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*Stroke* 2002;33;1209-1213
DOI: 10.1161/01.STR.0000015031.57955.D1

Stroke is published by the American Heart Association. 7272 Greenville Avenue, Dallas, TX 72514
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Paul Muntner, PhD; Elizabeth Garrett, PhD; Michael J. Klag, MD, MPH; Josef Coresh, MD, PhD

Background and Purpose—Stroke mortality in the United States has declined since 1900. Primary prevention of stroke incidence did not decline and may have increased during the 1980s, whereas survival after stroke improved substantially during the 1970s and 1980s. The effect of these trends on the prevalence and number of stroke survivors in the United States has not been determined.

Methods—The prevalence and number of noninstitutionalized stroke survivors in the United States was estimated through self-report for 3 time periods: 1971–1975, 1976–1980, and 1988–1994, using data from the National Health and Nutrition Examination Surveys (NHANES) I, II, and III, respectively. Prevalence and number of stroke survivors were analyzed by age (25 to 59 and 60 to 74 years), race (non-Hispanic whites/Mexican-Americans and non-Hispanic blacks), and sex. Estimates were limited to the US population ages 25 to 74 years because NHANES I and II did not include persons older than 75 years.

Results—The age-, race-, and sex-adjusted prevalence of stroke increased from 1.41% to 1.87% from 1971–1975 to 1988–1994, an average increase of 7.5% (95% confidence interval: −2%, +18%) for each 5-year period during this time. Additionally, during this period, the estimated number of noninstitutionalized stroke survivors increased by 930,000 (95% CI: 300,000 to 1.6 million) from 1.5 million to 2.4 million. Additionally, the average “health in general” among stroke survivors was similar in all 3 periods.

Conclusions—These data point to the increasing importance of the care and rehabilitation of stroke survivors. (Stroke. 2002;33:1209-1213.)

Key Words: disability evaluation □ epidemiology □ prevalence □ stroke

Aggregated mortality from stroke in the United States has declined since the turn of the century, when mortality records started to be kept.1,2 The rate of this decline accelerated during the 1970s.13–15 Despite the growth and aging of the US population, there were 145,000 stroke-related deaths (61 per 100,000 population) in 19892 compared with 207,000 deaths from stroke (106 per 100,000 population) in 1970.4 Over the past decade, several hypotheses for the accelerated decline in stroke mortality have been proposed. These include primary prevention and improved stroke survival.5–12 The incidence of stroke declined during the 1970s in several population-based studies; however, in these same populations, stroke incidence did not decline during the 1980s,13–15 Also, data have consistently shown improved short- and long-term survival after stroke during the 1970s and 1980s.16–18 Stroke prevalence integrates stroke incidence, survival, and mortality into a single measure, which is important for healthcare planning and long-term resource utilization.

We explored whether a substantial increase in stroke prevalence (ie, percentage of the population with a history of stroke at a given time) in the US population occurred during the 1970s and 1980s. Given the increased size and aging of the US population, it was hypothesized that the number of stroke survivors also has increased. These hypotheses were tested using data from 3 national health surveys.

Methods

First, secular trends in stroke mortality for persons 25 to 74 years of age were abstracted from the National Center for Health Statistics Compressed Mortality Files.19 The Compressed Mortality Files include individual records abstracted from every death certificate for persons dying within all 50 states and the District of Columbia except for 1972 where sampling, at a rate of 50%, was performed and deaths were weighted accordingly. Mortality from stroke was defined by International Classification of Disease (ICD)-9 codes between 430 and 438 listed as the underlying cause or mentioned on the death certificate.

The prevalence of stroke was estimated using self-report from 6,906, 13,600, and 14,174 interview respondents between 25 and 74 years of age, interviewed in National Health and Nutrition Examination Surveys (NHANES) I, II, III, respectively.20–22 Each NHANES survey respondent was asked, “Have you ever been told by a doctor that you have had a stroke?” Self-reported “health in
general” among stroke survivors was assessed on a nominal scale (1=excellent, 2=very good, 3=good, 4=fair, 5=poor). Data for the 3 NHANES surveys were collected from 1971–1975, 1976–1980, and 1988–1994 (study mid-points 1973, 1978, and 1991), respectively, and used multistage probability sampling designs. Prevalence and count estimates for each study are averages for the period of time during which the study was conducted.

Because NHANES is limited to the noninstitutionalized US population, we used data from the National Hospital Discharge Survey to assess changes in the number and percentage of patients with an underlying discharge diagnosis of stroke transferred to a “long-term care institution.” The National Hospital Discharge Survey is conducted annually and maintains medical and demographic information from a sample of discharge records selected from a national sample of non-Federal short-stay hospitals and can be weighted to estimate inpatient hospital utilization for the United States.

Statistical Methods
For each time period, the demographic (age [25 to 39, 40 to 49, 50 to 59, and 60 to 74 years], race [black, white, and other], and sex) composition of the US population was estimated. Additionally, using NHANES interview response, the prevalence of persons reporting a history of stroke for each time period was estimated for the overall noninstitutionalized US population and for each age, race, and sex subgroup.

Changes in stroke prevalence and number of stroke survivors across the 3 time periods were assessed using Poisson regression with parametric bootstrapping techniques to estimate standard errors (SE). Trends in prevalence and number of stroke survivors for the overall population and race-sex subgroups were regressed on calendar year difference between the NHANES survey midpoints (5 years between NHANES I and II [1973 and 1978]; 12 years between NHANES II and III [1978 to 1991]). Calendar years elapsed was analyzed as a linear variable with estimates expressed for 5-year time increments. Time elapsed was also modeled using higher order terms; however, as a result of the potential of overfitting the data, only the results from the linear models are being presented. Because of changes in the demographic composition of the US population occurring between the 3 study periods, the prevalence of stroke was determined after direct adjustment for age group (25 to 39, 40 to 49, 50 to 59, and 60 to 74 years), race, and sex using the 1973 US population (NHANES I) as the standard. However, because we were interested in changes in healthcare burden, direct adjustment was not used in the analyses investigating changes in the number of stroke survivors. Because of the low prevalence of stroke in the 25 to 39, 40 to 49, and 50 to 59 year age groups, results for these groups are presented combined. Mean response for “health in general” among persons with and without a history of stroke were compared across time periods. Change in the number and percentage of patients 25 to 74 years of age with an underlying diagnosis of stroke (ICD-9 code 430 to 438) discharged to a long-term care institution were assessed from 1981 (the initial year for which this data were collected) through 1994.

Race was recorded differently in the 3 surveys; therefore, Mexican-Americans were grouped with non-Hispanic whites. Persons of race/ethnicity other than non-Hispanic white, non-Hispanic black, or Mexican-American were excluded from the race-specific analyses. National estimates for the prevalence and number of stroke survivors among the noninstitutionalized population of the United States were derived through the application of sampling weights to the survey response.44

Results
US Population Characteristics
The number of persons (SE) aged 25 to 74 years in the noninstitutionalized population of the United States increased from 106.6 (2.2) million in 1971–1975 to 114.3 (2.3) million in 1976–1980 and to 146.2 (5.0) million in 1988–1994. The percentage of the US population that was black or male did not change substantially. All demographic subgroups, except persons aged 50 to 59 years, increased in absolute size.

Stroke Mortality
In contrast to the increase in the size of the US population, the number of stroke deaths among the population aged 25 to 74 years consistently declined between 1971 and 1994 from 81 000 to 44 000, a decrease of 47%. The stroke mortality rate declined monotonically by more than 50% between 1971 and 1994, from 79 to 29 deaths per 100 000 population.

Stroke Prevalence Rate
Overall, 292, 387, and 324 participants reported a history of stroke in NHANES I, II, and III, respectively. The prevalence of stroke in the United States increased between 1973 and 1978 from 1.41% (SE=0.2%) to 1.73% (SE=0.1%). However, the prevalence of stroke in the United States in 1991 was not significantly different from the second period (prevalence=1.70%; SE=0.2%; Figure 1). After adjustment for age, race, and sex, the prevalence of stroke was 1.41 (SE=0.2%) in 1973, 1.69 (SE=0.2%) in 1978, and 1.87% in 1991; the age-, race-, and sex-adjusted prevalence of stroke increased by 7.5% (95% CI: −2%, +18%) with every 5-year period between 1973 and 1991.

Among the population 25 to 59 years old, the prevalence increased from 0.65% to 0.88% between the first and second time period and was 0.80% in the third time period (Figure 1). Neither of the changes between the 2 time periods nor the trend across the 3 time periods was consistent with a statistically significant increase or decrease in stroke prevalence. The prevalence of stroke among the US population 60 to 74 years old increased from 4.2% to 5.0% to 5.2% during the period studied (Figure 1). On average, the prevalence of stroke increased by 6.4% per 5 years (95% CI: −3%, +17%). Among white males, the age-adjusted prevalence of stroke increased an average of 12% per 5-year period across the 3 study periods; however, this increase was not statistically significant (95% CI: −2%, +24%; Table 1). The prevalence of stroke was similar in each of the 3 study periods among both white females and black males and increased by 28% (95% CI: +3%, +56%) for each 5-year period between 1973 and 1991 among black females.
Number of Stroke Survivors

The number of persons in the United States with a history of stroke increased between the 3 time periods (Figure 2); overall, there were 1.5, 2.0, and 2.4 million stroke survivors in 1973, 1978, and 1991, respectively. For each 5-year period during the study, the number of stroke survivors increased by 286,000 (95% CI: +139,000, +433,000).

Within both age groups examined, the number of persons reporting a history of stroke increased (Figure 2). The number (SE) of stroke survivors between 25 and 59 years old increased from 590,000 (130,000) to 768,000 (101,000) to 965,000 (172,000) stroke survivors across these time periods. An increase in number of stroke survivors was observed in all age, race, and sex groups. These results are concordant with the decrease in stroke mortality observed in data obtained from the compressed mortality files and stable stroke incidence observed during the 1980s in population-based studies. In sum, these data point to a long-term care-facility compared with 8.9% (40,900) patients of similar age in 1994.

Hospital Discharge to Long-term Care Facilities

The number of persons 25 to 74 years of age discharged from hospitals in the United States with an underlying diagnosis of stroke remained relatively constant between 1981 and 1994; there were 447,000 and 457,000 patients (both dead and alive) aged 25 to 74 years discharged from hospitals in the United States with an underlying diagnosis of stroke in 1981 and 1994, respectively. In contrast, the number and percentage of patients aged 25 to 74 years discharged directly to a long-term care facility increased at a constant rate between 1981 and 1994. In 1981, 6.3% (28,200) of those with a diagnosis of stroke under age 75 were discharged directly to a long-term care facility compared with 8.9% (40,900) patients of similar age in 1994.

Discussion

Among the US population aged 25 to 74 years, the crude prevalence of stroke was similar in 1973, 1978, and 1991; however, after adjustment for age, race, and sex, the prevalence of stroke increased from 1.41% to 1.69% to 1.87% across these time periods. An increase in number of stroke survivors was observed in all age, race, and sex groups. These results are concordant with the decrease in stroke mortality observed in data obtained from the compressed mortality files and stable stroke incidence observed during the 1980s in population-based studies. In sum, these data point to a decreased stroke case-fatality rate which, if present, clearly would be a medical triumph. However, its consequence, an increase in stroke survivors potentially living with disabilities, places a burden on the survivor’s family, the community, and the healthcare system, which must be recognized.

The current study did not have data to permit the investigation of trends in disability among the stroke survivor population. Although changes in “health in general” among stroke survivors were determined to be minimal, this can only be considered a crude measure of disability after stroke. Future investigations should endeavor to generate more

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**TABLE 1. Age-adjusted Prevalence of Stroke Among Noninstitutionalized White and Black Males and Females in the United States for 3 Time Periods**

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<tbody>
<tr>
<td>White males, n*</td>
<td>110</td>
<td>167</td>
<td>116</td>
<td>+12% (−2%, +29%)</td>
</tr>
<tr>
<td>Adjusted prevalence</td>
<td>1.4 (0.3)</td>
<td>1.7 (0.2)</td>
<td>2.0 (0.3)</td>
<td></td>
</tr>
<tr>
<td>White females, n*</td>
<td>111</td>
<td>156</td>
<td>97</td>
<td>−3% (−15%, +11%)</td>
</tr>
<tr>
<td>Adjusted prevalence</td>
<td>1.5 (0.3)</td>
<td>1.7 (0.2)</td>
<td>1.4 (0.2)</td>
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</tr>
<tr>
<td>Black males, n*</td>
<td>27</td>
<td>27</td>
<td>51</td>
<td>−3% (−15%, +11%)</td>
</tr>
<tr>
<td>Adjusted prevalence</td>
<td>1.9 (0.6)</td>
<td>2.6 (0.8)</td>
<td>2.1 (0.3)</td>
<td></td>
</tr>
<tr>
<td>Black females, n*</td>
<td>42</td>
<td>33</td>
<td>60</td>
<td>+28% (+3%, +56%)</td>
</tr>
<tr>
<td>Adjusted prevalence</td>
<td>0.8 (0.4)</td>
<td>2.6 (0.6)</td>
<td>2.8 (0.4)</td>
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CI indicates confidence interval; NHANES, National Health and Nutrition Examination Survey; SE, standard error.

*Number of persons self-reporting a history of stroke in NHANES.
complete data that will allow for integration of morbidity and mortality as a better measure of the success of a decrease in stroke case-fatality.25

One previous study that reported on trends in stroke prevalence for the US population11 found the prevalence of stroke in the community-dwelling US population older than 45 years of age increased from 2.57% to 3.33% between 1979–1981 and 1989–1991.11 Overall the authors concluded that the prevalence of stroke was found to be “somewhat higher at the end of the 1980s than it was at the beginning.” This interpretation is consistent with results from the current analysis that also indicated a higher age-, race-, and sex-adjusted stroke prevalence in the later time periods. Several differences between the current study and the previous study are worth noting. First, estimates in the previous study were based on data from National Health Interview Survey (NHIS). Age-specific stroke prevalence estimates in NHIS are about 50% lower than estimates based on NHANES data.11 For example, based on NHIS estimates, stroke prevalence among the population ≥45 years of age for the period 1989–1991 was reported to be 3.3%. Using NHANES III data, the prevalence of stroke between 1988 and 1994 for this same age group was 4.6%. Similar discrepancies in disease prevalence between NHANES and NHIS are present for myocardial infarction27,28 and may be a result of the use of proxy interviews in NHIS. Second, NHIS reported on data from 1979–1991,11 whereas our study used data collected between 1971 and 1994. Additionally, the previous study of stroke trends in the US population investigated trends in disability due to stroke and concluded that “the prevalence of limitation of activity due to stroke did not increase.” Our study was limited to self-reported health in general, and similar to the previous study’s results, this measure remained unchanged among stroke survivors in all 3 periods. Finally, the current study extends previous reports by combining prevalence and population trends to calculate trends in stroke survivor counts, an important component in assessing the burden of stroke survival on the family, community, and healthcare system.

There are several caveats that should be kept in mind when making inferences from these results. First, the assessment of stroke was based on self-report. In other studies, about 80% of self-reports of strokes can be validated by medical records.29 If the validity of self-reports is similar for the NHANES surveys, estimates of relative change in stroke prevalence will be unaffected by such misclassification.30 However, because of improved neurological imaging procedures, stroke may be better detected and more accurately reported in the later periods. Second, the NHANES surveys are limited to the noninstitutionalized civilian population of the US; a large proportion of stroke survivors may have severe disabilities, be in nursing homes, and not part of the surveyed (target) population in NHANES.11 Thus, the report likely underestimates the population burden of disease. However, data from the National Hospital Discharge Survey indicates that a substantial change in the number of hospital-discharged patients aged 25 to 74 years sent to long-term care facilities did not occur between 1981 and 1994. Third, the recording of race groups in NHANES I and II necessitated the grouping of Mexican-Americans with non-Hispanic whites.

The prevalence of a history of stroke was different between Mexican-Americans and whites in NHANES III, but we were unable to assess trends in any such difference. Although the overall results are unaffected by this concern, the race-specific analyses should be interpreted with caution. Finally, the prevalence of stroke is low, limiting the precision of the estimates. For example, in NHANES I, only 292 participants had a self-reported history of stroke; this relatively small number resulted in substantial variability in estimates, wide confidence intervals surrounding point estimates resulting in nonstatistically significant results, and an inability to investigate trends in more refined subgroups. However, the survey methodology applied in the current analysis takes into account the sampling design used in NHANES, providing confidence that the estimates attained are reliable.

The NHANES I and II surveys included only the population under age 75 years.20,21 Thus, trends in stroke prevalence in the US population older than age 75 years cannot be estimated. The population older than 75 years of age comprises a substantial percentage of stroke incidence, prevalence, and mortality. In NHANES III, the prevalence of stroke among the population older than age 75 years was 11.3% (95% CI: 10.0%,12.8%), more than twice that of the 60- to 74-year-old age group. Additionally, there were 1.3 million stroke survivors older than 75 years of age in NHANES III, bringing the total number of stroke survivors in the US population at that time to 3.7 million. Between 1973 and 1991, the US population older than age 75 years increased from 7 million to 11.9 million persons.31,32 Even if the prevalence of stroke remained constant (11.3%) in this age group, the number of stroke survivors age 75 and older would have increased by more than 400 000 ([11.9 million to

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**TABLE 2.** Estimated Number of Noninstitutionalized White and Black Male and Female Stroke Survivors in the United States for 3 Time Periods

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<tr>
<td></td>
<td>n=292*</td>
<td>n=387*</td>
<td>n=324*</td>
<td>Mean (95% CI)</td>
</tr>
<tr>
<td>Population Age 25–74</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White males</td>
<td>625 (126)</td>
<td>806 (86)</td>
<td>1128 (154)</td>
<td>+159 (+30, +288)</td>
</tr>
<tr>
<td>White females</td>
<td>743 (136)</td>
<td>863 (94)</td>
<td>873 (173)</td>
<td>+41 (+81, +163)</td>
</tr>
<tr>
<td>Black males</td>
<td>48 (23)</td>
<td>159 (46)</td>
<td>127 (15)</td>
<td>+18 (+1, +34)</td>
</tr>
<tr>
<td>Black females</td>
<td>90 (29)</td>
<td>132 (40)</td>
<td>215 (35)</td>
<td>+39 (+11, +67)</td>
</tr>
</tbody>
</table>

*Number of persons self-reporting a history of stroke in NHANES.
the extent that survival from stroke improved during the 1980s. The changes in prevalence and number of stroke survivors for the population older than 75 years may have a substantial effect on stroke trends if these changes differ from trends in younger age groups. Future investigations should focus on the prevalence of stroke among the population older than 75 years.

In conclusion, the age-, race-, and sex-adjusted prevalence of stroke among the US population 25 to 74 years of age increased by 30% in the United States between 1973 and 1991. Over the same time period, the number of stroke survivors younger than age 75 years increased by 930,000. These data highlight the importance of the care and rehabilitation of a growing stroke survivor population.

References