Stroke Declines From Third to Fourth Leading Cause of Death in the United States

Historical Perspective and Challenges Ahead

Amytis Towfighi, MD; Jeffrey L. Saver, MD

Background and Purpose—Stroke recently declined from the third to the fourth leading cause of death in the United States, its first rank transition among sources of American mortality in nearly 75 years.

Methods—This is a narrative review supplemented by new analyses of Centers for Disease Control and Prevention National Vital Statistics Reports from 1931 to 2008.

Results—Historically, stroke transitioned from the second to the third leading cause of death in the United States in 1937, but stroke death rates were essentially stable from 1930 to 1960. Then a long, great decline began, moderate in the 1960s, precipitous in the 1970s and 1980s, and moderate again in the 1990s and 2000s. By 2008, age-adjusted annual death rates from stroke were three fourths less than the historic 1931 to 1960 norm (40.6 versus 175.0 per 100 000). Total actual stroke deaths in the United States declined from a high of 214 000 in 1973 to 134 000 in 2008. Improved stroke prevention, through control of hypertension, hyperlipidemia, and tobacco, contributed most greatly to the mortality decline with a lesser but still substantial contribution of improved acute stroke care. Persisting challenges include race—ethnicity, sex, and geographic disparities in stroke mortality; the burden of stroke disability; the expanding obesity epidemic and aging of the US population; and the epidemic of cerebrovascular disease in low- and middle-income countries worldwide.

Conclusions—The recent rank decline of stroke among leading causes of American death is testament to a half century of societal progress in cerebrovascular disease prevention and acute care. Renewed commitments are needed to preserve and broaden this historic achievement. (Stroke. 2011;42:2351-2355.)

Key Words: age-adjusted ■ cause of death ■ death rates ■ mortality ■ stroke ■ total deaths ■ trends ■ United States

Trends in Causes of Death in the United States, 1931 to 2008

For historical perspective, it is useful to consider the long arc of changing stroke mortality rates going back to the last time stroke transitioned among the ranks of the leading causes of death. Figure 1 shows age-adjusted death rates in the United States from 1931 to 2008 for the current top 10 causes of death using data from the Centers for Disease Control and Prevention’s National Vital Statistics Reports. In 1931, stroke was the second leading cause of death, after heart disease, with an overall mortality rate of 195.0 per 100 000. Over the next 20 years, stroke death rates declined slightly, whereas cancer death rates climbed a little, with crossover in 1937, but these 2 remained a close and essentially stable number 2 and number 3 through the early 1960s. Then a long,
great decline in age-adjusted stroke death rates began, dropping modestly but steadily through the 1960s (falling by 1.2 per 100,000 per year), rapidly in the 1970s (−5.6 per 100,000 per year) and 1980s (−3.3 per 100,000 per year), mildly in the 1990s (−0.4 per 100,000 per year), and moderately in the 2000s (−2.5 per 100,000 per year). By 2008, the stroke mortality rate was three fourths less than its historic 1931 to 1960 norm (40.6 versus 175.9 per 100,000). Cardiac mortality rates exhibited a similar pattern, suggesting parallel sources of change in death rates for the 2 major vascular diseases.

This historical view places in perspective a technical aspect of the National Center for Health Statistics methodology. The crossover in 2008 between stroke and CLRD mortality was artifactual in part, occurring in this particular year because the National Center for Health Statistics changed the method for counting CLRD deaths. The National Center for Health Statistics in 2008 departed from past practices by including in the CLRD category deaths due to pneumonia, influenza, and bronchitis. As a result, from 2007 to 2008, CLRD death rates jumped sharply, a contrast to the mild decline of the prior 5 years (7.8% versus −1.7% per year). At the same time, stroke death rates from 2007 to 2008 fell a little less than usual compared with the prior 5 years (−3.8% versus −6.1% per year). The rationale for including seemingly acute pulmonary conditions, like pneumonia and influenza, in the category of CLRD has been questioned. However, seen from the long historic view, the change in CLRD death definition is not the fundamental explanation for the rank transition among causes of death. Even without the definition change, stroke mortality rates were trending to fall below CLRD rates in the near future. The definition alteration only moved up by a few years, a moment of triumph that is the culmination of 40 years of progress in control of stroke mortality.

Indeed, the historic perspective captured in Figure 1 affords hope that we will shortly be celebrating another milestone. If recent trends in age-adjusted death rates continue, stroke will soon decline even further, from fourth to fifth, among the leading causes of death, below accidents.

Age-adjusted death rates correct for variations over time in the age distribution of Americans, permitting valid comparisons to be made across eras. However, for health policy planning and additional historical perspective, it is also important to consider total actual deaths due to different diseases. Total actual deaths reflect not only disease control, but also the growth in the overall size of the US population over time and changes in its age distribution, including the recent demographic aging of American society. Figure 2 shows total actual deaths for...
the top 10 causes of death from 1931 to 2008. In 1931, stroke was the fifth leading cause of actual deaths, after heart disease, influenza and pneumonia, malignancy, and nephritis (Figure 2). Total stroke deaths then increased along with the size of the US population, modestly in the 1930s and 1940s and sharply in the 1950s. The rate of growth moderated in the 1960s and early 1970s, because decline in age-adjusted stroke death rates partially counter-balanced the continued overall population increase. Total stroke deaths declined from 1976 to 1992, rose a bit through 2002, and declined again through 2008, reflecting the contending effects of further declines in stroke mortality rates and overall population growth. In 2008, stroke fell from third to fourth, below CLRD, among the leading causes of total actual deaths in the United States. The 133 750 stroke deaths in 2008 are 38% less than the historic high of 214 313 stroke deaths experienced in 1973.

Disparities in Stroke Mortality in the United States

The welcome news of a general decline in stroke mortality is tempered by evidence of substantial ongoing disparities in the distribution of this success. A recent analysis of the National Center for Health Statistics mortality data from 1996 to 2005 identified important racial and sex disparities in stroke death rates. Stroke became the fifth leading cause of death in men and fourth leading cause of death in whites but remained the second leading cause of death in women and blacks. Moreover, several studies have identified important regional differences in stroke mortality rates with disproportionately higher rates in the “stroke belt” (North Carolina, South Carolina, Georgia, Alabama, Mississippi, Arkansas, Tennessee, and Louisiana). These states have a stroke mortality rate approximately 40% higher than the rest of the nation.

Potential Reasons for the Decline in Stroke Mortality

Better stroke prevention is almost certainly the larger contributor to the dramatic decline of stroke deaths over the past 40 years with a lesser, but not insubstantial, contribution from improved acute treatment. The fall in stroke mortality parallels a sharp decrease in stroke incidence during this time period. Numerous studies have illustrated the declines in incidence of stroke, particularly among white populations. An analysis of predominantly white individuals aged ≥55 years followed in the Framingham Heart Study for up to 50 years over 3 consecutive periods (1950 to 1977, 1978 to 1989, and 1990 to 2004) revealed that the age-adjusted incidence of first stroke per 1000 person-years in each of the 3 periods was 7.6, 6.2, and 5.3, respectively, in men (P=0.02 for trend) and 6.2, 5.8, and 5.1 in women (P=0.01 for trend). The lifetime risk at age 65 years decreased from 19.5% to 14.5% in men (P=0.11) and 18.0% to 16.1% in women (P=0.61). The Greater Cincinnati Northern Kentucky Stroke Study demonstrated a racial disparity with stroke incidence declining over the past decade in whites but stable among blacks. Hospitalizations for stroke have declined in tandem with incidence. An assessment of primary and secondary stroke hospitalizations in the United States between 1997 and 2006 using the Nationwide Inpatient Sample revealed that age-adjusted stroke admission rates per 100 000 persons decreased from 282.7 to 210.4 in men (26%; P=0.001) and from 240.5 to 184.7 in women (23%; P=0.05), highlighting sex disparities in declines in stroke incidence.

Declines in stroke incidence have coincided with improvements in vascular risk factor control. Consecutive National Health and Nutrition Examination Surveys reveal that treatment and control rates of hypertension have improved, particularly among non-Hispanic white and black men. In addition, statin use has increased considerably in the United States. In 1999/2000, 2001/2002, and 2003/2004, statins were being used by 19.6%, 27.3%, and 35.9% of US adults with high low-density lipoprotein cholesterol levels, respectively (P trend <0.001). Age-standardized mean low-density lipoprotein cholesterol declined from 119.9 to 112.0 to 100.7 mg/dL among statin users between 1999 to 2000, 2001 to 2002, and 2003 to 2004. Low-density lipoprotein cholesterol control to ATP-III-recommended targets was achieved by 49.7%, 67.4%, and 77.6% of statin users in 1999/2000, 2001/2002, and 2003/2004, respectively (P trend <0.001). In addition, cross-sectional population-based surveys over the past 20 years in Minnesota revealed that (1) blood pressure decreased and awareness, treatment, and control of hypertension increased; (2) total cholesterol levels decreased and awareness, treatment, and control of hypercholesterolemia increased; and (3) smoking rates decreased. Among stroke survivors in the Framingham Heart Study, mean systolic blood pressure and cholesterol levels, prevalence of hypertension, proportion of all participants receiving treatment for hypertension, and prevalence of current smoking decreased significantly over 3 consecutive periods (1950 to 1977, 1978 to 1989, and 1990 to 2004). However, the prevalence of diabetes in women and of atrial fibrillation in men, and the mean body mass index in both sexes, worsened significantly over time.

Improved acute stroke management has likely also contributed to the mortality decline, albeit to a lesser degree. In controlled clinical trials, organized stroke care reduces mortality modestly (OR, 0.86; 95% CI, 0.76 to 0.98; P=0.02). With the spread of organized stroke care and Primary Stroke Centers in the United States, reductions in mortality among stroke admissions have been noted in actual practice.

Impact of the Obesity Epidemic and Population Aging on Stroke Mortality

Unfortunately, the recent lows in stroke mortality may be short-lived. The obesity epidemic and the aging of the population in the United States threaten the improvements in stroke mortality achieved by better control of blood pressure, cholesterol, and tobacco use over the past 4 decades. In 2007/2008, the age-adjusted prevalence of obesity was 33.8% (95% CI, 31.6% to 36.0%) overall, 32.2% (95% CI, 29.5% to 35.0%) among men, and 35.5% (95% CI, 33.2% to 37.7%) among women. The corresponding prevalence of over-
weight and obesity combined (body mass index $\geq 25$ kg/m$^2$) was 68.0% (95% CI, 66.3% to 69.8%), 72.3% (95% CI, 70.4% to 74.1%), and 64.1% (95% CI, 61.3% to 66.9%).$^{17}$ If the trajectory of the past 30 years continues, 86% of Americans will be overweight or obese by the year 2030.$^{18}$ As a result of burgeoning obesity prevalence, rates of diabetes and hypertension have increased. National Health and Nutrition Examination Survey data reveal that crude prevalence of diagnosed diabetes in adults rose from 5.1% in 1988 to 1994 to 7.7% in 2005 to 2006 ($P<0.0001$)$^{19}$ and the age-standardized prevalence rate of hypertension increased from 24.4% in 1988 to 1994 to 28.9% in 1999 to 2004 ($P<0.001$) with the largest increases among non-Hispanic women.$^{9}$ Depending on sex and race/ethnicity, from one fifth to four fifths of the increase could be accounted for by increasing body mass index.$^{9}$

Obesity affects poststroke survival. Among adults with prevalent stroke in the United States who participated in National Health and Nutrition Examination Surveys 1988 to 1994 followed through 2000, risk for all-cause mortality increased per kg/m$^2$ of higher body mass index ($P=0.030$). The association of higher body mass index with mortality was strongest in younger individuals and declined linearly with increasing age.$^{20}$

Moreover, for the next 2 decades, the demographic aging of the US population appears destined to bring an increase in the total actual deaths due to stroke, whatever the course of age-adjusted stroke death rates. This year, 2011, the first of the baby boomers turns 65 years of age and enters the most stroke-prone years. Individuals aged $>65$ years have a higher prevalence of cardiovascular and cerebrovascular disease, and this segment of the population is projected to increase substantially over the next 2 decades. By 2030, it is estimated that an additional 27 million people will have hypertension, 8 million will have heart disease, and 4 million will have had a stroke.$^{21}$

**Stroke Remains a Leading Cause of Disability in the United States**

A tradeoff of mortality reduction through better acute stroke care is an increase in survivors with poststroke morbidity. Despite improvements in stroke death rates, stroke remains a leading cause of serious, long-term disability in the United States, costing an estimated $73.7$ billion in economic costs in 2010 and a human cost to patients and families that is incalculable. As more and more individuals survive their strokes, the burden of poststroke disability will be an increasing public health priority. It will be of utmost importance to rigorously assess and design interventions to improve functional outcomes and quality of life after stroke.

**Stroke Mortality Worldwide**

Despite improvements in stroke mortality in the United States, stroke remains the second leading cause of death worldwide. Over two thirds of stroke deaths worldwide occur in developing countries.$^{22}$ The World Health Organization estimates for 2001 indicate that 4.61 million people died from cerebrovascular disease, accounting for 9.5% of deaths.$^{23}$ Although rates of stroke mortality and burden vary greatly among countries, low-income countries are the most severely affected. There has been a $42$% decrease in stroke incidence in high-income countries and $>100$% increase in low- to middle-income countries.$^{24}$ The progress in prevention and mortality achieved in developed world urgently need to be translated to middle- and lower-income societies.

**Conclusions**

The decline in stroke from the third to fourth leading cause of death in the United States marks an important milestone in prevention and care of cerebrovascular disease. For stroke health professionals, this accomplishment is an occasion for celebration and rededication. Let us pause, for a moment, to be justly proud of the achievement of generations of public health, primary care and specialist physicians, and allied health professionals in reducing stroke mortality. Then let us take up our burden anew and focus on the challenges we, and our patients, still face: (1) reducing racial/ethnic, sex, and regional disparities in stroke incidence and outcomes; (2) reducing the incidence of obesity; (3) achieving even greater gains in blood pressure, cholesterol, and tobacco control; (4) iteratively improving acute stroke care systems; (5) reducing poststroke disability and improving quality of life after stroke; and (6) improving stroke prevention and care efforts in low- and middle-income countries.

**Disclosures**

None.

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