Contributors to the Excess Stroke Mortality in Rural Areas in the United States

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Background and Purpose—Stroke mortality is 30% higher in the rural United States. This could be because of either higher incidence or higher case fatality from stroke in rural areas.

Methods—The urban–rural status of 23 280 stroke-free participants recruited between 2003 and 2007 in the REGARDS study (Reasons for Geographic and Racial Differences in Stroke) was classified using the Rural–Urban Commuting Area scheme as residing in urban, large rural town/city, or small rural town or isolated areas. The risk of incident stroke was assessed using proportional hazards analysis, and case fatality (death within 30 days of stroke) was assessed using logistic regression. Models were adjusted for demographics, traditional stroke risk factors, and measures of socioeconomic status.

Results—After adjustment for demographic factors and relative to urban areas, stroke incidence was 1.23-times higher (95% confidence intervals, 1.01–1.51) in large rural town/cities and 1.30-times higher (95% confidence intervals, 1.03–1.62) in small rural towns or isolated areas. Adjustment for risk factors and socioeconomic status only modestly attenuated this association, and the association became marginally nonsignificant (P=0.071). There was no association of rural–urban status with case fatality (P>0.47).

Conclusions—The higher stroke mortality in rural regions seemed to be attributable to higher stroke incidence rather than case fatality. A higher prevalence of risk factors and lower socioeconomic status only modestly contributed to the increased risk of incident stroke risk in rural areas. There was no evidence of higher case fatality in rural areas. **(*Stroke*. 2017;48:1773-1778. DOI: 10.1161/STROKEAHA.117.017089.)**

Key Words: case fatality ■ census ■ incidence ■ life expectancy ■ mortality ■ stroke

The rural–urban deficit in life expectancy has increased from 0.4 years in 1969 to 1971 to 2.0 years in 2005 through 2009,[1] with 7.1% of the deficit attributable to stroke.[2] Stroke mortality in the United States increases monotonically across the spectrum from counties classified as the most urban (large central metro) to counties that are the most rural (noncore), with ≈30% higher mortality in the noncore than in large central metro regions.[3] The shorter life expectancy and higher disease burden in rural areas motivated strategic plans of the National Institutes of Health to include rural persons in their definition of health disparity populations.[4] Despite this commitment, there are no publications examining rural–urban differences in the incidence of stroke, and there is only a single report on rural–urban differences in case fatality from stroke.[5] A recent review[6] identified only a single publication on the rural–urban differences in stroke burden focusing only on prevalence.[7]

Higher rural stroke mortality could be attributable to either rural residents having a higher likelihood of developing a stroke (higher incidence) or a higher likelihood of dying from stroke once it occurs (higher case fatality) or both. The implications of whether incidence or case fatality is the major contributor are profound. Should incidence be the contributing factor, then efforts to reduce the disparity should be community-based primordial or primary prevention to reduce and manage risk factors for incident stroke in rural regions. Conversely, if case fatality is a contributor, then hospital-based efforts need to focus on improving the care of stroke patients in rural areas.

With community-dwelling participants residing in 1831 counties from 10 250 unique Census tracts, the REGARDS study (Reasons for Geographic and Racial Differences in Stroke) offers an opportunity to evaluate this question.

Methods

REGARDS is a longitudinal cohort study that enrolled 30 239 community-dwelling black and white participants aged ≥45 years between 2003 and 2007 and is continuing to follow up participants for incident stroke events since recruitment. Participants were sampled from the 48 contiguous US states using a commercially available list, with oversampling of blacks and residents of the stroke buckle (coastal plain of North Carolina, South Carolina, and Georgia) and stroke

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belt (the remainder of North Carolina, South Carolina, Georgia; plus Tennessee, Alabama, Mississippi, Louisiana, and Arkansas). Participants were recruited through a combination of mail and telephone contact. For those agreeing to participate (participation rate ≈30%), a structured telephone interview was conducted to collect demographic, medical, and lifestyle history. An in-home examination was performed ≈2 weeks later, where blood pressure, venipuncture, urine collection, an ECG, height, weight, and medication inventory were collected. The participants were then followed up at 6-month intervals for ascertainment of incident stroke. The medical records of suspected strokes were retrieved and adjudicated by a panel of stroke physician experts. Details of the study design[8] and the stroke adjudication process[9] are available elsewhere. The study was approved by all participating institutional review boards, and all participants provided written informed consent.

The primary exposure variable was the rural–urban status of each participant. Because there can be a substantial heterogeneity in the rural–urban status of residences within a county, we used the Rural–Urban Commuting Area (RUCA) classification that is available at the Census tract level.[10] This choice for defining rural status was motivated by the relatively small size of census tracts, providing a much more homogenous characterization of neighborhood than the larger county definitions. On the basis of the 2004 census, the 4-level RUCA classification categorizes 81.0% of the US population as urban, 9.6% as large rural city/town, 5.2% as small rural town, and 4.2% as isolated small rural.[10] To provide stable estimates, we combined the small rural town and isolated small rural categories.

Factors potentially contributing to rural–urban differences were classified in groups of demographic, risk factors, and socioeconomic status (SES) factors. Demographic factors included age, race, sex, and geographic region. The selection of risk factors for analysis was guided by measures included in the Framingham Stroke Risk Function.[11] Hypertension was defined as systolic blood pressure ≥140 mm Hg or diastolic blood pressure ≥90 mm Hg or self-reported use of antihypertensive medications. Diabetes mellitus was defined as fasting glucose ≥126 mg/dL (or ≥200 mg/dL among those failing to fast) or self-reported use of antihyperglycemic medications. Current smoking was defined by self-report. Atrial fibrillation was defined by ECG evidence or self-report of a physician diagnosis. Left ventricular hypertrophy was defined using ECG evidence using the Sokolow and Lyon[12] criteria. Heart disease was defined by baseline ECG evidence of a myocardial infarction; self-reported physician diagnosis of myocardial infarction; or previous coronary artery bypass graft, angioplasty, or coronary stenting. Measures of individual SES included self-reported household income (<$20K, $20K–$35K, $35K–$75K, and $75K+, and refused to provide data), and self-reported education (less than high school, high-school graduate, some college, or college graduate or more). In addition, a measure of neighborhood SES was included, modeled as a continuous index with higher values indicating higher neighborhood SES. The measure accounted for neighborhood-level median household income, median value of housing units, proportion of households receiving interest-dividend-rental income, proportion of adults with a high-school diploma, proportion of adults with college degree, and proportion of people used in executive-managerial-professional occupations.[13]

The odds of having prevalent risk factors or low SES indices in rural areas (relative to the urban area) were assessed using logistic regression with adjustment for demographic factors. For analysis of incident stroke, the outcome was the time to first stroke event during follow-up. The association with urban–rural status was assessed in a series of incremental Cox proportional hazards models: (1) after adjustment for demographic factors (age, race, age-by-race interaction, sex, and state of residence), (2) after further adjustment for traditional risk factors, and (3) after further adjustment for measures of socioeconomic status. The significance of the magnitude of attenuation of the association between rural–urban status and stroke risk across these incremental models was assessed by the change in the rural–urban regression coefficient divided by the SE of the change in coefficients (with the SE of change estimated by bootstrap techniques with 500 replications). The definition of case fatality was the proportion of incident strokes with death from any cause within 30 days of stroke event. The association of rural–urban status with case fatality was assessed using logistic regression, using a similar incremental modeling approach. Because analysis of case fatality had a smaller sample size because of restriction to only those with incident stroke events, we restricted the number of variables in the logistic regression by adjusting for region (stroke belt, stroke buckle, or rest of the nation) rather than state.

Of the 30 239 REGARDS participants, 56 were excluded for data anomalies, 1810 for missing predictor variables, 2187 for diagnosis of a prior stroke or lack of follow-up, and 2906 for insufficient geocoding accuracy to identify census tract residence. A total of 23 280 individuals were included in the final analysis.

Results

Using the RUCA 4-level code, 18 705 (80.3%) REGARDS participants were classified as urban, 2645 were (11.4%) large city/town, and 1932 (8.3%) were small rural town or isolated region, proportions generally reflecting the US population in the 2004 census (81.0%, 9.6%, and 9.4%, respectively). A description of the study population by the RUCA strata is provided in Table 1. During an average follow-up of 8.1 years (maximum follow-up 12.8 years), there were 982 (4.2%) stroke events, among which 148 (15.1%) were fatal (Table 2).

The proportion of black participants was notably higher in urban regions (45.2%) than the 2 more rural regions (27.3% and 22.8%; Table 1). Risk factor differences between RUCA categories were relatively small, and differences in individual SES were only modest. As shown in Table 3, with the exception of smoking, adjustment for the demographic factors unmasked the existence of a consistently more detrimental risk factor profile in rural areas.

Table 4 provides the hazard ratio for incident stroke by rural–urban status. In the demographic model, compared with urban regions, the hazard of stroke was 1.23 times higher (95% confidence interval [CI], 1.01–1.51) in large rural city/towns and was 1.30 times higher (95% CI, 1.03–1.62) in small rural city/towns or isolated areas (P_{trend}=0.0073). Further adjustment for risk factors resulted in a modest attenuation of the association (hazard ratio, 1.21; 95% CI, 0.99–1.48 for large rural city/towns; hazard ratio, 1.26; 195% CI, 1.01–1.58 for small rural city/towns or isolated areas), with the mediation between the demographic and risk factor models being nonsignificant (*P*=0.20 for large rural town and *P*=0.11 for small rural city) and with the test for trend remaining significant (*P*=0.015). Further adjustment for SES factors was associated with a nonsignificant mediation of the association for the large rural region (*P*=0.062) and a modestly significant attenuation for the small rural city (*P*=0.013), with the test of trend becoming marginally nonsignificant (*P*=0.071). With this adjustment for SES, the association of stroke risk was no longer different in both the large rural region (hazard ratio, 1.18; 95% CI, 0.96–1.44) and small rural cities (hazard ratio, 1.19; 95% CI, 0.94–1.50).

Table 4 also provides the odds ratio for case fatality among those with incident stroke by rural–urban status. Neither the individual odds ratios nor the tests for trend were significant in any of the models.

Table 1. Description of Study Population by RUCA Strata at the Census Tract Level

			Urban	Large City/Town	Small Rural City/ Town or Isolated Area	
No. of participants			18 705	2645	1930	
Demographic factors	Age (mean±SD)		64.7±9.4	64.6±9.4	64.4±9.2	0.28
	Male, %		45.2	45.3	44.1	0.48
	Black, %		44.6	27.3	22.8	<0.0001
	Region, %	Belt	32.1	43.1	44.0	<0.0001
		Buckle	16.1	40.6	37.0	
		Nonbelt	51.9	16.3	19.0	
Risk factors	Hypertension, %		57.8	58.6	57.7	0.82
	Diabetes mellitus, %		20.7	21.7	20.6	0.63
	Smoking, %		14.1	13.7	14.0	0.72
	Atrial fibrillation, %		7.9	9.5	8.6	0.032
	Left ventricular hypertrophy, %		9.9	9.0	9.3	0.15
	Heart disease, %		15.9	19.0	18.3	<0.0001
Socioeconomic factors	Income	<$20K	16.4	19.5	16.8	<0.0001
		$20K–$35K	23.8	22.5	26.0	
		$35K–$75K	30.9	29.6	30.6	
		$75K+	17.2	15.7	14.1	
		Refused	11.6	12.7	12.5	
	Education	<HS	11.0	13.2	13.8	<0.0001
		HS graduate	24.5	29.33	30.4	
		Some college	27.5	24.3	24.5	
		College graduate	37.1	33.2	31.4	
	Neighborhood SES (mean±SD)		0.69±5.63	−1.53±3.96	−2.71±2.73	<0.0001

Region was defined as the buckle of the stroke belt, the stroke belt, and the rest of the 40 contiguous US states. Predictor variables classified as demographic (age, sex, race, and region), risk factors (hypertension, diabetes, smoking, atrial fibrillation, left ventricular hypertrophy, and heart disease), and socioeconomic factors (individual income and education and neighborhood SES). *P* value is a test of trend with the exception of categorical factors with more than 2 levels (region, income, and education), where the *P* value is a χ^2. HS indicates high school; RUCA, Rural–Urban Commuting Area; and SES, socioeconomic status.

Discussion

These data suggest that the higher stroke mortality in rural regions is primarily attributable to a higher stroke incidence, with the estimated risk of incident stroke 23% higher in large rural cities/towns, and 30% higher in small rural towns or isolated regions (compared with urban areas). This magnitude of increased risk is consistent with the 30% increased risk of stroke mortality observed in vital statistics data between

Table 2. Number of Participants, Incident Stroke (and % of patients), Person-Years of Exposure, Incidence Rate (With 95% Confidence Intervals) per 100 000 Person-Years, and Fatal Strokes (and % of incident stroke) by RUCA Strata at the Census Tract Level

	Urban–Rural Classification		
	Urban	Large City/Town	Small Rural City/Town or Isolated Area
No. of participants	18 705	2645	1930
No. (%) of incident strokes	766 (4.1)	123 (4.7)	93 (4.8)
Person-years of exposure	152 370	21 023	15 536
Incidence rate (95% confidence interval) per 100 000	502 (468–539)	585 (490–698)	599 (488–733)
No. (%) of fatal strokes	118 (15.4)	20 (16.3)	10 (10.8)

RUCA indicates Rural–Urban Commuting Area.

Table 3. Odds Ratio for Prevalent Risk Factors, Low Income (<$35K), and Low Education (High-School Graduate or Less) by RUCA Strata at the Census Tract Level After Adjustment for Age, Sex, Race, and Geographic Region

		Urban–Rural Classification		
		Urban	Large City/Town	Small Rural City/Town or Isolated Area
Risk factors	Hypertension, %	1.00 (ref)	1.23 (1.13–1.34)	1.25 (1.13–1.38)
	Diabetes mellitus, %	1.00 (ref)	1.28 (1.15–1.41)	1.26 (1.12–1.42)
	Smoking, %	1.00 (ref)	1.01 (0.90–1.14)	1.06 (0.93–1.22)
	Atrial fibrillation, %	1.00 (ref)	1.20 (1.04–1.38)	1.08 (0.91–1.28)
	Left ventricular hypertrophy, %	1.00 (ref)	1.07 (0.93–1.24)	1.18 (1.00–1.39)
	Heart disease, %	1.00 (ref)	1.22 (1.09–1.36)	1.18 (1.04–1.34)
Socioeconomic factors	Income ≤$35K	1.00 (ref)	1.35 (1.23–1.49)	1.48 1.33–1.65)
	Education ≤HS graduate or less	1.00 (ref)	1.22 (1.09–1.36)	1.18 (1.04–1.34)
	Neighborhood SES (mean±SE)	0.86±0.03	−2.17±0.9	−3.56±0.11

Given are also least-squares mean (and SE) for the neighborhood SES score after adjustment for age, sex, race, and geographic region. HS indicates high school; RUCA, Rural–Urban Commuting Area; and SES, socioeconomic status.

the most rural (noncore) and most urban areas (large central metro).[3] There was only modest mediation of the observed difference in stroke incidence by stroke risk factors and socioeconomic factors.

Our study reinforces the wealth of previous data demonstrating a more detrimental stroke risk factor profile in rural areas. Data from the National Health and Nutrition Examination Survey has shown the prevalence of diagnosed diabetes mellitus to be higher in rural regions (6.5% for whites and 9.5% for blacks) than urban regions (4.5% in whites and 6.0% in blacks).[14] Likewise, the prevalence of hypertension is higher in rural blacks (36.0%) and whites (28.5%) than those in urban regions (28.8% and 23.3%, respectively).[14] The proportion of persons with diabetes mellitus with poor control was higher in rural than urban regions for blacks (60.6% versus 45.4%) but was better controlled in rural than urban whites (32.6% versus 42.6%).[14] The proportion of blacks with systolic blood pressure ≥140 mm Hg was higher in rural than urban regions (44.1% versus 41.7%); however, rates of blood pressure control were similar for rural and urban whites (38.1% versus 38.6%).[14] Data from the Behavioral Risk Factor Surveillance System also have shown a poorer risk factor profile in rural than urban regions for self-reported diabetes mellitus (9.9% versus 9.0%), self-reported diagnosis of coronary heart disease or angina (4.9% versus 4.0%), and smoking (22.7% versus 18.6%).[15]

The higher prevalence of hypertension and diabetes mellitus in rural areas is potentially a product of a higher prevalence of obesity in rural areas. Data from the National Survey of Children's Health has documented a higher prevalence of obesity in children aged 10 to 17 years living in rural (16.5%) than urban (14.3%) regions, a difference that persisted after adjustment for potential confounders including physical activity (odds ratio, 1.13; 95% CI, 1.01–1.25).[16] This higher childhood

Table 4. Hazard Ratio for Incident Stroke for the RUCA Classifications and Odds Ratio for Case Fatality

			Age–Race–Sex and Region	+Risk Factors	+SES
Hazard ratio for incident stroke	County urban/rural status	Urban	1.00 (ref)	1.00 (ref)	1.00 (ref)
		Large rural	1.23 (1.01–1.51)	1.21 (0.99–1.48)	1.18 (0.96–1.44)
		Small rural city/town or isolated area	1.30 (1.03–1.62)	1.26 (1.01–1.58)	1.19 (0.94–1.50)
	P value for trend		0.0073	0.015	0.071
Odds ratio for case fatality	Urban/rural status	Urban	1.00 (ref)	1.00 (ref)	1.00 (ref)
		Large rural city/town	1.22 (0.70–2.15)	1.25 (0.71–2.21)	1.13 (0.63–2.01)
		Small rural town or isolated area	0.73 (0.36–1.48)	0.77 (0.38–1.58)	0.70 (0.33–1.44)
	P value for trend		0.61	0.74	0.47

Models are provided after (1) adjustment for age, race, sex, and state, (2) further adjustment for risk factors (hypertension, diabetes mellitus, smoking, atrial fibrillation, left ventricular hypertrophy, and heart disease), and 3) further adjustment for SES factors (individual income and education and neighborhood SES). Also, a *P* value for trend across RUCA classification is provided. Odds ratio for case fatality (death within 30 d of incident stroke) is calculated using a similar modeling approach as for incident stroke, using region (stroke belt, stroke buckle, and rest of the nation) rather than the state limits the number of variables in the model. RUCA indicates Rural–Urban Commuting Area; and SES, socioeconomic status.

obesity in rural areas persists to adulthood, where National Health and Nutrition Examination Survey data has shown the prevalence of obesity in rural regions to be 39.6%±1.5% versus 33.4%±1.1%, a difference that remained significantly elevated after adjustment for demographic, diet, and physical activity (odds ratio, 1.18; 95% CI, 1.01–1.38).[17]

Rural counties fare poorly compared with urban counties on almost every measure of individual SES, including worse proportions of college graduates (15.1% versus 17.5%), median family income ($46 681 versus $50 835), poverty rate (17.1% versus 16.4%), households with low income and more than 1 mile to a grocery store (32.2% versus 22.3%), medically underserved counties (62.4% versus 35.6%), population <65 without health insurance (20.2% versus 17.2%), number of doctors per 10 000 population (5.9 versus 12.9), and number of nurses per 10 000 population (16.9 versus 31.7). Because lower neighborhood SES has also been shown to be associated with higher stroke risk,[18,19] interventions that may blunt the impact of lower SES on stroke risk could be considered to reduce the rural excess stroke risk. However, we anticipate this effect to be small, as we observed only modest attenuation of rural–urban disparity in stroke incidence with adjustment for SES factors.

Our data also demonstrate that, even after adjustment for demographic factors (primarily race), rural regions have a more detrimental stroke risk factor profile and a lower SES than urban regions. Specifically, the odds of hypertension, diabetes mellitus, and heart disease were all ≈25% higher in rural than urban areas. In addition, the odds of having a household income <$35K were 35% higher in large rural cities/towns and 48% higher in small rural towns or isolated areas. We had hypothesized that the higher prevalence of risk factors and the lower individual and neighborhood SES in rural areas would be a major contributor to the observed higher incidence. However, we observed that adjustment for these factors only modestly (and largely nonsignificantly) attenuated the relation between rural status and stroke risk, suggesting that these factors are not primary contributors to the higher incidence in rural areas. It is not clear what factors, beyond those we considered, could be contributing to the higher stroke incidence in rural areas. It is possible that residual confounding or measurement error in assessing the risk factors could be playing a role; however, these risk factors were strongly associated with stroke risk, and we used measured levels of risk factors for precision in assessment, suggesting that this is relatively unlikely as an explanation.

We were surprised that stroke case fatality was not higher in rural areas. Although in the general US population, 87% of those living in major cities live within 60 minutes travel to a primary stroke center, only 9% of those living in the suburbs and 1% living in rural areas had such access.[20] Data from the National Inpatient Sample suggests that the rural–urban gap in treatment with tPA (tissue-type plasminogen activator) substantially widened between 2001 and 2010.[21] Among those experiencing a stroke between 2008 and 2011 in the Ontario, Canada, compared with those in a large urban area (population ≥100 000), those residing in rural areas (population <10 000) were less likely to be treated in a stroke care unit, to receive brain imaging within 24 hours, to be seen by a neurologist, or to be transferred to an inpatient rehabilitation service.[5] In contrast, in 2006, there were not substantial rural versus urban differences in the quality of stroke care provided by Veterans Administration Medical Centers.[22]

Others have observed a similar stroke case fatality in rural and urban areas. In the report from Ontario described above, mortality within 30 days was only marginally higher in the rural (9.4%) than urban (9.2%) areas; furthermore, death at 30 days or disability at discharge was lower in the rural (39.8%) than urban (42.3%) areas.[5] In addition, functional outcomes were similar for those in rural and urban areas of Ontario.[23] Likewise, rural and urban residents in participating in the AVAIL study (Adherence eValuation After Ischemic Stroke – Longitudinal) experiencing a stroke have a similar rate of recurrent stroke and rehospitalization within 12 months.[24] One potential reason for the apparent lack of rural–urban difference in stroke outcomes is that rural residents commonly receive their stroke care in an urban setting. In a nationwide survey of stroke patients, 97.5% of rural patients were treated in a primary stroke center, compared with 99.1% of urban patients.[24] In addition, a rapidly growing use of telestroke in the United States has a profound potential for reducing the differences by rural–urban status in quality of care after stroke.[25,26]

This report is part of a series assessing the contribution of stroke incidence and stroke case fatality to different disparities in stroke mortality. The first of these reports demonstrated that the majority of the excess stroke mortality in blacks compared with whites is attributable to higher stroke incidence.[27] The second suggested both a higher incidence and a higher case fatality contribute to the higher stroke mortality in the southeastern stroke belt.[28] Herein, we demonstrate that, like the stroke mortality in blacks, the rural disparity in stroke death is primarily attributable to higher incidence and not case fatality.

A major strength of this work is the geographically heterogeneous REGARDS study, with ≈1000 stroke events, offering the opportunity to better estimate the association of the rural–urban status on stroke risk. This large number of events also allowed adjustment for state in the model; hence, the analysis is contrasting urban and rural areas within a state and reduces the likelihood of confounding of the higher risk in the stroke belt. Although having 148 deaths (among 982 stroke events) offers the prospect of assessing predictors of case fatality, the precision of these estimates is not as great as for the incident stroke events. Also, the distribution of the US population, with only 9.6% in large rural towns and 9.4% in small rural towns or isolated areas contributes to less precise estimation of stroke risk and stroke case fatality in these regions. We also used the residence of the participant at baseline to characterize their rural–urban status, and it is possible that they moved during follow-up. Finally, the participation rate in REGARDS is estimated to be ≈30%, opening the possibility of nonresponse bias; however, a lower participation rate generally has a minimal impact on the estimation of exposure–disease relationships in longitudinal studies.[29]

In conclusion, the 30% increased stroke mortality in rural regions seems to be primarily driven by a higher incidence of stroke in these regions. Although we also documented a higher prevalence of risk factors and lower SES in rural areas, these seem to be only modestly contributing to this higher risk of stroke. In contrast, little of the excess rural stroke mortality seemed to be attributable to a higher rural stroke case fatality, suggesting that the focus on efforts to reduce the rural disparity in stroke mortality should focus primarily on risk factor prevention and control to reduce the excess rural incident stroke rates.

Disclosures

None.

References

1. Singh GK, Siahpush M. Widening rural-urban disparities in life expectancy, U.S., 1969-2009. *Am J Prev Med*. 2014;46:e19–e29. doi: 10.1016/j.amepre.2013.10.017.
2. Singh GK, Siahpush M. Widening rural-urban disparities in all-cause mortality and mortality from major causes of death in the USA, 1969–2009. *J Urban Health*. 2014;91:272–292. doi: 10.1007/s11524-013-9847-2.
3. Howard G. Ancel keys lecture: adventures (and misadventures) in understanding (and reducing) disparities in stroke mortality. *Stroke*. 2013;44:3254–3259. doi: 10.1161/STROKEAHA.113.002113.
4. *NIH Health Disparities Strategic Plan and Budget. Fiscal Years 2009–2013*. https://www.nimhd.nih.gov/docs/2009-2013nih_health_disparities_strategic_plan_and_budget.pdf. Accessed August 28, 2016.
5. Koifman J, Hall R, Li S, Stamplecoski M, Fang J, Saltman AP, et al. The association between rural residence and stroke care and outcomes. *J Neurol Sci*. 2016;363:16–20. doi: 10.1016/j.jns.2016.02.019.
6. Joubert J, Prentice LF, Moulin T, Liaw ST, Joubert LB, Preux PM, et al. Stroke in rural areas and small communities. *Stroke*. 2008;39:1920–1928. doi: 10.1161/STROKEAHA.107.501643.
7. Adams PF, Hendershot GE, Marano MA, Centers for Disease Control and Prevention/National Center for Health Statistics. Current estimates from the National Health Interview Survey, 1996. *Vital Health Stat*. 1999;10:1–203.
8. Howard VJ, Cushman M, Pulley L, Gomez CR, Go RC, Prineas RJ, et al. The reasons for geographic and racial differences in stroke study: objectives and design. *Neuroepidemiology*. 2005;25:135–143. doi: 10.1159/000086678.
9. Howard VJ, Kleindorfer DO, Judd SE, McClure LA, Safford MM, Rhodes JD, et al. Disparities in stroke incidence contributing to disparities in stroke mortality. *Ann Neurol*. 2011;69:619–627. doi: 10.1002/ana.22385.
10. RUCA: Rural–Urban Commuting Area. Rural Health Research Center. http://depts.washington.edu/uwruca/. Accessed August 28, 2016.
11. Wolf PA, D'Agostino RB, Belanger AJ, Kannel WB. Probability of stroke: a risk profile from the Framingham Study. *Stroke*. 1991;22:312–318.
12. Sokolow M, Lyon TP. The ventricular complex in left ventricular hypertrophy as obtained by unipolar precordial and limb leads. 1949. *Ann Noninvasive Electrocardiol*. 2001;6:343–368.
13. Diez Roux AV, Merkin SS, Arnett D, Chambless L, Massing M, Nieto FJ, et al. Neighborhood of residence and incidence of coronary heart disease. *N Engl J Med*. 2001;345:99–106. doi: 10.1056/NEJM200107123450205.
14. Mainous AG 3rd, King DE, Garr DR, Pearson WS. Race, rural residence, and control of diabetes and hypertension. *Ann Fam Med*. 2004;2:563–568. doi: 10.1370/afm.119.
15. O'Connor A, Wellenius G. Rural-urban disparities in the prevalence of diabetes and coronary heart disease. *Public Health*. 2012;126:813–820. doi: 10.1016/j.puhe.2012.05.029.
16. Liu J, Bennett KJ, Harun N, Probst JC. Urban-rural differences in overweight status and physical inactivity among US children aged 10-17 years. *J Rural Health*. 2008;24:407–415. doi: 10.1111/j.1748-0361.2008.00188.x.
17. Befort CA, Nazir N, Perri MG. Prevalence of obesity among adults from rural and urban areas of the United States: findings from NHANES (2005-2008). *J Rural Health*. 2012;28:392–397. doi: 10.1111/j.1748-0361.2012.00411.x.
18. Kleindorfer DO, Lindsell C, Broderick J, Flaherty ML, Woo D, Alwell K, et al. Impact of socioeconomic status on stroke incidence: a population-based study. *Ann Neurol*. 2006;60:480–484. doi: 10.1002/ana.20974.
19. Howard VJ, McClure LA, Kleindorfer DO, Cunningham SA, Thrift AG, Diez Roux AV, et al. Neighborhood socioeconomic index and stroke incidence in a national cohort of blacks and whites. *Neurology*. 2016;87:2340–2347. doi: 10.1212/WNL.0000000000003299.
20. Mullen MT, Wiebe DJ, Bowman A, Wolff CS, Albright KC, Roy J, et al. Disparities in accessibility of certified primary stroke centers. *Stroke*. 2014;45:3381–3388. doi: 10.1161/STROKEAHA.114.006021.
21. Gonzales S, Mullen MT, Skolarus L, Thibault DP, Udoeyo U, Willis AW. Progressive rural-urban disparity in acute stroke care. *Neurology*. 2017;88:441–448. doi: 10.1212/WNL.0000000000003562.
22. Phipps MS, Jia H, Chumbler NR, Li X, Castro JG, Myers J, et al. Rural-urban differences in inpatient quality of care in US Veterans with ischemic stroke. *J Rural Health*. 2014;30:1–6. doi: 10.1111/jrh.12029.
23. Allen L, McIntyre A, Janzen S, Richardson M, Meyer M, Ure D, et al. Community stroke rehabilitation: how do rural residents fare compared with their urban counterparts? *Can J Neurol Sci*. 2016;43:98–104. doi: 10.1017/cjn.2015.324.
24. Rodriguez D, Cox M, Zimmer LO, Olson DM, Goldstein LB, Drew L, et al; AVAIL Investigators. Similar secondary stroke prevention and medication persistence rates among rural and urban patients. *J Rural Health*. 2011;27:401–408. doi: 10.1111/j.1748-0361.2010.00352.x.
25. Wechsler LR, Demaerschalk BM, Schwamm LH, Adeoye OM, Audebert HJ, Fanale CV, et al; American Heart Association Stroke Council; Council on Epidemiology and Prevention; Council on Quality of Care and Outcomes Research. Telemedicine quality and outcomes in stroke: a scientific statement for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2017;48:e3–e25. doi: 10.1161/STR.0000000000000114.
26. Kulcsar M, Gilchrist S, George MG. Improving stroke outcomes in rural areas through telestroke programs: an examination of barriers, facilitators, and state policies. *Telemed J E Health*. 2014;20:3–10. doi: 10.1089/tmj.2013.0048.
27. Howard G, Moy CS, Howard VJ, McClure LA, Kleindorfer DO, Kissela BM, et al. Where to focus efforts to reduce the black-white disparity in stroke mortality: incidence versus case fatality? *Stroke*. 2016;47:1893–1898. doi: 10.1161/STROKEAHA.115.012631.
28. Labarthe DR, Howard G, Safford MM, Howard VJ, Judd SE, Cushman M, et al; Reasons for Geographic and Racial Differences in Stroke (REGARDS) Investigators. Incidence and case fatality at the county level as contributors to geographic disparities in stroke mortality. *Neuroepidemiology*. 2016;47:96–102. doi: 10.1159/000449102.
29. Galea S, Tracy M. Participation rates in epidemiologic studies. *Ann Epidemiol*. 2007;17:643–653. doi: 10.1016/j.annepidem.2007.03.013.

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