The Current State and Future of Stroke

Temporal and Geographic Trends in the Global Stroke Epidemic

Anthony S. Kim, MD, MAS; S. Claiborne Johnston, MD, PhD

The Burden of Stroke in the United States

Stroke continues to present a significant public health challenge for the United States. Stroke is a leading cause of adult disability1; race-ethnic and geographic disparities in stroke incidence and outcomes have remained stubbornly persistent,2 and the total number of deaths from stroke is projected to increase in the coming decades as the population ages.3 However, there is also reason for optimism. During the last 40 years, there has been a >60% decline in the age-adjusted mortality rate from stroke in the United States,4 and stroke has recently moved from its prior position as the third leading cause of death to become the fourth leading cause of death overall.5

Although there are multiple factors to help to explain this trend, improvements in blood pressure control at the population level are likely to be playing a major role. During the last few decades, each successive national health survey has recorded improvements in population systolic blood pressure and hypertension control. For example, the median systolic blood pressure among aged 60 to 74 years in 1960–1962 was ≈150 mm Hg.6 In subsequent surveys, the median systolic blood pressure has consistently declined and by the 1988–1991 National Health and Nutrition Examination Survey III, the median systolic blood pressure had decreased to 130 mm Hg.6

Improvements in blood pressure have been particularly pronounced among those with very high blood pressure, which confers a disproportionately higher risk for stroke. For instance, during the same period, the 90th percentile for systolic blood pressure decreased from >190 mm Hg to <160 mm Hg.6 This pattern of improved hypertension control has also been demonstrated in other high-income countries, which have experienced a 42% decrease in stroke incidence overall during the past 40 years.7

The Ongoing Global Epidemic of Stroke

From the global prospective, the outlook for stroke is quite distinct. The conventional wisdom is that heart disease and stroke are primarily diseases of the developed world, although in point of fact most of the burden of cardiovascular disease and stroke is borne by countries in the developing world.5,6 Stroke continues to be the second leading cause of death worldwide (second only to cardiovascular disease) and accounts for ≈1 in 10 deaths or 5.7 million deaths a year.8 This mortality burden has come with a more than doubling of the stroke incidence in low- and middle-income countries with incidence rates that commonly surpass the incidence rates seen in most high-income countries.7 So not only is the overall disease burden of stroke higher in the developing world but stroke also accounts for a greater relative proportion of total deaths in low- and middle-income countries as well.

There is substantial variation in the distribution of stroke burden by geographic region and by country—the level that may be most relevant for policy and program development. These regional and national hot spots constitute a global stroke belt that parallels the well-documented geographic variations of stroke burden within the stroke belt of the southeastern United States.11 The burden of stroke is particularly high in Eastern Europe, North Asia, Central Africa, and the South Pacific with a 10-fold difference in stroke mortality and morbidity rates between the most affected and least affected countries.12 For example, Russia’s standardized stroke mortality rate is 251 per 100,000 compared with a rate of 32 per 100,000 in the United States.10 The pattern is quite similar for disability adjusted life year loss rates—a measure of overall disease burden that takes into account both years of potential life lost from premature deaths and long-term disability from stroke.12

Once again, the reasons for this geographic variation in the burden of stroke globally are quite complex. However, national income has emerged as a particularly strong predictor of stroke burden.13 The association between lower national income per capita and higher burden of stroke persists even after adjustment for national measures of typical cardiovascular risk factors, such as physical inactivity, hypertension, diabetes mellitus, tobacco use, alcohol use, and dyslipidemia.12 The strong association of stroke with national income is consistent with an overall shift from communicable diseases to noncommunicable diseases, such as heart disease and stroke, with rising income in what has been termed the epidemiological transition.13 Infection, nutrition, and perinatal disease accounted for 34% of deaths in 1990 but are projected to account for just 15% of total deaths in 2020.14 In contrast, the proportion of deaths from cardiovascular diseases, including stroke, is projected to increase from 28% to 34% during that same period.14

A similar geographic pattern is also seen for the burden of ischemic heart disease worldwide which is not surprising given that these 2 forms of vascular disease have overlapping atherosclerotic disease mechanisms and have major modifiable risk factors in common. But although ischemic heart disease is the predominant form of vascular disease burden overall, stroke is the predominant form of vascular disease for many...
lower income countries.\textsuperscript{15} For example, ischemic heart disease mortality rates are slightly higher than stroke mortality rates in North America, Western and Northern Europe, and Australia.\textsuperscript{15} In contrast, stroke mortality rates are substantially higher than ischemic heart disease mortality rates in much of Africa and Asia (Figure 1). In South Korea and China, for example, 17\% to 18\% of all deaths are from stroke compared with just 6\% to 8\% for ischemic heart disease. This concentration of stroke burden in low-income countries and in Asia and Africa suggests that a targeted approach for addressing stroke in the developing world may be warranted.\textsuperscript{10}

### The Case of China

In this global epidemic, the recent experience of China is deserving of special attention. Not only is China an outlier in terms of its substantial absolute stroke burden but also China is an outlier in terms of its high relative burden of stroke compared with ischemic heart disease.\textsuperscript{15} The sobering projections of stroke incidence for the coming decades provide a case study of the current challenges in addressing this epidemic.

Stroke is the leading cause of death in China with an estimated 2.5 million incident strokes and 1.6 million deaths from stroke each year.\textsuperscript{16} As previously described, stroke is the predominant form of vascular disease in China. The stroke mortality rate far exceeds the ischemic heart disease mortality rate in a pattern that is shared by many low- and middle-income countries.\textsuperscript{15} Hemorrhagic strokes also make up a larger proportion of incident strokes as well.\textsuperscript{15} In fact, the incidence of hemorrhagic stroke alone exceeds the incidence of myocardial infarction. This pattern of hemorrhage stroke subtypes and a higher relative burden of stroke compared with heart disease contributes to substantial societal costs since each stroke is associated with upward of 10 times the cost of myocardial infarction.\textsuperscript{16}

On the basis of current demographic and population-level vascular risk factor trends, current projections are for an unprecedented 50\% increase in stroke incidence in China during the next 20 years.\textsuperscript{17} Although demographic changes do account for some of the expected increases in coronary artery disease and stroke incidence, trends in virtually all the major vascular risk factors, including systolic blood pressure, cholesterol, diabetes mellitus, and smoking, are unfavorable and will account for a substantial proportion of the expected excess burden of stroke moving forward.\textsuperscript{17} Mean population body mass index has been increasing for decades; mean cholesterol, mean systolic blood pressure, and mean blood glucose have been steadily increasing since the early 1990s (Figure 2); and the prevalence of smoking has remained persistently high during the past 20 years.\textsuperscript{18} In contrast, the United States and Japan have seen steady improvements in population-level measures of cholesterol, systolic blood pressure, and smoking prevalence, although obesity and mean body mass index, as well as mean serum glucose continue to trend upward.\textsuperscript{18}

### Limitations

As we move forward to meet these challenges, the limited availability of high-quality epidemiological data on stroke and the challenge of integrating heterogeneous data sources will continue to make an accurate transnational picture of the global stroke epidemic a challenging task. Country-level analyses do not take into account the joint distribution of risk factors in important subnational groupings (e.g., by region or by urban/rural area) and may be subject to the ecological fallacy, whereby an inference made at the population level is falsely assumed to apply at the individual level. However, together as a whole, available data do provide a hint of the magnitude and scope of the challenge and will help to inform public health priorities and policy planning moving forward.

### Conclusions

Stroke is the second leading cause of death worldwide. In the ongoing global epidemic of cardiovascular disease, stroke has emerged as a major cause of preventable death and morbidity, particularly in the developing world where stroke is the predominant subtype of vascular disease. Demographic and vascular risk factor trends suggest that there will be an even greater burden of disease.
from stroke in coming years and will represent a major public health challenge moving forward.

Sources of Funding
None.

Disclosures
None.

References

Key Words: China stroke ■ ischemic heart disease ■ risk factors ■ world health
Temporal and Geographic Trends in the Global Stroke Epidemic
Anthony S. Kim and S. Claiborne Johnston

Stroke. 2013;44:S123-S125
doi: 10.1161/STROKEAHA.111.000067
Stroke is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2013 American Heart Association, Inc. All rights reserved.
Print ISSN: 0039-2499. Online ISSN: 1524-4628

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://stroke.ahajournals.org/content/44/6_suppl_1/S123

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Stroke can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Stroke is online at:
http://stroke.ahajournals.org/subscriptions/