

Declining Stroke Incidence and Improving Survival in US Communities

Evidence for Success and Future Challenges

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Stroke affects an estimated 795 000 Americans each year, remains the fourth leading cause of death, and is the main cause of adult disability in the United States.¹ Worldwide, stroke ranks as the second leading cause of



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death, responsible for 9.5% of total deaths each year, with a greater burden in developing countries.² Over the past decade, overall stroke mortality has declined, primarily in western countries. Moreover, several studies have documented a decrease in stroke incidence rates.³⁻⁶ These favorable trends are likely due to better vascular risk factor control and improvements in acute stroke treatment at many institutions, including specialized stroke centers.⁷ In the United States, however, there are persistent racial, ethnic, sex, and regional disparities in age-adjusted stroke mortality rates,⁸⁻¹⁰ and long-term temporal trend data on validated stroke incidence by race and ethnicity are scarce.

In this issue of *JAMA*, Koton and colleagues evaluate temporal trends in stroke incidence and all-cause mortality after stroke among black and white adults in the well-designed prospective Atherosclerosis Risk in Communities (ARIC) cohort.¹¹ This well-known cohort consisted of residents who were aged 45 to 65 years at baseline and recruited using probability sampling in 4 different communities. From 1987 to 2011, the investigators followed up 14 357 participants free of stroke at baseline for all stroke hospitalizations and ascertained stroke deaths through linkage with the National Death Index. Physicians adjudicated all possible strokes and classified them as definite or probable ischemic or hemorrhagic events. Data on cardiovascular risk factors were collected at baseline and 3 follow-up visits, and annual phone interviews and active surveillance of discharges from local hospitals were conducted using consistent methods across time and study centers. The richness of this data set permits examination of several important questions.

During the 24-year study period, 1051 participants (7%) had an incident stroke, for an overall rate of 3.56 per 1000 person-years. The ARIC data confirm the greater relative incidence of stroke among men compared with women and among blacks compared with whites. The important new results demonstrate a substantial and similar decrease in stroke incidence per 10 years among men, women, whites, and blacks, with an overall absolute decline of 0.93 per 1000 person-years over each 10-year interval. The decline in stroke incidence among blacks is encouraging because this population has had some of the great-

est stroke risks in multiple studies, including ARIC. However, the declines in stroke incidence rates were evident only among those aged 65 years or older, not among those younger than 65 years. These temporal trends persisted after adjusting for multiple demographic variables and the time-varying effects of risk factors such as smoking, hypertension, diabetes, coronary heart disease, and use of cholesterol-lowering medications. Moreover, among the 1051 patients with incident stroke, there were 614 deaths from all causes. All-cause mortality after stroke decreased over time (overall absolute decline of 8.09 per 100 strokes after 10 years), and the decrease was greater in patients with incident stroke who were younger than 65 years.

Comparisons of the time-varying vascular risk factors can provide several data-driven insights to the potential reasons for these temporal trends. First, comparison of participants aged 55 to 64 years at the first visit (1987-1989) to those aged 55 to 64 years at visit 4 (1996-1998) showed an increase in prevalence of use of cholesterol-lowering medications (from 3.8% to 12.9%) and a 20-mg/dL reduction in median low-density lipoprotein cholesterol levels. Importantly, multivariable analyses demonstrated the association between use of cholesterol-lowering medications use and lower risk of incident stroke (risk ratio, 0.80; 95% CI, 0.68-0.93). Second, the use of hypertension medication increased from 29.5% at the first visit to 43.4% at visit 4, and this increase was noted predominantly among those older than 65 years and not among those aged 55 to 64 years. This may partially account for the differential temporal trends in stroke incidence between younger and older age groups. Third, the prevalence of current smoking decreased in total or same-age group comparisons between the 2 visits. Successes in the control of cholesterol levels, blood pressure, and smoking habits over the last decades are likely partially responsible for the decline in stroke incidence.

Despite a number of strengths of this report, several questions remain. Although adjustments were made for time-varying effects of a variety of vascular risk factors, the authors were unable to adjust for the intensity of risk factor control. Body mass index and diabetes prevalence increased in the cohort, and there was no adjustment for control of diabetes. Moreover, there was no adjustment for other modifiable behaviors such as physical activity, diet, and alcohol consumption. The increase in rates of obesity, diabetes, and lack of physical activity reported in other studies could be a potential explanation for the lack of a decline in stroke incidence in middle-aged and younger populations.¹² These in-

creases in behavioral risk factors could limit the future decline in stroke incidence.

The results for black participants in ARIC are based on a small sample size restricted to Forsyth County, North Carolina, and a larger sample from Jackson, Mississippi, and may not be generalizable to other US regions.¹² Like many studies, the study by Koton et al did not include Hispanics, the largest minority group in the United States. The higher incidence of diabetes, obesity, physical inactivity, and stroke in Hispanics in the United States raises significant concerns for increased stroke burden,^{13,14} but community-based studies on Hispanic-white disparities in stroke incidence trends remain scarce.

In another article in this issue of *JAMA*, Jørgensen and colleagues¹⁵ examined the risk of major adverse cardiovascular outcomes (ischemic stroke, acute myocardial infarction, and cardiovascular mortality) and all-cause mortality up to 30 days after elective noncardiac surgery among a Danish nationwide cohort of patients with (n = 7137) and without (n = 474 046) prior stroke. The crude incidence of major adverse cardiac events was significantly greater among patients with prior stroke than those without a history of stroke (54.4 vs 4.1 per 1000 patients), as was 30-day mortality (35.6 vs 6.1 per 1000 patients). The adverse risk attenuated 9 months after stroke but still remained 2 to 3 times higher than those who never had a stroke. Although mortality after stroke may be declining, patients who experienced prior stroke remain at substantially elevated risk of a stroke recurrence or an adverse outcome after surgery.

Despite the decline in stroke incidence and all-cause mortality after stroke reported in the ARIC cohort, future chal-

lenges remain regarding the public health burden of stroke. The aging and changing demographics of the population will lead to a substantial increase in the prevalence of stroke. By 2030, it is estimated that 4% of the US population will have had a stroke, leading to a projected additional 3.4 million people with stroke in 2030 and an estimated total annual cost of \$240.67 billion by 2030.¹⁶ These stroke survivors will be at increased risk of adverse outcomes after surgical procedures, and an increased number of patients will require greater efforts to treat, rehabilitate, and prevent stroke. Moreover, stroke is only one part of the overall danger to brain health. Vascular risk factors and unhealthy lifestyles also have a major influence on the risk of cognitive decline and dementia.¹⁷

Whether the decline in stroke incidence and mortality will continue in older age groups is still speculative, and the absence of a decline in younger age groups could be an early warning sign. Although there has been significant progress in reducing smoking and lowering blood pressure and cholesterol, formidable challenges to address stroke disparities and successfully control risk factors and lifestyle behaviors across race, ethnicity, and regions persist. Unless health disparities are addressed and innovative strategies to change behavior are developed and adopted, the cerebrovascular health of the population will be unlikely to improve. Greater improvements in brain health, especially with controllable risk factors such as diet, exercise, smoking, and obesity, among younger segments of the population are required to reduce the risk of stroke and enhance the chance of successful cognitive aging for all adults.

ARTICLE INFORMATION

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