates decrease.
†Average annual percent change in case fatality rate from 1988 to 1997; minus indicates decrease.

...previous stroke is a major risk factor for a subsequent stroke, and the largest increase of hospitalization was in older patients, the increasing admissions may be explained in part by improved survival after initial events.

The steady decline in days of hospital stay reflects a dramatic change in patterns of practice. Implementation of the Medicare prospective payment system stimulated a marked decline in length of hospital stay for stroke patients.26 As a result, even in the face of increased total stroke hospitalization, the total number of hospital days for the nation decreased. At the same time, introduction of designated stroke units appears to have improved inpatient care.27,28 The data here suggest that shorter hospitalization did not put patients at greater immediate risk; in fact, quite the opposite occurred. It is, of course, possible that posthospital death may have increased,29 but this seems unlikely in view of overall decline in national stroke mortality.

The data here do not necessarily augur well for the future. The factors that have thus far contained hospital use by stroke patients may not be sustainable. There must be a limit to the ability to reduce length of stay. If recent trends for persons aged ≥75 years persist, an aging US population will, in the near future, probably increase consumption of medical resources by stroke patients.

The importance of hypertension, coronary artery disease, and diabetes, both as risk factors for stroke and as determinants of outcome, is well established and is reflected in these data. Interestingly, and somewhat paradoxically, stroke patients with each of these conditions tended to have a lower case fatality rate than those without. Perhaps the presence of these diagnoses signified more widespread participation in the medical care system and thus access to specific or nonspecific therapies that decreased the lethality of stroke. The impact of prior antihypertensive therapy on survival during hospitalization for stroke could not be detected from the present data set, although hypertension control clearly reduces stroke incidence.30–33 The increasing fraction of stroke patients with hypertension over the 10 years may reflect either increasing stroke among older hypertensive patients or better detection of hypertension. Coding bias might also relate to the observed association. Perhaps terminally ill patients will have more severe acute conditions or complications recorded to the exclusion of less urgent chronic diseases. This is possible because the NHDS permits the recording of only 6 comorbidities.34

National hospital discharge records permit the monitoring of morbidity as well as in-hospital mortality. The strength of this database includes its large size and the fact that it represents the entire US population. However, hospital discharge surveys lack clinical detail regarding treatment and course. Moreover, in this analysis, hospitalization rates were determined by combining 2 data sets. Both were national samples but involved different sampling weights. Although the different sampling weights were accounted for in the 2 data sets in this analysis, it is still possible that the calculated hospitalization rates were inaccurate. This should not affect the internal accuracy of this study, however. In addition, despite the quality control of NHDS,18 there may well have been some mistakenly coded stroke patients included in this analysis.35,36 Nevertheless, NHDS may be particularly useful for monitoring...
stroke morbidity. Since stroke is a serious but not usually immediately fatal condition, hospitalization provides one potential useful view of stroke incidence and mortality patterns.

In summary, these national data suggest an evolving dissociation between trends in morbidity and mortality. The disappointing failure to detect a decline in hospitalization is balanced by a decline in hospital case fatality, as well as declining total person-days in hospital. The implication of these findings in the context of an aging population is that the burden of stroke disease is unlikely to decrease in coming decades. For nearly 30 years, preventive efforts have been largely based on reduction of blood pressure, yet since hypertension control rates seem to have stabilized, our current national strategy may not be adequate in the face of what threatens to be a growing burden of increasing stroke disease.

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References


During the past decade, we have witnessed significant advances in our ability to treat patients presenting with an acute stroke. These advances include the effectiveness of thrombolytic agents in treating ischemic stroke patients who present within 3 hours of stroke onset,1 of aspirin in treating a broad spectrum of ischemic stroke patients,2 as well as the evidence from multiple randomized controlled trials demonstrating that organized stroke care in a stroke unit leads to reductions in morbidity and mortality.3 However, physicians’ optimism regarding their ability to treat stroke patients must be tempered by the failure of many trials of new neuroprotective agents to demonstrate a difference in outcome4 and evidence of continued suboptimal management of important stroke risk factors such as hypertension and atrial fibrillation.5,6 Therefore, the question remains: Are we winning the battle against stroke?

In their article, Fang and Alderman, using the National Hospital Discharge Survey, provide new data on nationwide trends in the rate of stroke hospitalization and case-fatality rates between 1988 and 1997 in the United States. Although these data are not only the barometer by which progress should be measured, they are important because they offer a broad population-based perspective on recent trends in stroke hospitalization and outcomes in the “real world” of community practice, across a large and diverse country with thousands of patients, providers, and hospitals.

Several positive findings were noted in this study, of which the decline in the in-hospital case-fatality rate from stroke was arguably the most important. The decline in case-fatality suggests that there have either been (1) general improvements in the management of acute stroke patients, (2) decreases in the severity of strokes, or (3) the detection of milder cases of stroke, secondary to greater use of neuroimaging technology, in the United States.7 The data sources used in this study do not permit us to determine which of these explanations is the most important, although all may have played a role. The decline in case fatality, also observed in other countries,8,9 should be tempered by the recognition that part of the decline may have been due to the shorter lengths of stay resulting in more out-of-hospital deaths.

More sobering is the finding that stroke hospitalization rates increased 18.6% between 1988 and 1997, with the increase found largely in elderly patients aged 65 years and older. Ideally, this analysis should have been restricted to first “incident” strokes. However, it was not possible to distinguish first from recurrent strokes with these administrative databases. Nevertheless, given that other studies have shown that most strokes are first-incident strokes,10 the data suggest that the overall incidence of stroke may be increasing in the United States. Factors contributing to the rising hospitalization rates in the United States most likely include the aging of the US population, success in treating other conditions such as coronary heart disease, and suboptimal primary prevention efforts. These results demonstrate a worrisome trend that has important cost and utilization implications for an overburdened healthcare system and therefore warrants our close attention.

Overall, the data from Fang and Alderman reveal a mixed picture with regard to the state of the battle against stroke. While remarkable progress has occurred over the past decade in the field of stroke, the data suggest that now is not the time for complacency. The clinical and research communities need to continue their aggressive fight against the scourge of stroke. Progress is urgently needed across the full spectrum of stroke, from primary prevention and identification of new stroke risk factors, to acute-care management and reorganization of stroke care, and improved rehabilitation so that survivors can be more fully reintegrated into the community. It will be important to continue to monitor both the successes and failures, as the battle against stroke continues.

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Jack V. Tu, MD, PhD, FRCPc, Guest Editor
Institute for Clinical Evaluative Sciences and Division of General Internal Medicine
Sunnybrook and Women’s College Health Sciences Centre
University of Toronto
Toronto, Ontario, Canada

References
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