Geographic Variation in Stroke Risk in the United States

Region, Urbanization, and Hypertension in the Third National Health and Nutrition Examination Survey

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Background—In the United States, stroke mortality is higher in the south than in other regions. Hypertension is the main risk factor for stroke among older adults; however, few studies have examined group-specific regional and urbanization differences in hypertension prevalence.

Methods—Data from the Third National Health and Nutritional Examination Survey (NHANES III), 1988 to 1994, were analyzed to calculate the prevalence of hypertension (systolic >140 mm Hg and/or diastolic >90 mm Hg and/or taking antihypertensive medication) by region and urbanization for age (40 to 59 and 60 to 79 years), sex, and ethnic subgroups. Logistic regression models were fitted to estimate the association of hypertension with region and urbanization.

Results—With age and urbanization kept constant, southern residence was associated with hypertension among middle-aged non-Hispanic white men (odds ratio [OR], 1.49; 95% confidence interval [CI], 1.12 to 1.90; $P<0.006$), non-Hispanic black men (OR, 1.36; 95% CI, 1.05 to 1.66; $P=0.019$), and non-Hispanic black women (OR, 1.23; 95% CI, 1.01 to 1.45; $P=0.034$). Among older non-Hispanic white men, a significant interaction was noted between region and urbanization ($P=0.01$), with a higher prevalence in the south only for nonmetropolitan residents (OR, 1.32; 95% CI, 1.06 to 1.56; $P<0.013$). A similar but not statistically significant trend was also confirmed among non-Hispanic black men in logistic regression analysis (OR, 1.38; 95% CI, 0.97 to 1.68; $P=0.061$). No statistically significant association was observed for urbanization or region in the other subgroups.

Conclusions—Southern residence was associated with increased hypertension prevalence among middle-aged non-Hispanic white men, non-Hispanic black men and women, and older non-Hispanic white men. **(*Stroke*. 2000;31:19-25.)**

Key Words: aged ■ blacks ■ cross-sectional studies ■ geography ■ hypertension

Stroke is a leading cause of death and disability among the elderly in the United States, and hypertension is a major risk factor for stroke, coronary artery disease, congestive heart failure, renal insufficiency, and peripheral vascular disease.[1–5] Similarities in the geographical distribution of stroke mortality and several major stroke risk factors, including hypertension, have been reported.[5] Therefore, epidemiological studies targeted at improved understanding of the role of stroke risk factors in producing geographical variation in stroke mortality and incidence are of high public health interest.

The positive association between systolic and diastolic blood pressures and stroke risk has long been recognized among persons with and without coronary artery disease.[6,7] Several interventions targeting lifestyle risk factors for hypertension and treatment modalities currently exist.[1] However, for these interventions to have optimal benefit and to maximize their relative cost-effectiveness, it may be desirable to target high-risk populations. The southeastern part of the United States has long been identified as the stroke belt region, thus making it a target for hypertension intervention.[5,8,9] However, few studies have examined group-specific regional and urbanization differences in the prevalence of hypertension and consequently stroke risk in the US population. Such studies are even rarer in the US elderly population.

In this study, we examined regional and urbanization-based differences in the prevalence of hypertension, a prime risk factor for stroke, in 8 sex, ethnic, and age subgroups. Our hypotheses were that hypertension prevalence is higher in the south than in other regions and that hypertension prevalence differs between metropolitan and nonmetropolitan areas after adjustment for regional differences.

Subjects and Methods

To investigate regional variations in the prevalence of hypertension in the United States, we analyzed data from the Third National Health and Nutrition Examination Survey (NHANES III), 1988 to 1994. NHANES III was conducted by the National Center for Health Statistics of the Centers for Disease Control and Prevention between

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TABLE 1. Regional Distribution of Metro and Nonmetro Counties

Code, n	United States, n	Northeast, n	Midwest, n	South, n	West, n
Metro	714	117	195	326	76
0	54	15	13	14	12
1	173	29	65	61	18
2	289	62	55	152	20
3	198	11	62	99	26
Nonmetro	2383	100	860	1061	362
4	137	25	42	49	21
5	151	6	44	62	39
6	552	31	197	288	36
7	757	24	262	335	136
8	229	9	56	137	27
9	557	5	259	190	103
Total	3097	217	1055	1387	438

1988 and 1994 through a national multistage probability sample of the civilian noninstitutionalized population of the United States.[10] The initial NHANES III sample consisted of 33 994 individuals 2 months to 99 years of age; the survey design ensured oversampling of non-Hispanic blacks, Mexican-Americans, persons 2 months to 5 years of age, and those ≥60 years of age. Data were collected from each participant through face-to-face interview, physical examination, and laboratory analyses. The overall survey design and provisions for informed consent have been previously detailed.[10]

The age limits for inclusion in the analysis were set along sampling stratum. First, we set the lower age limit at 40 years because of the low rates of hypertension in this age group. Second, we set the upper age limit at 79 years because a significantly higher percent of persons ≥80 years of age who suffered disproportionately higher rates of hypertension and other comorbid conditions were institutionalized and excluded from the NHANES III survey. Overall, this analysis was restricted to the 6278 noninstitutionalized non-Hispanic whites and non-Hispanic blacks 40 to 79 years of age for whom complete data on hypertension were available.

Data on systolic or diastolic blood pressures were missing for 30 participants. Even though NHANES III provides information on Mexican-Americans, we chose not to include them in this study because of their geographical concentration outside the historic stroke belt. NHANES III includes Texas, with its high percentage of Mexican-American population, in the southern region. The inclusion of Texas may therefore redefine the stroke belt and make the overlap of the south and the stroke belt less exact. Persons of other ethnic origins were excluded because of small sample size.

Region and Urbanization Classification

Urbanization classification was based on the USDA rural-urban continuum codes[11,12] that describe metropolitan communities by degree of urbanization and nearness to metropolitan areas (Tables 1 and 2). The USDA codes were recoded into 2 categories, metro and nonmetro, to prevent identification of counties that were sampled in the survey. Region of residence describes 4 broad geographic regions as defined by the Bureau of the Census. Table 3 shows the states included in the southern region. In the analysis presented here, the northeast, midwest, and west were combined as the nonsouthern region.

Blood Pressure Measurements

Blood pressure was measured on 2 occasions. Three measurements for participants ≥17 years of age were taken during the home interview by a trained interviewer, and 3 more measurements were taken from all participants ≥5 years at the Mobile Examination Center by the examining physician. All 6 measurements were taken with the participant in the sitting position after 5 minutes of rest. Blood pressure was measured with a standard mercury sphygmomanometer (Baumanometer, WA Baum Co, Inc) and 1 of 5 available cuffs (infant, regular, adult, large, and thigh) selected on the basis of the circumference of the participant's arm. Before the survey started and periodically thereafter, all blood pressure observers, both interviewers and physicians, received training in the use of a standardized protocol for measurement of blood pressure.[10] Maximum inflation levels were predetermined before the first blood pressure measurement.[13] The first and fifth Korotkoff sounds defined systolic and diastolic blood pressures in participants ≥20 years of age. The average of all available readings is reported here. A positive response to the question "Are you taking prescribed medication?" indicated the use of antihypertensive medication. This question was asked of the participants who reported having been told by a doctor that they had hypertension and also reported having received a prescription for antihypertensive medication.[10] In this study, we define hypertension as an average systolic blood pressure ≥140 mm Hg and/or diastolic blood pressure ≥90 mm Hg and/or currently taking antihypertensive medication.[1] For descriptive analyses, persons reporting a medical history of hypertension were categorized separately as "hypertension aware" group. Individuals currently taking antihypertensive medications were classified as treated; of these subjects, those having systolic blood pressure <140 mm Hg and/or diastolic blood pressure <90 mm Hg were considered as persons with controlled hypertension.

TABLE 2. Rural-Urban Continuum Code

Metro counties
Central counties of metro areas of ≥1 million population
Fringe counties of metro areas of ≥1 million population
Counties in metro areas of 250 000 to 1 million population
Counties in metro areas of <250 000 population
Nonmetro counties
Urban population of ≥20 000 adjacent to a metro area
Urban population of ≥20 000 not adjacent to a metro area
Urban population of 2500 to 19 999 adjacent to a metro area
Urban population of 2500 to 19 999 not adjacent to a metro area
Completely rural or <2500 urban population adjacent to a metro area
Completely rural or <2500 urban population not adjacent to a metro area

Statistical Analysis

Age-adjusted hypertension prevalence and percent of hypertension awareness, treatment, and control were calculated by the direct method with the 1990 US population as standard. Because of the well-known difference in mean blood pressure by sex, race-ethnic, and age groups,[14] analyses of the distribution of hypertension by southern and nonsouthern and metro and nonmetro residence were conducted for each of the 8 demographic subgroups formed by the combination of sex, race-ethnicity, and age groups. Analyses were performed separately for persons 40 to 59 and 60 to 79 years of age. The χ^2 test statistics and 95% confidence intervals (CIs) were used to determine statistical significance. We performed exploratory logistic regression analysis of hypertension prevalence[15] using the Statistical Analysis System (SAS).[16] Initial logistic regression analyses includ-

TABLE 3. States in Study Region

Region	States Included
South	Delaware, Maryland, District of Columbia, West Virginia, Virginia, Kentucky, Tennessee, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Oklahoma, Arkansas, and Texas.

TABLE 4. Region-, Urbanization-, and Age-Adjusted Hypertension Prevalence, Percent of Awareness, Treatment and Control, and Mean Systolic Blood Pressure in Persons 40 to 59 Years of Age, NHANES III, 1988–1994

Ethnicity/ Urbanization	Prevalence			Awareness			Treatment			Controlled			SBP, mm Hg		
	South	Nonsouth	*P*	South	Nonsouth	*P*	South	Nonsouth	*P*	South	Nonsouth	*P*	South	Nonsouth	*P*
Black women															
Total	45.6	39.4	0.094	84.8	76.5	0.084	65.4	63.5	0.280	38.3	25.8	0.047	129.8	128.3	0.376
Metro	50.1	39.2	0.018	79.6	77.2	0.717	63.1	64.0	0.117	33.2	23.4	0.182	131.8	128.1	0.101
Nonmetro	43.1	41.7	0.738	88.5	*	0.074	67.6	*	0.657	40.0	*	0.899	129.2	129.7	0.871
Black men															
Total	44.1	36.7	0.050	65.1	67.0	0.637	38.6	50.4	0.584	14.8	7.5	0.534	133.0	129.7	0.033
Metro	47.4	38.2	0.119	63.8	71.3	0.376	32.0	3.4	0.252	12.1	16.8	0.445	133.4	129.8	0.165
Nonmetro	42.5	39.9	0.692	65.7	*	0.513	41.1	*	0.915	15.0	*	0.236	132.7	136.7	0.221
Non-Hispanic white women															
Total	21.4	19.8	0.617	78.6	79.9	0.827	62.2	67.2	0.800	41.8	44.6	0.646	120.6	119.6	0.402
Metro	23.4	17.0	0.444	*	83.5		*	74.5		42.3	54.5	0.149	121.3	118.4	0.124
Nonmetro	20.2	22.3	0.481	77.3	77.7	0.965	58.8	59.1	0.275	41.7	36.5	0.371	120.3	120.6	0.783
Non-Hispanic white men															
Total	33.1	23.0	0.012	71.4	74.3	0.826	43.2	2.5	0.186	19.8	29.5	0.161	127.3	123.6	0.002
Metro	33.1	23.8	0.118	74.2	61.9	0.226	53.0	5.8	0.072	19.6	23.8	0.451	125.8	124.3	0.346
Nonmetro	33.3	22.3	0.011	72.2	86.1	0.108	35.6	0.2	0.953	19.5	6.1	0.251	128.3	122.8	0.000

Age-adjusted to the 1990 U.S. population. Blacks in the study are also of non-Hispanic origin.
*Estimate based on <25 observations.

ing all participants showed that there was a significant interaction between age and hypertension prevalence. To address this interaction, the study population was divided into 2 age groups for further analyses: those 40 to 59 and those 60 to 69 years of age. Separate logistic regression models were constructed for each of the 8 demographic subgroups. Both regions (south versus nonsouth) and urbanization (metro versus nonmetro) were examined in a multivariate model. To assess for possible interaction between region and urbanization, separate additional logistic regression models testing the association between region and hypertension were fitted, including the interaction terms "region*urbanization," "region*age," and "urbanization*age." Significant "region*urbanization" interaction was noted only in the older age group. For this reason, separate models were constructed for metro and nonmetro areas including region and age in the group 60 to 79 years of age for non-Hispanic white men and non-Hispanic black men. Final models for women 60 to 79 years of age and for the entire group 40 to 59 years of age included region, urbanization, and single years of age. Because of the multistage complex survey design of NHANES III, all final analyses including the interaction models were performed in SUDAAN, software that accounts for the design effect in computing variance estimates[17] Appropriate sampling weights were used to account for oversampling and nonresponse.[10] The adjusted odds ratios were corrected by use of the method described by Zhang et al[18] to avoid overestimation of risk because the prevalence of hypertension in the study population was >30%.

Results

In Table 4, we present age-adjusted prevalence of hypertension, mean systolic blood pressure, and percent aware of, treated for, and control of hypertension in region and urbanization categories among participants 40 to 59 years of age. In this age group, non-Hispanic black men and women had the highest mean systolic pressure, whereas a relatively low percent of non-Hispanic black men achieved control of their high blood pressure. Statistically significant regional differences in mean systolic blood pressure were noted in southern non-Hispanic white men (127.3 versus 123.6 mm Hg, $P=0.002$) and non-Hispanic black men (133.0 versus 129.7 mm Hg, $P=0.033$) for south and nonsouth, respectively. Only non-Hispanic black women residing in the south showed a higher rate of blood pressure control while receiving medication treatment compared with non-Hispanic black women residing in nonsouthern regions (38.3% versus 25.8%, $P=0.047$, respectively). Overall, non-Hispanic white women had the lowest prevalence of hypertension of all the demographic subgroups without significant regional differences. Also, 33.1% of southern non-Hispanic white men (95% CI, 27.3 to 38.9) compared with 23.0% of nonsouthern non-Hispanic white men (95% CI, 18.4 to 27.6) had hypertension.

Table 5 shows the results of a logistic regression analysis examining regional variations in the prevalence of hypertension while controlling for age and urbanization for those 40 to 59 years of age. Statistically significant associations between residence in the south and hypertension were noted in non-Hispanic black women (OR, 1.23; 95% CI, 1.01 to 1.45; $P=0.034$), non-Hispanic black men (OR, 1.36; 95% CI, 1.05 to 1.66; $P=0.019$), and non-Hispanic white men (OR, 1.49; 95% CI, 1.12 to 1.90; $P<0.006$) but not among non-Hispanic white women (OR, 1.05; 95% CI, 0.71 to 1.49; $P=0.801$). However, no statistically significant urbanization differences were observed in any of the demographic subgroups 40 to 59 years of age.

Overall, in the United States, age-adjusted prevalence of hypertension was higher among 60- to 79-year-old southern residents compared with nonsouthern residents of the United States (59% versus 54%; $P=0.04$; Table 6). A higher percent of older southern non-Hispanic white women and non-Hispanic white men had hypertension compared with similar

TABLE 5. Logistic Regression Analysis of Prevalence of Hypertension by Sex and Ethnic Group Among Persons 40 to 59 Years of Age, NHANES III, 1988–1994

	Region, South vs Nonsouth			Urbanization, Metro vs Nonmetro		
Sex/Ethnicity	Odds Ratio	95% CI	*P*	Odds Ratio	95% CI	*P*
Black women	1.23	1.01–1.45	0.034	1.08	0.90–1.28	0.380
Black men	1.36	1.05–1.66	0.019	1.16	0.91–1.42	0.201
White women	1.05	0.71–1.49	0.801	0.86	0.58–1.22	0.386
White men	1.49	1.12–1.90	0.006	1.07	0.84–1.34	0.551

Blacks in the study are also of non-Hispanic origin. Odds ratio was corrected and adjusted. Hypertension prevalence: systolic blood pressure ≥140 mm Hg and/or diastolic blood pressure ≥90 mm Hg and/or on antihypertensive medication.

ethnic-sex groups in the nonsouthern region. Table 6 shows age-adjusted hypertension prevalence and mean systolic blood pressure in persons 60 to 79 years of age by region and urbanization. Older southern non-Hispanic white men (54.9% versus 47.4%, $P=0.012$) and non-Hispanic black men (66.6% versus 62.3%, $P=0.050$) exhibited higher rates of hypertension than nonsouthern residents. Interestingly, older non-Hispanic black men in the south demonstrated higher awareness (78.3% versus 67.3%, $P=0.043$) and treatment (65.7% versus 53.1%, $P=0.035$) rates but a lower rate of blood pressure control with medication (34.5% versus 45.4%, $P=0.041$) compared with their nonsouthern counterparts. Mean systolic blood pressure showed differences only within urbanization groups, with levels higher among southern nonmetro non-Hispanic white men (139.9 versus 133.8 mm Hg, $P=0.001$) and non-Hispanic black men (143.7 versus 133.4 mm Hg, $P=0.003$) compared with nonmetro nonsouthern residents of similar ethnicity. Non-Hispanic white women showed no regional differences but higher rates of awareness ($P=0.010$) and treatment ($P=0.036$) among southern nonmetro residents compared with their nonsouthern counterparts.

A significant interaction was noted between region and urbanization in older non-Hispanic white men ($P=0.006$), with a higher prevalence in the south only for nonmetro residents. Similarly, statistically significant region and urbanization interaction was noted in older non-Hispanic black men ($P=0.031$), with hypertension prevalence also being higher for nonmetro residents in the south. However, in age-adjusted logistic regression analysis for the group 60 to 79 years of age, in an examination of regional differences in the prevalence of hypertension among the different sex-ethnic groups, only nonmetro southern non-Hispanic white men (OR, 1.32; 95% CI, 1.06 to 1.56; $P=0.013$) showed a higher risk of having hypertension compared with their nonsouthern counterparts (Table 7). A similar but not statistically significant trend was also confirmed among non-Hispanic black men in logistic regression analysis (OR, 1.38; 95% CI, 0.97 to 1.68; $P=0.061$). No statistically significant association was observed for urbanization in the other demographic subgroups.

TABLE 6. Region-, Urbanization-, and Age-Adjusted Hypertension Prevalence, Percent Awareness, Treatment and Control, and Mean Systolic Blood Pressure in Persons 60 to 79 Years of Age, NHANES III, 1988–1994

	Prevalence			Awareness			Treatment			Controlled			SBP, mm Hg		
Ethnicity/ Urbanization	South	Nonsouth	*P*	South	Nonsouth	*P*	South	Nonsouth	*P*	South	Nonsouth	*P*	South	Nonsouth	*P*
Black women															
Total	73.6	75.0	0.656	81.3	80.3	0.841	75.2	71.2	0.687	38.4	41.7	0.397	144.2	142.3	0.350
Metro	67.1	74.1	0.329	80.5	82.0	0.842	69.6	70.7	0.487	19.7	43.8	0.028	148.6	142.3	0.107
Nonmetro	74.8	79.6	0.351	82.5	71.0	0.119	76.1	71.0	0.878	42.5	33.6	0.667	143.1	142.3	0.747
Black men															
Total	66.6	62.3	0.465	78.3	67.3	0.043	65.7	53.1	0.035	34.5	45.4	0.041	142.2	140.3	0.383
Metro	54.3	64.7	0.270	83.9	68.1	0.013	69.0	55.1	0.622	23.8	43.1	0.018	137.5	141.7	0.194
Nonmetro	70.4	50.0	0.092	77.0	66.6	0.164	65.2	52.2	0.065	37.4	65.8	0.016	143.7	133.4	0.003
Non-Hispanic white women															
Total	60.1	56.3	0.289	79.8	74.5	0.057	64.2	61.6	0.132	45.7	42.8	0.558	138.7	136.6	0.120
Metro	60.7	53.9	0.315	76.9	76.7	0.993	57.6	65.8	0.966	36.2	44.0	0.285	140.1	136.4	0.182
Nonmetro	60.3	58.3	0.599	79.7	72.5	0.010	66.5	58.0	0.036	46.5	44.0	0.538	138.6	136.8	0.222
Non-Hispanic white men															
Total	54.9	47.4	0.071	68.0	65.0	0.504	55.2	53.0	0.153	35.3	41.9	0.657	138.2	135.6	0.093
Metro	44.7	50.8	0.162	66.5	58.7	0.312	61.8	45.5	0.399	60.9	38.5	0.049	131.4	137.3	0.000
Nonmetro	57.2	43.8	0.015	69.3	73.1	0.460	54.7	62.5	0.375	29.7	45.9	0.122	139.9	133.8	0.001

SBP indicates systolic blood pressure. Age-adjusted to the 1990 U.S. population. Blacks in the study are also of non-Hispanic origin.

TABLE 7. Logistic Regression Analysis of Prevalence of Hypertension by Sex and Ethnic Group Among Persons 60 to 79 Years of Age, NHANES III, 1988–1994

		Region, South vs Nonsouth			Urbanization, Metro vs Nonmetro		
Sex/Ethnicity	Area	Odds Ratio	95% CI	*P*	Odds Ratio	95% CI	*P*
Black women*		0.93	0.79–1.06	0.321	0.92	0.74–1.05	0.248
Black men†	Metro	0.83	0.54–1.11	0.239			
	Nonmetro	1.38	0.97–1.68	0.061			
White women*		1.05	0.90–1.18	0.504	0.94	0.81–1.08	0.400
White men†	Metro	0.86	0.67–1.07	0.169			
	Nonmetro	1.32	1.06–1.56	0.013			

See Table 4 for explanation.
*Models include age and region (south or nonsouth).
†Models include age (south or nonsouth) in metro and nonmetro.

Discussion

A statistically significantly higher prevalence of hypertension was noted among younger southern non-Hispanic white men and non-Hispanic black men and women compared with those residing in other regions (Table 4). Geographical variation in the prevalence of hypertension was not apparent among non-Hispanic white women. In those 60 to 79 years of age, a higher age-adjusted rate of hypertension was noted among southern non-Hispanic white men compared with nonsouthern residents of the United States only for nonmetropolitan residents (Table 6). The difference was not statistically significant for non-Hispanic black men and women after controlling for urbanization. Other significant differences by urbanization were not noted.

The higher rates of stroke incidence and mortality, as well as hypertension prevalence and systolic blood pressure, in the southeastern part of the United States make it a target for stroke intervention.[1–9,19] Regional variation in the distribution of stroke, for which hypertension is the leading cause, has been observed in the United States and in other parts of the world.[1–9,19–23] Recently, the south-central region has shown similar high rates because of a more rapid decline in stroke mortality among non-Hispanic whites in the southeastern area.[5,8,9] Although most recent studies suggest an overall decline in the rate of hypertension,[24] if more vigorous hypertension control efforts such as education and treatment had been mounted in the southeast in the 1980s, the result may have been a more rapid decline in hypertension prevalence and stroke mortality. A slowing down of the decline in overall stroke mortality rate in the United States has also been reported,[24,25] making the need for more effective, targeted interventions more urgent. Explanations for geographical differences in stroke risk have been elusive largely because of complex interactions of multiple causes, some of which may have differential effects on atherosclerosis and hypertension.[26] Furthermore, hypertension is a multifactorial disorder that emanates from a genetic and environment interaction.[27,28] These causes may have geographical distribution and therefore produce geographical variations in the prevalence of hypertension.[29,30] Consequently, profiles that delineate risk in 1 ethnic group may not necessarily represent risk factors in other groups.[31] Recently, Kiefe et al[32] also showed persistent regional differences in the rates of hypertension after adjusting for body mass index, weight gain, physical activity, dietary intake, alcohol, tobacco, education, contraceptive use, and family history of hypertension. Although environmental toxic elements such as lead and cadmium[33] were implicated in geographic variation in some studies, others have reported high salt intake, low dietary potassium, and magnesium and protein intake, particularly among southern blacks.[34–36] Also, the relationship between hypertension and psychological stress and socioeconomic status as measured by education, occupation, and area of residence may contribute to the geographical distribution.[37] Moreover, the prevalence of counseling that results in increased physical activity level and improved blood pressure control was lowest in the south and highest in the midwest.[38] Non-Hispanic blacks were substantially less likely than non-Hispanic whites and Hispanics to be counseled about physical activity. Similarly, a greater proportion of persons 50 to 64 years of age than those in other age groups was more likely to be counseled.[38] Collectively, these correlates of hypertension appear to parallel those reported for stroke with similar geographic, ethnic, and age distribution in the United States. One study suggested that the overall differential rates of stroke and hypertension may reflect a markedly higher rate of severe hypertension among southern blacks.[23] This notion is supported in the present study by the relatively lower rate of blood pressure control among older southern hypertensive black men treated with medication (Table 6). Furthermore, the interaction of region and urbanization among older white men is similar to the interaction reported previously for ischemic heart disease and stroke mortality.[19] Previously, explaining the higher rate of stroke among non-Hispanic white men in the south has been difficult. However, the findings of higher rates of hypertension, a statistically significant association between hypertension and residence in the south, and a significant interaction between region and urbanization among non-Hispanic white men help explain increased stroke risk in the region (Table 7).

The higher rates of hypertension among black men in the south are consistent with stroke mortality patterns or stroke incidence in the United States.[5,19] Similarly, previously discussed higher prevalence rates of self-reported hypertension among southeastern US residents is consistent with the

findings of the present study.[39] The lack of an overall association between region and hypertension among elderly black men and women may be due to selective mortality among hypertensives[23] and exclusion of the institutionalized population. Early onset of hypertension, the "ceiling effect," in which the rates were already high, and bias or confounding by factors not included in this analysis are alternative explanations for the lack of regional differences in the older age group.[39] Reduced access to healthcare services and consequent underutilization of preventive services is 1 possible reason for higher rate of stroke among the lower socioeconomic groups in the rural south.[40,41] Although a relatively higher awareness and treatment rate exists among older black men in the south compared with nonsouth, this treatment does not appear to be sustained because blood pressure control by both region and urbanization was poorer in this group, thus underscoring the contributions of socioeconomic and education factors to higher rates of sustained hypertension and stroke risk among older blacks in the south. It is also possible that black men in particular respond very poorly to treatment compared with persons of other ethnic origins. Additionally, lower rates of preventive services use reported in the southeast region and metropolitan areas in previous national surveys in 1973 and 1982[41,42] support the hypothesis of inadequately treated hypertension as a possible explanation for increased stroke risk in this region. The high rates of treatment that are not complemented by high rates of blood pressure control for those on medication treatment in the present study warrant increased focus on sustained blood pressure treatment and control, in addition to ongoing awareness education particularly among older blacks in the southern United States.

The strength of the this study lies in the fact that NHANES III provides the best available data for examination of group-specific regional differences in the prevalence, awareness, and treatment of hypertension in the US noninstitutionalized population. In addition to the large sample size, the accuracy of blood pressure was ensured by taking measurements on 2 occasions and then averaging them to get a more precise estimate. This avoids some inherent bias posed by pseudohypertension, particularly white-coat hypertension. The major limitation of the study is the lack of power for subgroup analysis of differences in awareness, treatment, and control of hypertension among subgroups 40 to 59 years of age. Other limitations include possible bias resulting from survey nonresponse and possible confounding by variables not controlled for in the analysis. The presence of higher rates of hypertension, stroke prevalence, and mortality among the institutionalized population may further bias the data in older age group.

In conclusion, analysis of the data from NHANES III showed regional differences in the prevalence of hypertension. Specifically, southern non-Hispanic white men and non-Hispanic black men and women 40 to 59 years of age had higher rates of hypertension compared with persons in other regions. One challenge for the next decade is the reduction of ethnic, socioeconomic, and regional variations in hypertension.[42] Group- and region-targeted hypertension and multiple risk factor intervention could be a useful and cost-effective measure to reduce the prevalence of hypertension and associated mortality. Despite numerous questions that remain unanswered regarding the cause of geographical variations in stroke incidence and mortality in the United States, currently available evidence supports an increased focus on hypertension education and intervention program in the southern United States. Improved access to health care and optimization of hypertension treatment strategies may reduce stroke rates in high-risk areas.

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