Stroke Mortality Disparities in the Population of the Appalachian Mountain Region

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Objectives: Racial and rural-urban differences in stroke were previously reported in demographically and socioeconomically heterogeneous populations. However, it is not clear whether they exist in more homogeneous populations. Compared to the rest of the United States, the Appalachian region is highly rural and more homogeneous, with a predominantly White and socioeconomically disadvantaged population. The goal of our study was to investigate whether racial disparities in stroke mortality exist among the Appalachian population.

Design, Setting, Participants: Patterns of stroke mortality for a seven-year period (2000–2006) were investigated in the Appalachian adult population of ≥25 years. Data on stroke deaths were obtained from the Centers for Disease Control and Prevention, National Center for Health Statistics. Multivariable Poisson regression models were used to estimate adjusted relative risks (RR), adjusting for confounding factors.

Main Outcome Measure: Stroke death rates.

Results: Stroke mortality in Appalachia was 20.5% higher than outside Appalachia (96.67 and 80.25 per 100,000 person-years, $P<.001$). Stroke mortality was statistically significantly higher in African Americans than in other racial groups: Caucasians (adjusted RR=1.428, $P<.001$), Asians (adjusted RR=2.821, $P<.001$), and Native American Indians (adjusted RR=3.571, $P<0.001$). Rural-urban stroke mortality disparities were statistically significant outside Appalachia but not within Appalachia.

Conclusions: Racial disparities in stroke mortality exist in the Appalachian region. Further studies are warranted to investigate the rationale for possible health policy interventions and socioeconomic measures. (*Ethn Dis.* 2013;23[3]:286–291)

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Introduction

Stroke constitutes a major public health, health care, and social problem. It is the fourth leading cause of death in the United States (was the third leading cause of death until 2008) and is responsible for more than 130,000 deaths annually.[1,2] Almost a third of stroke survivors acquire a disability.[2]

Of particular concern are stroke disparities that result in a disproportionate burden of stroke on some population groups. Stroke burden is excessive among socioeconomically disadvantaged populations and in rural areas.[3–5] Racial disparities in stroke have been reported across a variety of geographic areas.[6–8]

It is not clear, however, whether stroke disparities exist within economically disadvantaged areas that are relatively homogeneous for demographic and socioeconomic characteristics, such as Appalachia. The Appalachian region stretches along the Appalachian Mountains and covers about 205,000 square miles. Compared to other parts of the United States, the region is highly rural, and its population is predominantly White.[9] Poverty and unemployment rates in the Appalachian region exceed the United Sates national rates, and income levels in Appalachia are below the national average.[9]

The demographic, socioeconomic, and geographic characteristics of Appalachia suggest that the population of the region may be particularly vulnerable to a higher burden of stroke. This prompted us to investigate whether stroke mortality disparities exist among a relatively homogeneous, predominantly White and highly rural Appalachian population.

Methods

Study Population

We conducted a population-based study of stroke mortality in the Appalachian region for a seven-year period (2000–2006). Adults aged ≥25 years were included in the study. Data on stroke mortality on a county level were obtained from the US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics in the Compressed Mortality File format. Stroke deaths were identified using the I60–I69 codes of the International Classification of Diseases, 10th Revision (ICD-10). For each Appalachian county, data included the number of stroke deaths by race, sex, and age.[10]

Each county's rurality status was classified as rural/urban using the Beale Code system – the US Department of Agriculture (USDA) Economic Research Service's county Rural-Urban Continuum Code system (RUCC), developed by Calvin Beale. The continuum of the established RUCC codes ranges from 1 (counties in metro areas of ≥1 million

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Table 1. Demographic characteristics of the study population and the number of stroke deaths by the rurality status (2000–2006)

	Population, *n* (%)			Stroke Deaths, *n* (%)		
Population Groups	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**
Race						
African Americans	308,658 (24.9)	931,495 (75.1)	1,240,153 (100.0)	2,339 (26.9)	6,355 (73.1)	8,694 (100.0)
Asians	26,975 (16.1)	140,564 (83.9)	167,539 (100.0)	35 (16.0)	184 (84.0)	219 (100.0)
American Indians	22,083 (44.5)	27,490 (55.5)	49,573 (100.0)	40 (46.5)	46 (53.5)	86 (100.0)
Caucasians	5,724,008 (39.0)	8,950,420 (61.0)	14,674,428 (100.0)	40,223 (40.2)	59,942 (59.8)	100,165 (100.0)
Age						
25–34 years	1,148,023 (37.0)	1,958,582 (63.0)	3,106,605 (100.0)	145 (36.8)	249 (63.2)	394 (100.0)
35–44 years	1,287,576 (36.3)	2,255,337 (63.7)	3,542,913 (100.0)	557 (37.4)	934 (62.6)	1,491 (100.0)
45–54 years	1,291,658 (37.1)	2,185,260 (62.9)	3,476,918 (100.0)	1,445 (37.2)	2,438 (62.8)	3,883 (100.0)
55–64 years	993,327 (39.0)	1,553,107 (61.0)	2,546,434 (100.0)	2,871 (40.2)	4,279 (59.8)	7,150 (100.0)
65–74 years	715,783 (40.0)	1,074,052 (60.0)	1,789,835 (100.0)	6,307 (40.5)	9,266 (59.5)	15,573 (100.0)
75–84 years	474,001 (38.5)	758,484 (61.5)	1,232,485 (100.0)	14,493 (38.4)	23,280 (61.6)	37,773 (100.0)
85+ years	171,357 (39.3)	265,148 (60.7)	436,505 (100.0)	16,809 (39.2)	26,081 (60.8)	42,890 (100.0)
Sex						
Males	3,160,479 (37.5)	5,275,456 (62.5)	8,435,935 (100.0)	26,375 (38.8)	41,549 (61.2)	67,924 (100.0)
Females	2,921,244 (38.0)	4,774,513 (62.0)	7,695,757 (100.0)	16,262 (39.4)	24,978 (60.6)	41,240 (100.0)
Total	6,081,723 (37.7)	10,049,969 (62.3)	16,131,693 (100.0)	42,627 (39.1)	66,527 (60.9)	109,154 (100.0)

population) to 9 (completely rural or <2,500 urban population, not adjacent to a metro area). Codes 1 to 3 inclusive define metro counties, and codes 4 to 9 inclusive define non-metro counties. We used the USDA Economic Research Service's approach (2007) that classifies counties as rural if they belonged to the RUCC non-metro category, and as urban if they belonged to the metro category.[11] Of the total of 428 Appalachian counties, 284 were classified as rural and 144 as urban.

Statistical Analysis

The primary outcome variable was stroke mortality (ie, stroke death rates), calculated per 100,000 person-years, over a seven-year period. Relative risks (RR) of stroke death were calculated as stroke mortality ratios. A conventional statistical significance level of $P<.05$ (type I error alpha=.05) was used for all data analyses. Bonferroni correction was used for multiple comparisons.

To investigate stroke mortality patterns in the Appalachian population in relation to rurality status and demographic characteristics, we conducted both unadjusted and adjusted analyses. For multivariable adjusted analysis, the multivariable Poisson regression was used to obtain RR estimates and their 95% confidence intervals (CI), controlling for confounders. Overdispersion in the multivariable Poisson regression was adjusted for by a scaling factor; the scaled Pearson chi-square equaled 1.

Adjusted stroke death rates were calculated on a county level because counties' rurality status and demographic characteristics of the study population were obtained on a county level. Because the unit of analysis was the county, the generalized estimating equations method was used to adjust for the measurements on a county level. All statistical analyses were conducted with the SAS statistical software package, version 9.2 (SAS Institute Inc., Cary, NC).

RESULTS

Comparative Characteristics of Appalachian and Non-Appalachian Populations

The demographic characteristics of the study population (the Appalachian adult population aged ≥25 years) are presented in Table 1. The proportion of rural residents in the study population was 37.7%, about 2.5 times higher than outside Appalachia where only 15.3% of those ≥25 years reside in rural areas.

Unlike the rest of the United States, the Appalachian population is predominantly Caucasian, with Caucasians constituting 91.0% of our sample population, African Americans 7.7%, Asians 1.0%, and Native Americans 0.3%. Outside Appalachia, Caucasians constitute a smaller proportion of the same age population (82.3%), while African Americans, Asians, and Native Americans larger proportions (11.9%, 4.8%, and 1.0%, respectively) ($P<.01$ for all racial groups).

Stroke Mortality in Appalachia

During the seven-year period of 2000–2006, there were a total of 109,154 stroke deaths in the Appalachian population, of which 42,627 deaths (39.1%) occurred in rural counties (Table 1). Of all racial groups, African Americans had the highest stroke death rate, while Asians and Native American Indians had the lowest one (Table 2). Analysis of stroke mortality in the Appalachian population in relation to residency in rural/urban counties

Table 2. Unadjusted stroke mortality rates (per 100,000 person-years) and unadjusted RR of stroke mortality in the Appalachian population

Population Characteristics	Unadjusted Stroke Mortality (95% CI), per 100,000 Person-years	Unadjusted RR (95% CI)	*P*
Rurality			
Urban, ref.	94.57 (93.85, 95.28)	1.0	
Rural	100.15 (99.20, 101.10)	1.059 (1.046, 1.072)	<.001
Race			
African Americans, ref.	100.15 (98.04, 102.25)	1.0	
Asians	18.67 (16.20, 21.15)	.186 (.162, .212)	<.001
American Indians	24.78 (19.55, 30.02)	.247 (.195, .300)	<.001
Caucasians	97.51 (96.91, 98.12)	.974 (.953, .995)	.017
Sex			
Females, ref.	76.55 (75.82, 77.29)	1.0	
Males	115.02 (114.16, 115.89)	1.503 (1.484, 1.521)	<.001
Age			
25–34 years, ref.	1.81 (1.63, 1.99)	1.0	<.001[a]
35–44 years	6.01 (5.71, 6.32)	3.318 (2.980, 3.722)	
45–54 years	16.00 (15.49, 16.50)	8.828 (7.992, 9.838)	
55–64 years	40.11 (39.18, 41.04)	22.139 (20.091, 24.624)	
65–74 years	124.30 (122.34, 126.25)	68.604 (62.354, 76.204)	
75–84 years	437.83 (433.41, 442.24)	241.652 (219.812, 268.250)	
≥85 years	1403.68 (1390.40, 1416.97)	774.743 (704.769, 859.971)	

[a] *P* for trend, Wald statistic

indicated that all racial groups, except for Asians, had higher stroke death rates in rural than in urban areas (Table 3).

Results of the adjusted analysis demonstrated that after controlling for confounding effect of other variables, stroke mortality remained the highest among African Americans as compared to Asians ($P<.001$), American Indians ($P<.001$) and Caucasians ($P=.017$) (Table 4). Adjusted stroke mortality in rural counties remained higher than in urban, but the difference (2.1%) was no longer statistically significant (adjusted RR=1.021, $P=.389$).

Stroke Mortality Outside Appalachia

Unadjusted stroke mortality in Appalachia (96.67 per 100,000 person-years) was 20.5% higher than outside Appalachia (80.25 per 100,000 person-years, $P<0.001$). Adjusted stroke mortality was statistically significantly higher in rural non-Appalachian counties compared to urban non-Appalachian counties (adjusted RR=1.135, $P=.001$) (Table 5). As within Appalachia, adjusted stroke mortality outside Appalachia was statistically significantly higher in women than in men, in African Americans than in any other racial group, and was increasing with age ($P<.001$).

DISCUSSION

Within a highly rural (compared to the rest of the United States) and predominantly monoracial (ie, mostly Caucasian) population of Appalachia, African Americans have a statistically significantly higher risk of stroke death than any other racial group. Racial differences in stroke mortality were revealed in the multivariable adjusted analysis, controlling for the rurality status, sex, and age. Thus, racial stroke mortality disparities exist independently of these variables and cannot be attributed to their effect. Our findings of racial disparities in stroke mortality are consistent with findings from other studies that reported disproportionally higher stroke mortality in African Americans in different parts of the United States.[6–8,12]

Racial disparities in stroke mortality can be attributed to several factors. First, a higher incidence of stroke contributes to a higher rate of stroke deaths, and stroke incidence in a population is dependent on prevalence of stroke risk factors within the population. Second, disparities in case-fatality among those who have developed stroke also affect stroke mortality.

While a steady decline in stroke incidence between 1980 and 2000 was reported in a number of studies,[13–15] it has remained higher in African Americans than in Caucasians.[16] Notably, Black-White differences in stroke incidence were reported outside the United States too. In a prospective study with the South London Stroke Register, British researchers found that Blacks had a 2.2 times higher incidence of stroke than Whites, adjusted for age, social class, and sex.[17]

Both African American men and women have higher prevalence of major stroke risk factors (such as hypertension, smoking, and diabetes) than their Caucasian counterparts.[18,19] Mean systolic and diastolic blood pressure is

Table 3. Unadjusted stroke mortality rates (per 100,000 person-years) in rural and urban areas of the Appalachian region in relation to race and sex

Population Groups	Unadjusted Stroke Mortality (95% CI), per 100,000 Person-years	Unadjusted RR (95% CI)	*P*[a]
Race			
African Americans			
Urban, ref.	97.46 (95.07, 99.86)	1.0	
Rural	108.26 (103.87, 112.64)	1.111 (1.059, 1.164)	<.001
Asians			
Urban, ref.	18.70 (16.00, 21.40)	1.0	
Rural	18.54 (12.39, 24.68)	.991 (.653, 1.371)	.962
American Indians			
Urban, ref.	23.90 (17.00, 30.81)	1.0	
Rural	25.88 (17.86, 33.90)	1.082 (.699, 1.654)	.714
Caucasians			
Urban, ref.	95.67 (94.91, 96.44)	1.0	
Rural	100.39 (99.41, 101.37)	1.049 (1.036, 1.063)	<.001
Sex			
Females			
Urban, ref.	74.74 (73.81, 75.66)	1.0	
Rural	79.53 (78.30, 80.75)	1.064 (1.043, 1.085)	<.001
Males			
Urban, ref.	112.51 (111.43, 113.59)	1.0	
Rural	119.22 (117.78, 120.66)	1.060 (1.043, 1.076)	<.001

[a] with Bonferroni correction for multiple comparisons.

higher in African Americans than in Caucasians.[18] Prevalence of prehypertension is also higher in African Americans. Analysis of the more than 30,000 participants aged ≥45 years of the REGARDS (REasons for Geographic And Racial Differences in Stroke) Study found 62.9% of African Americans to be prehypertensive compared to only 54.1% of Caucasians.[20]

Stroke case-fatality is higher and stroke survival is lower in African Americans than in Caucasians.[21,22] Secondary stroke prevention among stroke survivors is crucial, and is dependent on optimal outpatient care, including physician access and medication access. Feng et al have reported that African Americans have a 16% higher risk of recurrent stroke than Caucasians.[23] Although stroke survivors aged 45–64 years who reported inability to afford medications and lack of access to physician care did not vary significantly across racial groups, African American and Mexican American stroke survivors aged ≥65 had significantly higher self-reported frequencies of lack of access to primary care and specialist physicians and inability to afford medications.[24] Differential care can also contribute to racial disparities in stroke case-fatality. Schwamm et al found that African American stroke patients were less likely to receive evidence-based care in a hospital than Caucasian patients.[25]

A number of factors should be considered to explain our findings of a statistically significant 20.5% increase in stroke mortality in Appalachia as compared to the non-Appalachian counties. First, prompt treatment within the first three hours is crucial for saving the life of an ischemic stroke patient.[26] Distance- and travel-related barriers to emergency health care and lack of emergency medical transportation can

Table 4. Adjusted RR of stroke death in relation to the rural-urban status and demographic characteristics: Appalachian region

Parameter	β coefficient	Standard Error	Adjusted RR of Stroke Death (95% CI)	*P*
Rural, compared to urban[a]	.0203	.0236	1.021 (.974, 1.069)	.389
African Americans, compared to Caucasians[b]	.3564	.0260	1.428 (1.357, 1.503)	<.001
African Americans, compared to Asians[b]	1.0371	.0837	2.821 (2.394, 3.324)	<.001
African Americans, compared to Native American Indians[b]	1.2729	.2739	3.571 (2.088, 6.109)	<.001
Females, compared to males[c]	.0347	.0068	1.035 (1.022, 1.049)	<.001
Age, compared to 25–34 years[d]				<.001[e]
35–44 years	1.2411	.0566	3.459 (3.096, 3.865)	
45–54 years	2.2373	.0528	9.368 (8.447, 10.390)	
55–64 years	3.1686	.0513	23.774 (21.499, 26.288)	
65–74 years	4.3064	.0559	74.173 (66.480, 82.765)	
75–84 years	5.5729	.0582	263.196 (234.839, 294.978)	
≥85 years	6.7394	.0597	845.054 (751.822, 949.941)	

[a] Adjusted for sex, race, and age.
[b] Adjusted for the rurality status, sex, and age.
[c] Adjusted for the rurality status, race, and age.
[d] Adjusted for the rurality status, sex, and race.
[e] *P* for trend, Wald statistic.

Table 5. Adjusted RR of stroke death in relation to the rural-urban status and demographic characteristics: outside Appalachian region

Parameter	β coefficient	Standard Error	Adjusted RR of Stroke Death (95% CI)	*P*
Rural, compared to urban[a]	.1268	.0171	1.135 (1.098, 1.174)	<.001
African Americans, compared to Caucasians[b]	.4097	.0179	1.506 (1.454, 1.560)	<.001
African Americans, compared to Asians[b]	.4883	.0334	1.630 (1.526, 1.740)	<.001
African Americans, compared to Native American Indians[b]	.7649	.0483	2.149 (1.955, 2.362)	<.001
Females, compared to males[c]	.0465	.0040	1.048 (1.039, 1.056)	<.001
Age, compared to 25–34 year-old[d]				<.001[e]
35–44 years	1.3664	.0223	3.921 (3.754, 4.097)	
45–54 years	2.4042	.0231	11.070 (10.580, 11.583)	
55–64 years	3.2738	.0234	26.412 (25.229, 27.652)	
65–74 years	4.4231	.0255	83.354 (79.281, 87.628)	
75–84 years	5.7099	.0282	301.841 (285.574, 319.003)	
≥85 years	6.9074	.0300	999.645 (942.560, 1060.292)	

[a] Adjusted for sex, race, and age.
[b] Adjusted for the rurality status, sex, and age.
[c] Adjusted for the rurality status, race, and age.
[d] Adjusted for the rurality status, sex, and race.
[e] *P* for trend, Wald statistic.

delay optimal treatment of stroke in rural areas.[27,28] Many rural residents seek health care for stroke in urban hospitals, and they die more often in urban hospital emergency departments than as in-patients.[29]

Second, involvement of a neurologist in care for a stroke patient is associated with less frequent worsening of stroke severity and lower in-hospital mortality.[30] However, as reported from the Paul Coverdall National Acute Stroke Registry, overall only 62.1% of stroke patients receive care by a neurologist, and most hospitals in rural areas do not have a neurologist on staff.[31] Third, primary prevention is crucial to decrease occurrence of new cases of stroke (ie, stroke incidence). In rural areas, fewer people with risk factors receive necessary stroke prevention interventions.[32,33]

Our findings demonstrated different patterns of the effect of rurality status on stroke mortality in the Appalachian vs non-Appalachian populations. Outside the Appalachian region, rural residential status was associated with a statistically significant 13.5% increase in stroke mortality (adjusted RR=1.135, $P<.001$), as compared to urban residency. But within the Appalachian region, the rurality-related increase in stroke mortality was no longer statistically significant in the adjusted analysis.

This lack of statistically significant rural-urban stroke mortality differences within the Appalachian region may possibly be attributed to several factors. Many urban counties in Appalachia may still be relatively remote in terms of access to health care due to Appalachia being a mountain region. Appalachia is one of the poorest regions in the United States,[9] and low socioeconomic status (SES) is associated with higher prevalence of stroke risk factors and stroke death rates.[3,34] Relatively homogeneous low SES across Appalachian counties may also contribute to smoothing of rural-urban differences in stroke mortality.

While investigating the effect of sex and age on stroke mortality was not the goal of our study, these findings are worth a brief discussion as they are consistent with contemporary medical knowledge of the effect of these demographic characteristics and thus support plausibility of our model, serving as indirect model quality indicators. Age is a well-established risk factor for stroke, and we observed an increase in stroke mortality with age in our study. We also found that stroke mortality in women (adjusted for race, age, and rurality status) was about 4% higher than in men. This is consistent with the existing body of evidence that, while men have higher stroke incidence, stroke mortality is higher in women because women have more severe strokes and higher case-fatality than men.[35–37]

Our study has some limitations. Only county-level data were available, and group-level (ie, county-level) measurements are a common limitation in ecologic studies.[38] Group-level measurements do not allow extrapolating the obtained group-level findings to the individual level. It would be helpful to have data on individual-level risk factors to get a deeper insight into their effect on stroke mortality. However, the goal of our study was to investigate a broader picture of whether stroke mortality disparities exist in Appalachia, and ecologic studies remain an effective method of modern spatial epidemiology designated to studying population-level aspects of public health and health policy processes and interventions.[38]

In conclusion, findings from our study make a contribution to the literature by providing evidence of existence of stroke mortality disparities within the predominantly monoracial and highly rural population of the Appalachian region. While the Appalachian population

A number of factors should be considered to explain our findings of a statistically significant 20.5% increase in stroke mortality in Appalachia as compared to the non-Appalachian counties.

is mostly Caucasian, African American residents of the region have disproportionally higher stroke death rates. Public health and health policy interventions are warranted to reduce stroke death rates and eliminate stroke mortality disparities in Appalachia.

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