During the past decade, there has been a documented decline in the incidence of stroke among several developed nations around the world.1–4 This welcome development in the alleviation of stroke burden has been attributed largely to better identification and treatment of traditional risk factors for stroke, especially hypertension.5 However, data on the extent to which various high-risk regions or demographic subgroups have recently fared with regard to improvement in stroke outcomes are sparse. Data from the Greater Cincinnati/Northern Kentucky Stroke Study (GCNKSS) recently showed that in recent years there has been a decrease in ischemic stroke incidence among whites. However, the incidence of overall ischemic stroke among blacks has remained virtually the same,6 and trends toward increasing stroke incidence at younger ages in both whites and blacks were also observed.7

A higher stroke incidence and mortality among blacks (versus non-Hispanic whites) has been present for several decades.8–12 This racial disparity is more prominent in the southeastern region of the United States, where the geographic concept of a stroke belt has been described.13,14 Within the stroke belt, 3 states, including South Carolina, have been recognized as representing the buckle of the stroke belt.11 South Carolina has consistently had high rates of stroke incidence and age-adjusted stroke mortality since the 1930s.15

It is unclear whether recent stroke incidence and mortality rates in South Carolina have corresponded with national

**Background and Purpose**—Mounting evidence points to a decline in stroke incidence. However, little is known about recent patterns of stroke hospitalization within the buckle of the stroke belt. This study aims to investigate the age- and race-specific secular trends in stroke hospitalization rates, inpatient stroke mortality rates, and related hospitalization charges during the past decade in South Carolina.

**Methods**—Patients from 2001 to 2010 were identified from the State Inpatient Hospital Discharge Database with a primary discharge diagnosis of stroke (International Classification of Diseases, Ninth Revision codes: 430–434, 436, 437.1). Age- and race-stroke–specific hospitalization rates, hospital charges, charges associated with racial disparity, and 30-day stroke mortality rates were compared between blacks and whites.

**Results**—Of the 84,179 stroke hospitalizations, 31,137 (37.0%) were from patients aged <65 years and 29,846 (35.5%) were blacks. Stroke hospitalization rates decreased in the older population (aged ≥65 years) for both blacks and whites (P<0.001) but increased among the younger group (aged <65 years; P=0.004); however, this increase was mainly driven by a 17.3% rise among blacks (P=0.001), with no difference seen among whites (P=0.84). Of hospital charges totaling $2.77 billion, $453.2 million (16.4%) are associated with racial disparity (79.6% from patients aged <65 years). Thirty-day stroke mortality rates decreased in all age-race-stroke–specific groups (P<0.001).

**Conclusions**—The stroke hospitalization rate increased in the young blacks only, which results in a severe and persistent racial disparity. It highlights the urgent need for a racial disparity reduction in the younger population to alleviate the healthcare burden. *(Stroke. 2014;45:1932-1938.)*

**Key Words:** epidemiology ▪ fees and charges ▪ middle aged ▪ minority health ▪ stroke

Received January 16, 2014; final revision received May 1, 2014; accepted May 6, 2014.

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Guest Editor for this article was Eric E. Smith, MD, MPH.

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Published in abstract form at the American Heart Association/American Stroke Association International Stroke Conference, Honolulu, HI, February 6–8, 2013.

The online-only Data Supplement is available with this article at http://stroke.ahajournals.org/lookup/suppl/doi:10.1161/STROKEAHA.114.004853/-/DC1.

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*Stroke* is available at http://stroke.ahajournals.org DOI: 10.1161/STROKEAHA.114.004853

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trends, especially among younger adults. Furthermore, with a projected substantial rise in future overall costs of stroke in the United States, it would be helpful to know more about the cost implications of recent stroke trends in a relatively poor state, such as South Carolina. The objectives of this study were to investigate the trends in stroke hospitalization and 30-day stroke mortality rates by age- and race-specific groups and the overall costs of stroke hospitalization and costs associated with racial disparity in South Carolina from 2001 to 2010.

Materials and Methods

Data Source
All hospitals in the state of South Carolina, with the exception of military and federal institutions, are mandated to provide data on every hospitalization, including demographic information, dates and type of hospitalization, discharge disposition (including death), diagnostic and procedure codes, insurance status, and hospital charges for itemized procedures, services, and overall costs. The state’s Office of Research and Statistics collects these data and provides investigators with a patient-based hospitalization database. Death certificate information, provided by the state Department of Health and Environment Control, is linked to the hospitalization database by Office of Research and Statistics. For this study, a database containing stroke hospitalizations from 2001 to 2010 was created by Office of Research and Statistics and provided to the study investigators. The study protocol was approved by the Institutional Review Board at the Medical University of South Carolina.

Population for Analysis
Patients discharged from January 1, 2001, through December 31, 2010, with a primary diagnosis of stroke, including acute ischemic stroke (AIS, 433, 434, 436, and 437.1), intracerebral hemorrhage (ICH, 431 and 432), and subarachnoid hemorrhage (SAH, 430) were identified using International Classification of Diseases, Ninth Revision (ICD-9), Clinical Modification diagnosis codes. We excluded ICD-9 codes 435 and 437.0 to 437.9 because of the low positive predictive value associated with these codes.17 In addition, ICD-9–associated procedure codes 38.12 (carotid endarterectomy), 00.61 (percutaneous angioplasty of extracranial vessels), and 00.63 (percutaneous insertion of carotid artery stents) were excluded to avoid duplicated counts of stroke-like events. Age at time of discharge and race were categorized based on the patient-level data reported in the state inpatient discharge database. Because our primary interest was the racial disparity between blacks and whites and other racial groups only comprise <6% of the population in South Carolina,14 stroke hospitalizations for nonblack or nonwhite patients were excluded from the analyses. Hospitalizations for patients who resided outside of South Carolina but hospitalized in South Carolina were excluded from analyses as well.

Statistical Analyses
Race- and age-specific strata were grouped a priori. Age was categorized into 6 groups as follows: 0 to 34, 35 to 44, 45 to 54, 55 to 64, 65 to 74, 75 to 84, and ≥85 years; however, much of the analyses was stratified across 2 age groups: <65 and ≥65 years. Age- and race-specific hospitalization rates were calculated per 100,000 population based on the year-specific US Census population estimates.15 Racial disparity measured by hospitalization rate ratios and 95% confidence intervals was calculated by dividing the 10-year average rate in blacks (eg, rate of AIS among blacks aged ≥85 years) by the corresponding rate in the whites using the Mantel–Haenszel method. Hospital charges associated with racial disparities were defined as the black age group–specific hospitalization rate minus the white rate, multiplied by the average stroke subtype–specific hospitalization charges and the total estimated number of blacks in each age group.16 Thirty-day stroke mortality rates were calculated and plotted by age, race, and stroke subtype groups during the 10-year period. Linear trend regression was conducted to assess significant trends in both hospitalization and 30-day mortality rates in the different race- and age-specific groups over time. No group comparisons were made. All P values were 2 sided and considered statistically significant at P<0.05. All statistical analyses were performed using SAS version 9.3 (SAS Institute Inc).

Results

Stroke Hospitalization Rate and 10-Year Trends
There were 84,179 stroke hospitalizations identified from the state administrative database from 2001 to 2010 in South Carolina (Figure 1). Blacks accounted for 29,846 (35.5%) and whites accounted for 54,333 (64.5%) of the strokes. Among blacks, 50.4% were aged <65 years compared with 29.6% among whites. The overall stroke hospitalization rate decreased during the 10-year period, but not at a statistically significant level (P=0.97) with a rate (per 100,000) of 219 in 2001, 201 in 2005, and 194 in 2010. There was a significant reduction in stroke hospitalization rate in the older (aged ≥65 years) populations (P<0.001) for both blacks (P<0.001) and whites (P<0.001) (Figure 1A). Whereas, in the younger populations (aged <65 years), the overall rate of stroke hospitalizations actually increased significantly (P=0.004); however, this increase was only associated with the blacks (P=0.001) not the whites (P=0.84; Figure 1B). For example, the hospitalization rate per 100,000 for the young blacks was 121 in 2001, 139 in 2005, and 142 in 2010, resulting in a 17.3% increase from 2001.

Racial Disparity in the Young/Middle-Aged Patients With Stroke
The racial disparity rate ratio for stroke hospitalization was consistently higher in the blacks for all stroke subtypes, with a decreasing trend as age increases (Figure 2A). This racial disparity was more severe in the younger group with the highest disparity seen in the 45- to 54-year age groups for both AIS and ICH and ≤34-year age group for SAH. For example, blacks aged 45 to 54 years were 4.3 times more likely to have ICH compared with their white counterparts. Furthermore, this racial disparity was persistent and showed no sign of decrease during the 10-year period (P=0.96; Figure 2B) for this age group.

Hospital Charges and the Proportion Associated With Racial Disparity
Stroke hospitalization charges during the 10-year period totaled $2.8 billion (AIS, $1,885.2 million; SAH, $278.4 million; and ICH, $603.2 million) and are summarized in the Table. Of this amount, $453.2 million (AIS, $301.6 million; SAH, $36.8 million; and ICH, $118.9 million) or 16.4% was associated with higher age-adjusted hospitalization rates among blacks compared with whites (ie, higher stroke hospitalization rate in the blacks), with a substantial proportion ($361.5 million or 79.6%) arising from the younger patients (aged <65 years), a finding that was consistent across all 3 stroke subtypes (AIS, $205.9 million [68.3%]; SAH, $33.6 million [91.3%]; and ICH, $97.7 million [82.1%]).

Thirty-Day Stroke Mortality Rate
Overall, 30-day stroke mortality rate steadily decreased during the 10-year period; for example, the rate was 16.5% in
2001, 15.6% in 2005, and 15.1% in 2010 (P<0.001). This decrease was consistent in all stroke subtypes (AIS, P<0.001; ICH, P<0.001; and SAH, P<0.001); however, there was a differential trend depending on the age-race-stroke subtype group (Figure 3). For example, 30-day stroke mortality rate for AIS only significantly decreased in blacks aged <65 years (P=0.001), but not in the other age–race groups. Thirty-day stroke mortality rate for ICH showed a decreasing trend in all groups, but was only statistically significant for the blacks (P=0.008 for younger blacks and P=0.047 for older blacks). For SAH, the rates significantly decreased in all groups (blacks aged <65 years, P=0.033; blacks aged ≥65 years, P=0.040; whites aged <65 years, P=0.007), except in the older white group (whites aged ≥65 years, P=0.170). There was no clear pattern of racial disparity in 30-day stroke mortality rate. For example, the stroke mortality rate was generally higher in the older white stroke patients with AIS or ICH compared with their black counterparts. Although the rate was higher in the younger black patients with AIS compared with their young white counterparts, the rates were similar with SAH. For in-hospital stroke mortality, see Figure I in the online-only Data Supplement.

Discussion
Data from the buckle of the stroke belt provides evidence that South Carolina is following the national trends with significant decreasing rates in stroke mortality although stroke hospitalization rate has a trend of decreasing but not at a statistically significant level. The state still lags behind in racial disparity reduction in stroke hospitalization, especially in the younger population (<65-year-old group). This disparity in the younger population is prominent and persists with no sign of reduction from 2001 to 2010. In contrast to stroke hospitalization rate, the 30-day mortality rate uniformly decreased in all stroke subtypes, although the extent of the decrease varied by age-race-stroke–specific groups. These unfortunate data have a profound economic impact to the state. Hospital charges cumulated $2.8 billion in the past decade with a substantial portion (16.4%) associated with the racial disparity, a majority (79.6%) of which arose from the younger age group.

Contrary to the findings from the Greater Cincinnati/Northern Kentucky Stroke Study (GCNKSS), which showed significant increasing trends in stroke incidence for both young blacks and whites, with a bigger magnitude of increase in blacks from 1993 to 2005, our data from 2001 to 2010 showed no changes in stroke hospitalization rate for young whites. However, similar to the results of the GCNKSS, we found significant increasing trends for young blacks. Both studies showed a significant decrease in stroke incidence for both blacks and whites in the older group, but the opposing trends between the young blacks and whites resulted in a worsening of the racial disparity in this group. This was also observed in another study from
the Nationwide Inpatient Sample of the Healthcare Cost and Utilization Project from 1995 to 2008, in which the rate of hospitalizations for AIS significantly increased in young males aged 5 to 44 years and slightly increased in young females aged 15 to 44 years. All studies highlighted an urgent issue of increasing stroke rates in the younger group.

The higher prevalence of stroke risk factors, including hypertension, diabetes mellitus, and smoking, in young/middle-aged blacks is perhaps the most important contributing factors for the excess strokes in the black population. Recently, the Reasons for Geographic and Racial Differences in Stroke (REGARDS) study discovered a differential

<table>
<thead>
<tr>
<th>Year</th>
<th>Stroke Hospitalization, n</th>
<th>Total Charges (AIS; SAH; ICH), $</th>
<th>Charges Associated With Racial Disparities (AIS; SAH; ICH), $</th>
<th>Charges Associated With Racial Disparities Among Patients Aged &lt;65 y (AIS; SAH; ICH), $</th>
<th>Charges Associated With Racial Disparities Among Patients Aged ≥65 y (AIS; SAH; ICH), $</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>8721</td>
<td>177.2 (127.9; 16.0; 3.4)</td>
<td>25.2 (17.8; 1.9; 5.8)</td>
<td>18.9 (10.8; 1.9; 6.2)</td>
<td>8.7 (7.6; 0.1; 0.9)</td>
</tr>
<tr>
<td>2002</td>
<td>8666</td>
<td>194.6 (141.0; 20.4; 33.1)</td>
<td>26.7 (18.8; 2.7; 5.47)</td>
<td>20.7 (12.3; 2.1; 6.0)</td>
<td>8.3 (7.0; 0.6; 0.7)</td>
</tr>
<tr>
<td>2003</td>
<td>8375</td>
<td>210.9 (152.9; 17.7; 40.4)</td>
<td>34.7 (25.1; 3.2; 6.9)</td>
<td>25.3 (15.4; 2.4; 7.5)</td>
<td>11.9 (10.2; 0.8; 0.9)</td>
</tr>
<tr>
<td>2004</td>
<td>8249</td>
<td>236.4 (160.9; 24.3; 51.2)</td>
<td>36.8 (24.6; 2.9; 9.3)</td>
<td>26.1 (14.1; 2.8; 9.6)</td>
<td>13.2 (11.0; 0.3; 1.2)</td>
</tr>
<tr>
<td>2005</td>
<td>8324</td>
<td>269.6 (184.4; 28.0; 57.1)</td>
<td>45.3 (30.2; 2.5; 12.8)</td>
<td>36.2 (20.8; 2.5; 12.3)</td>
<td>12.6 (10.1; 0.1; 2.2)</td>
</tr>
<tr>
<td>2006</td>
<td>8231</td>
<td>274.5 (188.9; 23.7; 62.0)</td>
<td>47.9 (32.5; 3.0; 12.8)</td>
<td>37.5 (21.4; 3.0; 13.5)</td>
<td>14.6 (12.2; 0.3; 1.8)</td>
</tr>
<tr>
<td>2007</td>
<td>8221</td>
<td>311.4 (199.9; 36.3; 75.2)</td>
<td>55.9 (35.2; 3.9; 16.7)</td>
<td>48.3 (26.3; 4.1; 16.7)</td>
<td>14.5 (10.9; 0.2; 3.2)</td>
</tr>
<tr>
<td>2008</td>
<td>8289</td>
<td>336.3 (221.7; 33.6; 81.0)</td>
<td>57.0 (35.9; 7.4; 15.8)</td>
<td>47.4 (25.4; 6.5; 15.4)</td>
<td>15.4 (11.7; 1.0; 3.0)</td>
</tr>
<tr>
<td>2009</td>
<td>8399</td>
<td>372.0 (246.6; 40.6; 84.8)</td>
<td>60.9 (40.7; 4.4; 15.4)</td>
<td>50.2 (30.0; 4.2; 15.4)</td>
<td>17.0 (13.3; 0.4; 3.1)</td>
</tr>
<tr>
<td>2010</td>
<td>8707</td>
<td>383.9 (261.1; 37.9; 85.0)</td>
<td>62.8 (40.8; 4.9; 18.2)</td>
<td>50.9 (29.7; 4.3; 16.4)</td>
<td>17.7 (13.1; 0.9; 4.2)</td>
</tr>
<tr>
<td>Total</td>
<td>84179</td>
<td>2767.8 (1895.2; 278.4; 603.2)</td>
<td>453.2 (301.6; 36.8; 118.9)</td>
<td>361.5 (205.9; 33.6; 97.7)</td>
<td>134.1 (107.1; 4.6; 21.2)</td>
</tr>
</tbody>
</table>

AIS indicates acute ischemic stroke; ICH, intracerebral hemorrhage; and SAH, subarachnoid hemorrhage.

*Hospital charge data were inflated to 2010 dollars based on the US Bureau of Labor Statistics’ Consumer Price Index.

†Hospital charge associated with racial disparities=(age group–specific stroke hospitalization rate in blacks–age group–specific stroke hospitalization rate in whites)×averaged charges of each hospitalization×total estimated numbers of blacks in the age-specific group. Numbers may not add together because of rounding.
impact of elevated blood pressure in blacks, suggesting that a 10-mm Hg difference in systolic blood pressure was associated with a 24% increase in stroke risk for blacks versus only an 8% increase for whites. Low socioeconomic status is another important contributing factor explaining 39% of excess stroke in blacks in the GCNKSS. The excess stroke incidence in blacks most likely explains the excess stroke mortality rate seen in blacks, however, our data showed that 30-day stroke mortality decreased in both groups during the past decade. Interestingly, the pattern of racial disparity in stroke mortality is not as clear as in stroke incidence. Excess strokes among blacks as well as the lingering racial disparity in the younger groups represent a serious public health issue. This issue is not limited to the stroke belt. Similar data have been discovered outside of the stroke belt as well. For example, a strong and persistent black–white disparity in stroke hospitalization rates existed in Florida for young adults aged 25 to 49 years from 2001 to 2006. The black stroke risk was 3 times that of the whites in this study, 2.4 times greater among patients aged 20 to 45 years in the Northern Manhattan Stroke Study, 2.2 times greater for ischemic stroke and 3.1 times greater for ICH among patients aged 15 to 44 years in the Baltimore-Washington Cooperative Young Stroke Study, and 2 to 5 times for any stroke in the GCNKSS for patients aged <65 years. This racial disparity issue is particularly problematic for young/middle-aged patients with ICH (aged 45–64 years) in our study. Lacking an effective treatment in the acute phase, ICH still carries a high fatality rate (30-day stroke mortality was 31.8% in 2010). Stroke survivors who experienced stroke at a young age are frequently left with significant disability that persists during their young adult years and time of peak productivity. They are less capable of contributing to society with lifetime needed medical care, placing an undue, both direct and indirect, burden to family as well as to society. Consequently, the overall cost of stroke far exceeds the acute hospitalization cost reported here. Collectively, these findings are important because to achieve the 2020 American Heart Association goal “to improve the cardiovascular health of all Americans by 20% while reducing deaths from cardiovascular diseases and stroke by 20%,” rigorous measures both in primary and secondary stroke prevention strategies need to be in place, especially in the younger group (ie, aged <65 years). It is noteworthy that 30-day stroke mortality rate for AIS only significantly decreased in blacks aged <65 years, whereas the same group had an increasing hospitalization rate. This might imply better recognition and response to less severe stroke symptoms among younger blacks; however, literature only suggests that younger individuals regardless of race do not actively seek treatment urgently because of poor symptom recognition. Because stroke more commonly occurs at older ages, younger individuals may be more likely to attribute stroke symptoms to other disease conditions. Our study does not have information about stroke symptoms or stroke severity, and we are not able to address the issue.

The advances of systematic stroke care in the acute phase may explain the unifying decrease of 30-day stroke mortality rate in South Carolina as well as nationwide. There are 6 Joint Commission–certified primary stroke centers as well as a statewide telestroke system. As a result of the significant decrease in stroke mortality, South Carolina no longer ranks highest in the nation for stroke mortality and even declined to the sixth place in 2010.
A major strength of this study is that our data were not based on sampling or survey data; rather, they were based on a real-world stroke hospitalization database mandated by a state agency. In addition, only the ICD-9 stroke codes that have been shown to identify stroke cases accurately from the administration databases were included for this study. This study, however, is not free from limitations. First, the state Office of Research and Statistics database does not include admissions of patients who received medical care in veterans/military hospitals. Additionally, there is a small percentage of patients who live close to neighboring states (Georgia or North Carolina), who choose to have medical care in those states. As a result, our data represents a close, but not a complete picture of stroke epidemiology in South Carolina. Second, patients with silent strokes usually do not present with outward neurological symptoms and are not always hospitalized; therefore, hospitalization rate is not same as incidence rate. It is possible that the stroke burden in South Carolina could be underestimated by this study. Third, initial stroke severity is not recorded because of the nature of the administrative database; our study could not provide sufficient information to analyze reasons for differing mortality between racial groups over time.

In summary, this study highlights the urgent need for a racial disparity reduction in the younger population to alleviate the healthcare burden. There are several key issues that require further study to better understand the current disparity gap. First, the prevalence of overweight/obesity has markedly increased in children and adolescents. The prevalence of diabetes mellitus has increased as well in 1 in 8 adults in South Carolina having diabetes mellitus. The situation generally is worse in minority groups. As a consequence, the population is at risk for stroke at an earlier age, especially among the minority groups. Second, the racial disparity is a more severe issue in the younger population and has a profound economic and health impact. The true economic burden is far greater than what we outlined in this study because we only captured the costs associated with the acute hospitalization. The financial burden from poststroke physical and cognitive disabilities would markedly increase when stroke occurs at an earlier age because many of these deficits persist over time. For example, the average lifetime cost of caring for 1 patient with stroke (all stroke subtypes on average) was estimated at $103,576 in 1990, which included the cost of acute care, rehabilitation care, ambulatory care, and nursing home care. The cost of the same amount care has escalated to $185,556 in 2013 after inflation adjustment. Third, there are other explanations for greater disparity gaps in the younger populations, such as sickle cell disease or behavioral issues, which place blacks at higher risk for stroke. These issues should be examined in detail with an ultimate goal to greatly reduce or close the current racial disparity gap.

Acknowledgments

We thank the State Office of Research and Statistics for providing the study database.

Sources of Funding

This research was supported by Southeastern Virtual Institute for Health Equality and Wellness, US Army Medical Research and Materiel Command and Telemedicine & Advanced Technology Research Center (W81XWH-10-2-0057); Stroke Education and Prevention—South Carolina, Health Sciences South Carolina; and Consortium for Southeastern Hypertension Control.

Disclosures

None.

References

Persistent Racial Disparity in Stroke Hospitalization and Economic Impact in Young Adults in the Buckle of Stroke Belt
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Stroke. 2014;45:1932-1938; originally published online June 19, 2014; doi: 10.1161/STROKEAHA.114.004853

Stroke is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0039-2499. Online ISSN: 1524-4628

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