Despite being both preventable and treatable, stroke remains one of the leading causes of death and disability in the United States. The public health burden of stroke is not evenly distributed across the United States, both among types of people as well as the places people live. Black Americans have a risk of first stroke that is twice that of white Americans with a 2- to 3-fold increase in age-specific stroke mortality. There may be an increased burden in people below the poverty line. There is considerable geographic variability as well. Rural areas may have more cerebrovascular disease than urban areas, and there is a well-described excess burden of stroke in the Southeastern United States, the “Stroke Belt.” Relatively little is known about why geographic disparities exist. Proposed explanations include differences in vascular risk factors, socioeconomic status, and access to care.

One possible driver of geographic disparities is the variable availability of stroke care across the United States. Studies have shown that organized stroke care reduces mortality after stroke. The Joint Commission (TJC), a nonprofit organization that accredits healthcare organizations, began certifying primary stroke centers (PSCs) in December 2003. The impact of TJC PSCs on population health is not fully understood. At the hospital level, PSCs have modestly lower 30-day mortality than non-PSCs; although, this may be attributable to baseline differences rather than certification. Recent studies have demonstrated greater use of recombinant tissue plasminogen activator (rt-PA) at TJC PSCs than non-PSCs, suggesting a
benefit of certification.13,14 The Brain Attack Coalition and American Stroke Association/American Heart Association have recommended developing systems of care based on an organized hierarchy of hospitals, similar to the US trauma system.15-17 PSCs are the basic building block of these systems, and there are >900 TJC PSCs spread across 48 states.18 Although TJC certifies PSCs, there is no oversight of which facilities apply to become PSCs. As a result, PSCs are not evenly distributed throughout the United States.19 Differences in geographic accessibility may lead to disparities in realized access to PSCs. We aimed to determine whether there were disparities in realized access to TJC PSCs on the basis of race, education, socioeconomic status, and geography for persons with suspected stroke events within a cohort of black and white community-dwelling individuals in the United States.

Methods

Study Design

The Reasons for Geographic And Racial Differences in Stroke (REGARDS) study is a prospective, longitudinal national cohort study of adults ≥45. The study sample was recruited between January 2003 and October 2007 using mail and telephone, with a 33% telephone response rate and a 49% cooperation rate. Study sampling was stratified by geography, race (non-Hispanic blacks and whites only), and sex. The study oversampled blacks and residents of the Stroke Belt (AL, AR, GA, LA, MS, NC, SC, and TN). The study achieved a sample of 30239 participants; 42% were black and 56% lived in the Stroke Belt. Data on medical history and socioeconomic status were obtained by telephone and in-home interview, including phlebotomy, blood pressure, and anthropometry. The protocol was approved by the institutional review boards at participating institutions, and all participants provided informed consent. The objectives and design of REGARDS have been published in detail elsewhere.20

After enrollment, subjects were contacted by telephone at 6-month intervals to ascertain hospitalizations, emergency department visits, rehabilitation and nursing home admissions, and deaths. Subjects were asked the reason for all medical encounters and the name of the facility where they received the majority of their evaluation and treatment. Transfers were not recorded. Medical records were obtained for suspected stroke, transient ischemic attack, death, sudden weakness, numbness, trouble speaking, loss of vision, headache, brain aneurysm, brain hemorrhage, and other stroke symptoms. For proxy reported deaths, an interview was conducted with next of kin. The present study was limited to subjects who sought care for suspected stroke events between December 9, 2005, to allow time for hospitals to become certified. The 200th PSC was certified by TJC on this date. A list of all TJC-certified PSCs with the date of initial certification was obtained directly from TJC on May 17, 2011 (personal communication, TJC). At that time, data on suspected events were available until January 6, 2011, setting the time period for the study.

Only the first suspected stroke event for each subject was used. Suspected strokes were used in the analysis rather than adjudicated strokes, recognizing that people cannot reliably diagnose themselves before seeking care. For each suspected stroke, it was determined whether the evaluating center was certified as a PSC on the date of admission and whether the center would become certified by May 17, 2011. This determination was performed blinded to all subject characteristics. Participants evaluated at outpatient clinics were categorized as evaluated at non-PSCs.

Covariates

Subjects were described in terms of sex and race. Smoking was categorized as ever versus never by participant report. History of stroke and carotid endarterectomy before enrollment were obtained by participant report. Hypertension was defined as systolic blood pressure >140 mm Hg or diastolic blood pressure >90 mm Hg or use of antihypertensive medications. Heart disease was defined as any self-reported myocardial infarction, coronary artery bypass surgery, coronary angioplasty or stenting, or evidence of myocardial infarction from ECG. Diabetes mellitus was defined as a fasting glucose level >126 mL/dL, nonfasting level >200 mL/dL, or self-reported medication use for glucose control. Chronic kidney disease was defined by a glomerular filtration rate <60 mL/min per 1.73 m calculated using the modification of diet in renal disease equation. Socioeconomic status was described using annual household income (dichotomized to <$20000 and >$20000 to approximate the poverty threshold) and education (dichotomized to high school graduate or not). Geographic location was described by region and rurality. Region was dichotomized as Stroke Belt residence or not, and rurality was dichotomized as urban or nonurban. Urban was defined by residence in a census tract that was ≥75% urban by the US Census. A significant proportion of subjects (11.8%) refused to provide income. There was minimal (<1%) missing data for all other variables.

Statistical Analysis

The primary dependent variable was PSC certification by TJC at the time of the event. There were 1000 suspected strokes included in the analysis, of which 383 strokes occurred in blacks, and 617 strokes occurred in whites; there were 546 suspected strokes in the Stroke Belt and 454 strokes outside the Stroke Belt. There were 204 subjects evaluated at hospitals that were TJC-certified PSCs at the time of the event, and 796 subjects were evaluated at noncertified hospitals. A lower proportion of women than men (17.8% versus 23.0%; P = 0.04), subjects with a self-reported history of stroke before enrollment (15.1% versus 21.6%; P = 0.04), Stroke Belt residents (14.7% versus 27.3%; P < 0.001), and nonurban residents (9.1% versus 23.9%; P < 0.001) were evaluated at PSCs. Complete univariate analysis is presented in Table 1.

In a multivariable logistic regression model, which incorporated age, race, sex, past medical history (previous stroke, diabetes mellitus, hypertension, coronary artery disease), and geography (urban versus nonurban, Stroke Belt versus non-Stroke Belt), subjects living in nonurban areas were less likely to be evaluated at TJC PSCs (odds ratio [OR], 0.39; 95% confidence interval [CI], 0.22–0.67). Even after accounting for rurality, subjects residing within the Stroke Belt were less likely to be evaluated at a PSC (OR, 0.54; 95% CI, 0.38–0.77). Subjects with a previous history of stroke were also less likely to be evaluated at a PSC (OR, 0.46; 95% CI, 0.27–0.78). Men (OR, 1.75; 95% CI, 1.19–2.50), subjects

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with hypertension (OR, 1.64; 95% CI, 1.08–2.44), subjects with an income <$20,000 (OR, 1.72; 95% CI, 1.10–2.70), and subjects who refused to provide their income (OR, 2.08; 95% CI, 1.10–3.57) were more likely to be evaluated at a PSC. Full model results are presented in Table 2. There was no interaction between rurality and region (P=0.98), race and region (P=0.27), or race and rurality (P=0.40).

In the secondary analysis, looking for disparities in evaluation at hospitals which would become TJC-certified PSCs by May 17, 2011, nonurban location (OR, 0.38; 95% CI, 0.24–0.59) and stroke-belt residence (OR, 0.46; 95% CI, 0.34–0.63) were associated with a reduced odds of evaluation at a future PSC. Black race (OR, 1.47; 95% CI, 1.06–2.08), hypertension (OR, 1.56; 95% CI, 1.10–2.22), and refusal...
Disparities in Evaluation at PSCs in REGARDS

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Table 2. Odds of Evaluation at a PSC, Multivariable Analysis

<table>
<thead>
<tr>
<th></th>
<th>OR</th>
<th>95% CI</th>
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</thead>
<tbody>
<tr>
<td>Nonurban location</td>
<td>0.39</td>
<td>0.22–0.67</td>
</tr>
<tr>
<td>Stroke Belt residence</td>
<td>0.54</td>
<td>0.38–0.77</td>
</tr>
<tr>
<td>Hx of previous stroke</td>
<td>0.46</td>
<td>0.27–0.78</td>
</tr>
<tr>
<td>Hx of hypertension</td>
<td>1.64</td>
<td>1.08–2.44</td>
</tr>
<tr>
<td>Black race</td>
<td>1.20</td>
<td>0.82–1.75</td>
</tr>
<tr>
<td>Male sex</td>
<td>1.75</td>
<td>1.19–2.50</td>
</tr>
<tr>
<td>No high school degree</td>
<td>0.77</td>
<td>0.58–1.32</td>
</tr>
<tr>
<td>Income</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;$20,000</td>
<td>1.72</td>
<td>1.10–2.70</td>
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<tr>
<td>=$20,000</td>
<td>ref</td>
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<tr>
<td>Refused</td>
<td>2.08</td>
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Adjusted for age, smoking, diabetes mellitus, and coronary artery disease. CI indicates confidence interval; OR, odds ratio; and PSCs, primary stroke centers.

to provide income (OR, 1.85; 95% CI, 1.15–2.94) were associated with an increased odds of evaluation at a PSC. Sex, income <$20,000, and history of previous stroke were no longer significantly associated with evaluation at a PSC.

Discussion

A health disparity is defined as a health difference that is closely linked with social, economic, or environmental disadvantage.21 Our study found that subjects living in Stroke Belt states were less likely to be evaluated at TJC-certified PSCs, even after adjusting for rurality, confirming a significant environmental disadvantage. There were no observed disparities in access to PSCs on the basis of race, despite previously described racial differences in emergency medical services use, emergency department wait time, and thrombolysis between racial groups.22 There were also no observed disparities in access to PSCs on the basis of education or low income.

Access to care is a multidimensional concept that depends on system level variables (eg, organization and distribution of hospitals/physicians) and individual characteristics (eg, socioeconomic status, attitudes toward care, trust/mistrust of providers).23,24 Accessibility, or geographic access, is the component of access, which encompasses the relationship between the location of healthcare resources and the location of patients incorporating time, distance, and cost. For an unplanned, time-critical condition like stroke, geographic access is extremely important.25,26 Persons with suspected stroke need to be transported rapidly to hospitals that are prepared to evaluate them efficiently and, if the diagnosis is confirmed, administer acute therapies. Paradoxically, our results suggest that those living in areas with a high burden of stroke had less access than those living in other areas.

TJC-certified PSCs are quickly proliferating throughout the United States. As of July 2012, 925 hospitals were certified, representing 18.6% of US nonfederal short-term general hospitals.27 There are 15 states that require or recognize TJC certification for PSC designation.18 Unfortunately, there is significant geographic variability in access to these centers. As of November 2008, there were 11 states in the United States in which <25% of the population had 60-minute access to a TJC PSC.19 Five of those states were in the Stroke Belt, despite an increased burden of cerebrovascular disease in that region.5,19,28,29 Maps of PSC access in 2010 show that this disparity continues to exist, and also demonstrate the lack of TJC PSCs in rural areas of the United States (Figure).

Currently, the decision to pursue certification occurs primarily at the individual hospital level. Optimally, certification decisions would occur at the societal level, balancing the local supply of and demand for acute stroke care.30 A system designed in this way would maximize its impact on population health. Because we did not find racial or socioeconomic disparities in access, such a system would likely benefit all people equally. Although public policy interventions should be able to improve geographic disparities by incentivizing certification of specific hospitals in areas of need, developing a comprehensive stroke care system poses several significant challenges. It may not be feasible to place a PSC in all areas with high stroke mortality rates because of limited healthcare resource availability. Telemedicine, hub-spoke complexes, and other regional partnerships may be able to increase specialized stroke care in these areas.31 Outcome measures relevant to population health must be developed to quantify the impact of the developing system of care and ensure that all patients are benefitting equally. Finally, there must be support and cooperation from professional societies, prehospital care providers, hospitals, and legislators. Despite these hurdles, there is some precedent for this approach. A county-based acute stroke care system in Orange County, CA, was recently reported to substantially improve thrombolysis rates.32 In the United Kingdom, the National Health Service dramatically

Figure. Sixty-minute access to The Joint Commission primary stroke centers by ground ambulance, 2010 (continental United States). Adapted with permission from www.strokemaps.org.
overhauled the delivery of acute stroke care in London in 2010. Preliminary results suggest a major increase in thrombolysis rates with reduced length of stay and lower than average 30-day mortality.13

This study has several limitations. As in all cohort studies, there is potential for selection bias because those who participated may not be representative of the general population. Our cooperation rate compares favorably with other observational cardiovascular studies.14,15 The evaluating hospital in this study represents the location where patients received the majority of their care. As a result, we are unable to assess the differences in the initial point of care, transfers, and telemedicine. Telemedicine may improve access, particularly in nonurban areas; although, telestroke care often focuses on acute stroke therapy, which is the only one component of PSC care. We are not able to determine whether disparities in evaluation at PSCs are changing over time because the number of certified PSCs has increased. Our secondary analysis, which looked at hospitals that would become certified PSCs by May 2011, showed the same geographic disparities as our primary analysis. Although not truly longitudinal, this suggests that geographic disparities are relatively stable. Location at stroke onset was not known; therefore, home address was used as a proxy. This should have a limited impact because previous studies show that >75% of strokes occur at home.16 Although we hypothesize that the observed disparities are attributable to geographic differences in the availability of PSCs, we have not directly quantified distance or transportation time to the nearest PSC for each event. Such calculations may be informative in future work investigating access to PSCs. We defined PSCs using certification by TJC because TJC provides a standardized, nationwide definition of specialized stroke care. This ignores state-based certification programs and quality improvement initiatives, such as Get with the Guidelines. As of July 2010, 14 states have their own PSC certification process (CT, GA, IL, MD, MA, MO, NJ, NY, ND, OK, RI, TX, VA, and WA).16 Because only one of these states is within the Stroke Belt, accounting for state-based stroke centers would likely increase the regional disparity that we observed. The relationship between race and access to a certified PSC may vary in urban, suburban, and rural areas, or in different regions of the country. We attempted to evaluate this by testing for interactions between race, region, and rurality. These tests were not statistically significant; although, the relatively low number of events limits power to detect an interaction, even if it truly exists. Finally, it should be noted that REGARDS, by design, does not necessarily represent the views of the Department of Health and Human Services. The other authors have no conflicts to report.

In conclusion, disparities in evaluation by TJC-certified PSCs are related to geographic factors, including region (Southeastern Stroke Belt versus non-Stroke Belt), and urbanicity (urban versus nonurban). Importantly, participants living in Stroke Belt states were less likely to be evaluated at a TJC PSC, despite an increased burden of cerebrovascular disease in this area. The geographic disparities that we observed are likely attributable to a reduced number of TJC PSCs in the Stroke Belt and in rural areas. Public policy and systems planning should ensure specialized stroke care is rapidly accessible in areas with the greatest need.

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Disclosures
Dr Carr spends time as a Senior Policy Analyst in the Office of the Assistant Secretary for Preparedness and Response. The findings/conclusions of this report are those of the author and do not necessarily represent the views of the Department of Health and Human Services or its components. The other authors have no conflicts to report.

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