

Awareness, Treatment and Control of Hypertension, Diabetes and Hyperlipidemia and Area-Level Mortality Regions in the Reasons for Geographic and Racial Differences in Stroke (REGARDS) Study

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Abstract: **Background.** Health Professional Shortage Areas (HPSA) receive extra federal resources, but recent reports suggest that HPSA may not consistently identify areas of need. **Purpose.** To assess areas of need based on county-level ischemic heart disease (IHD) and stroke mortality regions. **Methods.** *Need* was defined by lack of awareness, treatment, or control of hypertension, diabetes, or hyperlipidemia. Counties were categorized into race-specific tertiles of IHD and stroke mortality using 1999–2006 CDC data. Multivariable logistic regression was used to model the relationships between IHD and stroke mortality region and each element of need. **Results.** Awareness and treatment of cardiovascular (CVD) risk factors were similar for residents in counties across IHD and stroke mortality tertiles, but control tended to be lower in counties with the highest mortality. **Conclusions.** High stroke and IHD mortality identify distinct regions from current HPSA designations, and may be an additional criterion for designating areas of need.

Key words: Control, ischemia, stroke, HPSA.

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Cardiovascular disease (CVD) remains the leading cause of mortality in the U.S. in men and women of every major ethnic group.¹ Approximately 13 million individuals have a history of coronary artery disease and 7.2 million have suffered a myocardial infarction.¹ Elkins et al. reported that if recent trends in ischemic stroke mortality continue, increases in U.S. stroke deaths will outpace overall population growth, with a doubling in such mortality over the next 30 years.² While there has been an overall decline in the incidence of these diseases in the last few decades,³⁻⁴ the rate of this decline has differed by race, sex and age.⁴⁻⁶ Furthermore, this decline has not occurred in every part of the U.S. or among people in all socioeconomic strata.⁷⁻⁸ Reports indicate that an important reason for these observed disparities may lie in disparities in access to⁹⁻¹⁰ and the quality of health care.¹¹⁻¹²

In an effort to address such disparities, the U.S. Health Resources and Services Administration (HRSA) designates Health Professional Shortage Areas (HPSAs) for special resource allocations.¹³ An HPSA designation involves a complex process that factors in ratio of providers to patients in the geographic area; underserved population groups that share common cultures or socio-demographic uniqueness (e.g., migrant farmworkers, low-income populations and Alaska Natives); and health care facilities which provide primary medical services to a geographic or population group (e.g., health centers, correctional institutions).¹⁴ Many federally funded programs such as the National Health Service Corps (NHSC) Scholarship Programs, NHSC Loan Repayment Program, Exchange Visitor Program, Medicare and Conrad State 30 Program use HPSA designations to allocate their program's benefits or resources to targeted areas or groups,¹³ providing an additional incentive for areas or facilities to seek HPSA designation.

Health Professional Shortage Area designation is not permanent, and each year, the Department of Health and Human Services (HHS) is required by law to update and publish a list of newly designated HPSAs and indicate those entities that no longer have the designation.¹⁴ Unfortunately, this annual reassessment requirement has not been consistently met.¹⁴ Furthermore, published reports express concerns about using HPSA designation as currently construed to deploy scarce resources rationally.¹⁵ For example, the HPSA methodology may overstate the need for additional primary care providers. In the past, the HPSA methodology underestimated the number of available primary care physicians already providing services in shortage areas.¹⁴ Additionally, the current application process favors those states or agencies that have the skills and experience to complete and submit a HPSA designation request.¹⁴ For these reasons, the current approach for designation of HPSAs may not be a sufficient and comprehensive approach for judicious deployment of human and material resources¹⁶ if the second goal of *Healthy People 2020* is to be achieved, namely, to achieve health equity, eliminate health disparities, and improve health for all groups.¹⁷

As part of the process for designating areas of health manpower need, it may be worth exploring the readily available and objective yardstick of county level mortality rates. For example, ischemic heart disease (IHD) and stroke mortality rates are likely to be influenced by county residents' control of important CVD risk factors such as hypertension, diabetes and hyperlipidemia, which require chronic disease management by the area's health professionals.

We hypothesized that participants living in areas with higher IHD or stroke mortality

would have lower levels of awareness, treatment, and control of hypertension, diabetes, and hyperlipidemia compared to those living in areas with lower IHD or stroke mortality. We contrast these findings with our past work examining these same risk factors by HPSA designation at the county level, which found little evidence of need, as defined by risk factor control, in HPSA vs. non-HPSA areas.¹⁸⁻¹⁹

Methods

Study design and participants. The goals and design of the REGARDS study have been described elsewhere.²⁰ Briefly, the REGARDS participants included 30,239 community-dwelling adults aged 45 years and older at baseline. Enrollment began in January 2003 and was completed in October 2007. Individuals were recruited from commercially available lists using a combination of telephone and mail contacts. Of individuals contacted and for whom eligibility could be confirmed, 49% agreed to participate. Using sampling weights, sub-populations were over-sampled, resulting in a cohort that was 42% African American and 55% female. Incentives included test results after an in-home visit and \$30. Written informed consent was obtained. Participants are being followed by telephone interview every six months to detect potential study outcomes, which are later confirmed using medical record review procedures. Only baseline data were used in the current study. The Institutional Review Board of the University of Alabama at Birmingham and other participating centers approved the study methods prior to its commencement.

Study instruments and data collection. A computer-assisted telephone interview (CATI) was used to obtain socio-demographic and economic characteristics, past medical history, and measures of quality of life. During an in-home visit performed approximately three to four weeks after the telephone interview, health professionals obtained standardized physical measures such as participant's weight, height, blood pressure, and a resting electrocardiography (ECG), phlebotomy, and urine collection. During the in-home visit, as well, all prescription and over-the-counter medications were recorded.

Definition of variables. *Outcome variables.* Hypertension was defined as having a blood pressure $\geq 140/90$ mmHg ($\geq 130/80$ mmHg if the participant also had diabetes or chronic kidney disease, defined as estimated glomerular filtration rate [eGFR] < 60 ml/min/1.73m²),²¹ report of being told by a doctor or nurse they had hypertension or self-reported history of taking medication for hypertension. Diabetes was defined as a fasting blood sugar ≥ 126 mg/dL, having been told by a doctor or nurse they had diabetes, or treatment with a diabetes medication. Hyperlipidemia was defined as low-density lipoprotein > 130 mg/dL, having been told by a doctor or nurse they had high cholesterol, or treatment with a cholesterol-lowering medication. Awareness about disease was defined as the participant reporting that he/she had been told by a doctor or nurse that they had hypertension, diabetes, or hyperlipidemia, or treatment of these disorders with medications. The proportion who were aware of their condition was the number aware divided by the number who met the disease definition. Treatment was defined as taking medication to treat the respective diseases. The proportion treated was defined as those taking medications divided by those aware of their condition. Control was

based on having blood pressure, plasma glucose, and low-density lipoproteins below the cut points defined above. The proportion controlled was defined as the number controlled (by medication) divided by those treated for their condition.

Covariates from REGARDS data. Sociodemographic characteristics included age, sex, race, income, education, and insurance status. Age was categorized into 10-year intervals of 45–54, 55–64, 65–74, 75–84, and 85 years or older; race was self-reported as either African American or European American; educational attainment was categorized as less than high school, high school, some college, and college or more; and annual household income was grouped as less than \$25,000, \$25,000–\$50,000, and more than \$50,000. Insurance status was broadly classified as having or not having any type of insurance. We included body mass index (BMI), categorized as below 24.9kg/m², 25–29.9kg/m², and 30kg/m² or above. Health behaviors included physical activity, alcohol intake, and medication adherence. For exercise, participants were asked about frequency of their exercise in a week, with responses categorized into none, one to three per week, and four or more per week. Smoking was categorized as currently smoking, past smoking (but not currently), or never smoking. Alcohol consumption was categorized as currently consuming alcohol or not. Medication adherence was assessed using the validated four-item Morisky scale, with any *yes* response categorizing the participant as nonadherent.²²

Ischemic heart disease and stroke mortality data. The main exposure of interest was the participant's county of residence by tertile of IHD or stroke mortality (low, medium, or high). Mortality data were taken from the Centers for Disease Control Wonder system, a publicly available resource which provides overall and disease-specific mortality rates at the county level, by age groups and by race. Causes of death are based on death certificates. For this analysis, we used county-level IHD and stroke mortality rates from 1999–2006 for individuals age 45 and over.^{23–24} Since African American and European American mortality tertile designations were not strongly correlated, each county with a REGARDS participant was categorized into race-specific tertiles of IHD and, separately, stroke mortality (Figure 1).

HPSA and urban/rural designation. HPSA designation was based on population-to-Primary Care Physician Ratio, percent of the population with incomes below the poverty level, infant mortality rate or low birth weight rate (whichever score was higher), and travel time or distance to nearest available source of care (whichever scored more highly).^{25–26} Health Professional Shortage Area status is publically available on the HRSA web site.²⁵ We classified the counties with REGARDS participants into those that were designated as HPSAs, partial HPSAs and non-HPSAs in 2009 (Figure 2). Partial HPSA designation occurs because entities such as hospitals may receive HPSA designation, but the county in which they are situated may not. As in past reports on HPSA status, counties with partial HPSA status were excluded from analysis.²⁷ The rurality of the county was based on criteria set by the U.S. Census Bureau and available through HRSA along with the HPSA designation.²⁸ We defined rural as a county that is 25% or less urban; urban as those that are 75% or more urban; and mixed counties as 25%–75% urban.

Statistical analysis. Bivariate analyses were conducted to test the statistical significance of the association between each covariate and each of the outcome measures,

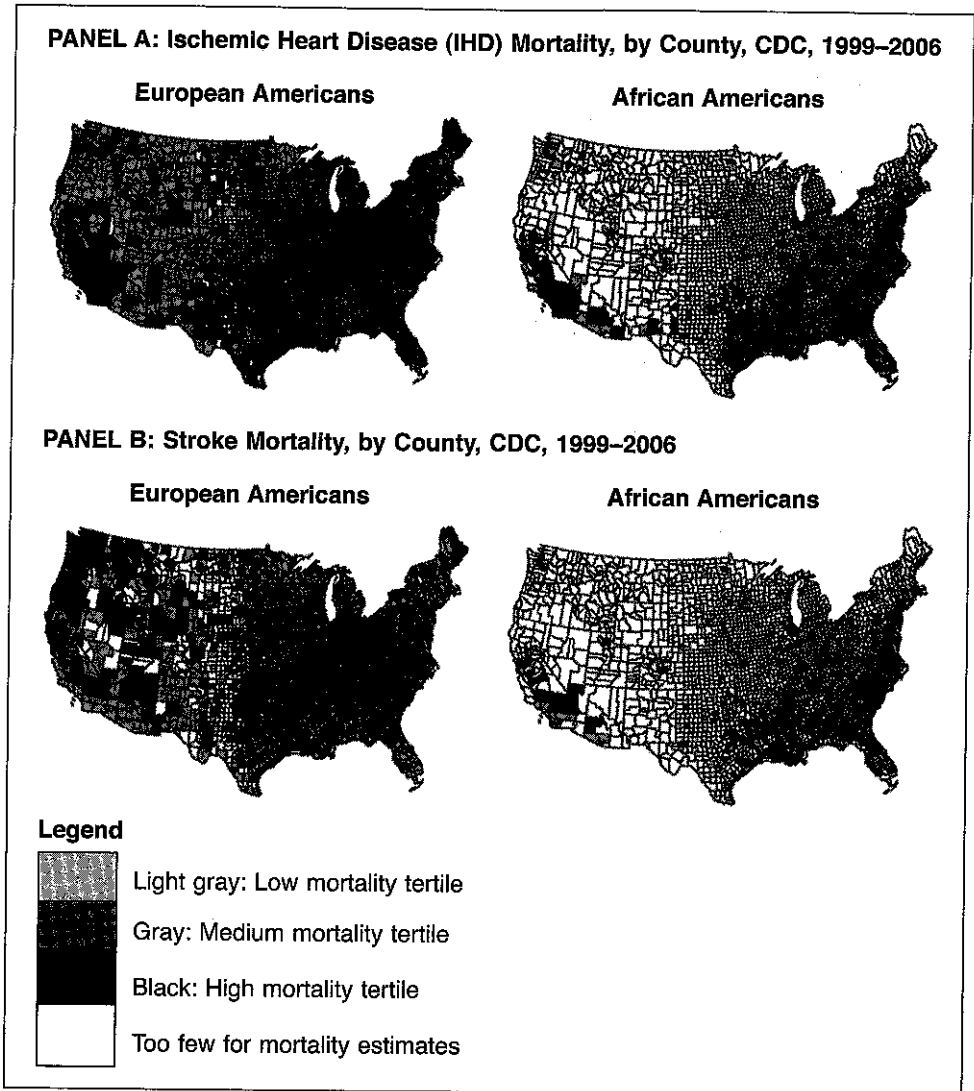


Figure 1. Maps showing race-specific Ischemic Heart Disease (Panel A) and stroke (Panel B) mortality tertiles from CDC by county, 1999–2006.

as defined above. Multivariable logistic regression analysis was used to investigate the association between county IHD mortality tertile, and, separately, stroke mortality tertile and each element of need (awareness, treatment and control of hypertension, diabetes and hyperlipidemia, as defined above). Variables such as socio-demographic characteristics and health behaviors that were statistically significant at $p < .05$ on bivariate analysis and those known to be associated with IHD and stroke mortality based on extant literature were incorporated into models.²⁹ Nine separate models were fit for IHD mortality tertiles, and nine additional models were fit for stroke mortality tertiles. Race-stratified tertiles were matched to the race of each patient in these models.

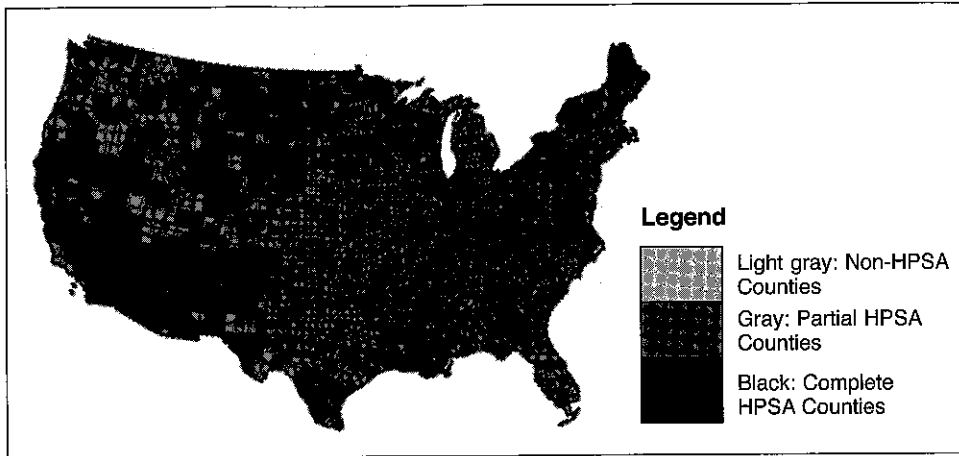


Figure 2. Map showing Health Professional Shortage Areas (HPSA) designation of U.S. counties in 2009.

Multi-level regression models were also used to account for clustering at the county level. Crude and fully adjusted odds ratios (ORs) and their 95% confidence intervals (CIs) are reported. Spearman's rank correlation was used to determine the correlation between high IHD/stroke mortality areas and HPSAs. Data were analyzed using SAS software version 9.2 (SAS Institute, Cary, NC).

Results

Although we assessed the association between IHD or stroke mortality and the cardiovascular risk factors, using multi-level models did not show significant variation at the level of the counties. For ease of interpretation, the results of the individual level analyses are shown below.

The characteristics of participants included in the analysis are shown in Table 1. Age and sex distributions in low and high mortality counties were largely similar. There was an overall pattern for a greater proportion of individuals with risk factors in high vs. low mortality counties, but the differences, if present, were modest. There was a tendency for high IHD and stroke mortality counties to have higher proportions of participants living in HPSA areas (17.2% vs. 11.1% and 14.6% vs. 8.3% respectively). The rural-urban difference in mortality risk was strikingly greater for stroke than for IHD (15.2% vs. 30.5%, and 22.2% vs. 25.4% respectively).

Figure 1 shows maps of the U.S. with 1,821 counties categorized into IHD and stroke mortality tertiles, by race (Panels A and B, respectively). The counties in the highest IHD mortality tertile form a crescent-like band stretching from the Northeast toward Texas, and hooking up into New Mexico, southern California and southwestern Nevada. The correlation between African American and European American county-level tertile was moderate (Spearman's $r=0.56$; $p<.0001$). For stroke, in European Americans, the highest mortality tertile counties were located in the Southeast, spreading northward

Table 1.

SOCIO-DEMOGRAPHIC CHARACTERISTICS OF REGARDS PARTICIPANTS RESIDING IN COUNTIES IN THE HIGH AND LOW IHD OR STROKE MORTALITY TERTILES^a

Socio-demographic variables	ALL Counties		Low IHD Mortality Tertile Counties		High IHD Mortality Tertile Counties		ALL Counties		Low Stroke Mortality Tertile Counties		High Stroke Mortality Tertile Counties	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
	N= 19,954		N=7,273		N=4,891		N=19,804		N=6,285		N=5,886	
Mean age in years ± SD	64.6 ± 9.4		64.7 ± 9.5		64.7 ± 9.3				64.9 ± 9.4		64.2 ± 9.4	
Age group												
45-54	2636	13.2	962	13.2	594	12.2	2621	13.2	758	12.1	853	14.5
55-64	7703	38.6	2802	38.6	1946	39.8	7641	38.6	2482	39.5	2272	38.6
65-74	6342	31.8	2259	31.1	1567	32.0	6294	31.8	1976	31.4	1868	31.8
75-84	2917	14.6	1107	15.2	697	14.3	2897	14.6	946	15.1	793	13.5
85+	348	1.7	139	1.9	86	1.80	343	1.7	122	1.9	97	1.65
Gender												
Female	10905	54.6	3967	54.5	2639	54.0	10814	54.6	3320	52.8	3317	56.4
Male	9049	45.4	3306	45.5	2252	46.0	8990	45.4	2965	47.2	2569	43.7
Race												
Black	7167	35.9	2530	34.8	1454	29.7	7110	35.9	2565	40.8	2011	34.2
White	12787	64.1	4743	65.2	3437	70.3	12694	64.1	3720	59.2	3875	65.8

p < .001

p = .001

p = .03

p = .39

p < .0001

(Continued on p. 910)

Table 1. (continued)

Socio-demographic variables	ALL Counties			Low IHD Mortality Tertile Counties			High IHD Mortality Tertile Counties		
	No.	%		No.	%		No.	%	
	N= 19,954		N=7,273			N=4,891			
Education									
<High School	2520	12.6	829	11.4	700	14.3			
High School	5209	26.1	1734	23.9	1332	27.3			
Some college	5354	26.9	1936	26.6	1319	27.0			
≥College	6860	34.4	2770	38.1	1535	31.4			
									<i>p</i> <.0001
Annual income									
<\$25,000	5475	31.3	1892	29.6	1403	32.8			
\$25,000-\$50,000	6069	34.7	2131	33.3	1538	36.0			
>\$50,000	5948	34.0	2374	37.1	1333	31.2			
									<i>p</i> <.0001
BMI									
≤24.9kg/m2	4962	25.1	1945	27.0	1240	25.5			
25-29.9 kg/m2	7300	36.9	2658	36.8	1771	36.5			
≥30kg/m2	7547	38.1	2619	36.3	1844	38.0			
									<i>p</i> <.0001

Socio-demographic variables	ALL Counties			Low Stroke Mortality Tertile Counties			High Stroke Mortality Tertile Counties		
	No.	%		No.	%		No.	%	
	N=19,804		N=6,285			N=5,886			
Education									
<High School	2495	12.6	717	11.4	888	15.1			
High School	5148	26.0	1528	24.3	1672	28.4			
Some college	5325	26.9	1679	26.7	1603	27.3			
≥College	6825	34.5	2358	37.5	1719	29.2			
									<i>p</i> <.0001
Annual income									
<\$25,000	5430	31.3	1558	28.1	1798	35.0			
\$25,000-\$50,000	6023	34.7	1877	33.8	1814	35.3			
>\$50,000	5916	34.1	2111	38.1	1527	29.7			
									<i>p</i> <.0001
BMI									
≤24.9kg/m2	4926	25.1	1567	25.1	1432	24.5			
25-29.9 kg/m2	7248	36.9	2386	38.2	2109	36.1			
≥30kg/m2	7487	38.1	2286	36.6	2302	39.4			
									<i>p</i> =.02

(Continued on p. 911)

Table 1. (continued)

Socio-demographic variables	ALL Counties		Low IHD Mortality Tertile Counties		High IHD Mortality Tertile Counties		ALL Counties		Low Stroke Mortality Tertile Counties		High Stroke Mortality Tertile Counties	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
	N= 19,954		N=7,273		N=4,891		N=19,804		N=6,285		N=5,886	
Current alcohol consumption												
Yes	9930	49.8	3775	51.9	2287	46.8	9862	49.8	3430	54.6	2497	57.6
No	10024	50.2	3498	48.1	2604	53.2	9942	50.2	2855	45.4	3389	42.4
						<i>p</i> <.0001						<i>p</i> <.0001
Tobacco use												
Current	2893	14.6	1015	14.0	724	14.9	2867	14.5	875	14.0	912	15.6
Never	9110	45.8	3372	46.6	2218	45.5	9044	45.8	2873	45.9	2716	46.3
Past	7878	39.6	2856	39.4	1932	39.6	7821	39.6	2515	40.2	2238	38.2
						<i>p</i> =.44						<i>p</i> =.02
Frequency of Exercise												
None	6682	34.0	2378	33.1	1732	36.1	6624	33.9	2099	34.0	1988	34.3
1-3 times/week	7020	35.7	2592	36.1	1641	34.2	6968	35.8	2236	36.2	2052	35.4
4 or more times/week	5938	30.2	2206	30.7	1425	29.7	5859	30.3	1849	30.0	1759	30.3
						<i>p</i> =.01						<i>p</i> =.88

(Continued on p. 912)

Table 1. (continued)

Socio-demographic variables	ALL Counties		Low IHD Mortality Tertile Counties		High IHD Mortality Tertile Counties		ALL Counties		Low Stroke Mortality Tertile Counties		High Stroke Mortality Tertile Counties	
	N = 19,954		N = 7,273		N = 4,891		N = 19,804		N = 6,285		N = 5,886	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Medication adherence												
Yes	12947	64.9	4698	64.6	3183	65.1	12838	64.8	3964	63.1	3949	67.1
No	7007	35.1	2575	35.4	1708	34.9	6966	35.2	2321	36.9	1937	32.9
						<i>p</i> = .81						<i>p</i> < .0001
Insurance												
Yes	18617	93.4	6785	93.4	4558	93.2	18481	93.4	5888	93.7	5457	92.8
No	1320	6.6	479	6.6	331	6.8	1306	6.6	395	6.3	422	7.2
						<i>p</i> = .88						<i>p</i> = .1
HPSA												
Yes	2531	12.7	808	11.1	840	17.2	2412	12.2	519	8.3	858	14.6
No	17423	87.3	6465	88.9	4051	82.8	17392	87.2	5766	91.7	5028	85.4
						<i>p</i> < .0001						<i>p</i> < .0001
Rurality of county ^b												
Urban	13023	65.3	4855	66.8	2896	59.2	12992	65.6	4835	76.9	3036	51.6
Rural	4453	22.3	1615	22.2	1240	25.4	4358	22.0	954	15.2	1792	30.5
Mixed	2478	12.4	803	11.0	755	15.4	2454	12.4	496	7.9	1058	17.9
						<i>p</i> < .0001						<i>p</i> < .0001

^aCounty level mortality tertiles derived from CDC Wonder data from 1999-2006; N = Number of participants in the country. Medication adherence assessed using the validated 4-item Morisky scale; Insurance defined as having or not having any type of insurance;

^bRurality of county based on criteria set by U.S. census bureau: Rural = ≤25% urban, Urban = ≥75% urban, Mixed = 25-75% urban; Total number of counties different for IHD and stroke mortality tertiles due to missing values for small counties.

BMI = Body Mass Index

HPSA = Health Professional Shortage Area

Figures in bold are significant

into the central Midwest, and scattered into the Northwest. In contrast, the highest stroke mortality tertile counties for African Americans were concentrated almost entirely in the Southeast over what is traditionally considered the Stroke Belt. The correlation between county-level tertile designation between African Americans and European Americans was also moderate (Spearman's $r=0.63$; $p<.0001$). High IHD and high stroke mortality tertile designation demonstrated low correlation (Spearman's $r=0.16$, $p<.0001$) indicating little overlap between these counties. Similarly, the correlation between HPSA designation and IHD and stroke mortality tertiles was low (Figure 2), 0.04 ($p=.08$) and .01 ($p=0.58$), respectively, suggesting that HPSA designation and high CVD mortality tertile identified largely distinct counties.

Table 2 presents awareness, treatment, and control of hypertension, diabetes, and hyperlipidemia by high and low mortality tertiles for IHD and stroke. Overall, awareness and treatment were high except for hyperlipidemia, but control was less optimal, ranging from 36–79%. For hypertension, control was similar across tertiles of IHD mortality (58.2% in high mortality counties vs. 57.7% in the mortality counties). However, there was less control in high vs. low IHD mortality counties for diabetes (35.8 vs. 40.9%, respectively) and hyperlipidemia (76.1 vs. 79.2%, respectively). Hypertension control was slightly lower in counties in the highest vs. lowest stroke mortality tertile (57.6 vs. 58.6%, respectively), but was similar for diabetes and cholesterol.

Table 3 presents the crude and adjusted odds ratios and confidence intervals for the highest vs. lowest mortality tertile, for awareness, treatment, and control of each of the three CVD risk factors (hypertension, diabetes, and hyperlipidemia), for both county-level IHD and stroke mortality. We found no statistically significant difference between awareness, treatment, or control of hypertension across counties in the IHD mortality tertiles, but the adjusted odds of control were 12% lower in the highest stroke mortality counties relative to the lowest stroke mortality counties. With respect to diabetes, we observed 26% higher unadjusted odds for treatment in the highest vs. lowest IHD mortality tertiles, but the 21% higher adjusted odds were no longer statistically significant. However, the adjusted odds for control were 21% lower in the counties in the highest vs. lowest IHD tertile, a statistically significant finding. A similar pattern for more treatment, but less control was seen in the highest vs. lowest stroke mortality counties, but this difference was not statistically significant. For participants with hyperlipidemia, awareness and treatment were not significantly associated with either IHD or stroke mortality tertile. However, compared with the lowest mortality counties, the high IHD mortality counties had 17% lower adjusted odds of control, a pattern not seen in the stroke mortality counties.

To facilitate interpretation, the predicted probabilities corresponding to these odds ratios indicate that the control differences in low vs. high IHD mortality counties for diabetes were 40% (95% CI 0.38–0.42) vs. 36% (0.33–0.38) and for hyperlipidemia were 80% (0.79–0.82) vs. 77% (0.75–0.79). Similarly, hypertension control in low vs. high stroke mortality counties were 40% (0.38–0.44) vs. 37% (0.33–0.42).

Table 2.

PROPORTION OF PARTICIPANTS WITH AWARENESS, TREATMENT AND CONTROL OF HYPERTENSION, DIABETES AND HYPERLIPIDEMIA, BY COUNTY IHD AND STROKE MORTALITY TERTILES (MEDIUM TERTILE OMITTED FOR CLARITY)^{a,b,c,d,e,f}

Cardiovascular risk factors	Outcomes	N	IHD			Stroke		
			Overall %	Low mortality tertile (%)	High mortality tertile (%)	Overall (%)	Low mortality tertile (%)	High mortality tertile (%)
Hypertension (N=12,747)	Awareness	11,460	89.9	88.8	89.8	89.9	89.5	90.2
	Treatment	10,923	95.3	95.3	95.7	95.3	95.7	95.1
	Control	6,366	58.3	57.7	58.2	58.3	58.6	57.6
Diabetes (N=4,887)	Awareness	4,410	90.2	89.8	89.4	90.2	89.8	90.5
	Treatment	3,577	81.1	79.8	83.3	81.1	80.1	82.0
	Control	1,411	40.4	40.9	35.8	40.3	41.4	38.4
Hyperlipidemia (N=14,065)	Awareness	10,422	74.1	73.9	75.2	74.2	73.8	73.5
	Treatment	6,603	63.4	62.4	63.6	63.4	62.8	63.4
	Control	5,119	77.5	79.2	76.1	77.6	77.8	77.2

^aAwareness; Knowledge of the participant about the cardiovascular disease risk factors.

^bTreatment; Whether the participant is receiving treatment for disease.

^cControl; An assessment of whether the cardiovascular disease risk factor is under control based on clinically defined cut-points.

^dHypertension; Defined as having a blood pressure of 140/90 or greater (130/80 or greater if the participant also had diabetes or chronic kidney disease, defined as estimated glomerular filtration rate [eGFR] <60 ml/min/1.73m), or report of being told by a doctor or nurse they had hypertension.

^eDiabetes = Defined as a fasting blood sugar >126 mg/dL, having been told by a doctor or nurse they had diabetes, or treatment with a diabetes medication.

^fHyperlipidemia = Defined as cholesterol >130mg/dL, having been told by a doctor or nurse they had high cholesterol, or treatment with a cholesterol medication.

IHD = Ischemic Heart Disease

Table 3.

ODDS RATIOS AND 95% CONFIDENCE INTERVALS FOR THE ASSOCIATION BETWEEN AWARENESS, TREATMENT AND CONTROL OF CARDIOVASCULAR DISEASE RISK FACTORS AND RESIDENCE IN THE HIGH VS. LOW ISCHEMIC HEART DISEASE (IHD) AND STROKE MORTALITY TERILES^{a,b,c,e,f}

Outcomes	IHD		Stroke	
	High vs. low IHD mortality		High vs. low stroke mortality	
	Crude OR (95% CI)	Adjusted OR (95% CI) ^a	Crude OR (95% CI)	Adjusted OR (95% CI)
Hypertension^d				
Awareness (n = 11549)	1.11 (0.96–1.29)	1.14 (0.97–1.35)	1.08 (0.94–1.26)	1.07 (0.90–1.28)
Treatment (n = 10380)	1.09 (0.87–1.38)	1.10 (0.85–1.43)	0.87 (0.70–1.09)	0.80 (0.61–1.04)
Control (n = 9909)	1.02 (0.93–1.13)	1.00 (0.89–1.12)	0.96 (0.87–1.06)	0.88 (0.78–0.99) ^g
Diabetes^e				
Awareness (n = 4380)	0.97 (0.76–1.23)	1.02 (0.78–1.34)	1.08 (0.85–1.37)	0.98 (0.73–1.31)
Treatment (n = 3975)	1.26 (1.03–1.54) ^g	1.21 (0.96–1.52)	1.13 (0.93–1.37)	1.12 (0.88–1.42)
Control (n = 3217)	1.08 (0.92–1.26)	0.79 (0.64–0.96) ^g	0.88 (0.74–1.05)	0.82 (0.64–1.05)
Hyperlipidemia^f				
Awareness (n = 12791)	1.07 (0.97–1.18)	1.05 (0.94–1.17)	0.99 (0.90–1.09)	0.98 (0.87–1.10)
Treatment (n = 9605)	1.05 (0.95–1.17)	1.06 (0.94–1.20)	1.03 (0.93–1.14)	1.02 (0.90–1.15)
Control (n = 6146)	0.84 (0.72–0.97) ^g	0.83 (0.70–0.98) ^g	0.97 (0.83–1.12)	0.95 (0.80–1.14)

^aAwareness = knowledge of the participant about the cardiovascular disease risk factors

^bTreatment = Whether the participant is receiving treatment for disease

^cControl = An assessment of whether the cardiovascular disease risk factor is under control based on clinically defined cut-points

^dHypertension = Defined as having a blood pressure of 140/90 or greater (130/80 or greater if the participant also had diabetes or chronic kidney disease, defined as estimated glomerular filtration rate [eGFR] <60 ml/min/1.73m), or report of being told by a doctor or nurse they had hypertension

^eDiabetes = Defined as a fasting blood sugar >126 mg/dL, having been told by a doctor or nurse they had diabetes, or treatment with a diabetes medication

^fHyperlipidemia: Defined as cholesterol >130mg/dL, having been told by a doctor or nurse they had high cholesterol, or treatment with a cholesterol medication

^gDenotes statistically significant figures

CI = Confidence Intervals; models adjusted for age, race, gender, education, income, Body Mass Index (BMI), exercise alcohol/tobacco use, medication adherence, and rurality

IHD = Ischemic Heart Disease

OR = Odds Ratio

Discussion

The results of our study suggest that control of two CVD risk factors, namely diabetes and hyperlipidemia, was less likely in counties with high IHD mortality than in counties with low IHD mortality. Similarly, the control of hypertension, a strong risk factor for stroke, was less likely among participants living in counties of high stroke mortality compared with those living in counties of low stroke mortality. Together with our previous reports that HPSA status was inconsistently associated with 1) awareness, treatment, and control of hypertension, diabetes, and high cholesterol; and 2) indicators of quality of CVD care,¹⁸⁻¹⁹ these findings suggest that area-level CVD mortality rates may be considered as an additional criterion for designating areas of need for federal resource allocation purposes.

Diabetes mellitus and hyperlipidemia are established risk factors for IHD.³⁰⁻³¹ Similarly, the literature is replete with studies that have linked hypertension with stroke.³²⁻³⁴ Our finding that counties with relatively high IHD mortality also have participants with less likelihood of having controlled diabetes and hyperlipidemia is noteworthy, especially considering the variables we used to adjust the analyses. We found little evidence for a difference between high and low IHD mortality counties in terms of awareness and treatment of the aforementioned IHD risk factors, possibly reflecting the effectiveness of national and regional public health campaigns to raise awareness about disease detection. In fact, we observed a trend for more treatment in high vs. low mortality areas for some risk factors. However, controlling risk factors almost always requires regular visits to health care providers and adjustment of medications, raising the possibility that access to optimum health care may be a factor in high CVD mortality regions. This is supported by our observation of no significant differences in characteristics such as insurance and medication adherence which may have explained why control is poor despite similar levels of awareness about the disease and treatment modalities.

One potential contributor to our findings may be the greater proportion of residents in rural areas in high CVD mortality regions. Residents of rural areas have a higher risk of developing diabetes and hypertension, as well as worse control of risk factors.³⁵ The challenges of accessing health care in rural areas have been reported, especially for those counties with a high proportion of minority populations.³⁶⁻³⁹ Poignantly, these studies suggest that residence in a rural area contributes to limited access to health care as a result of geographic distances as well as low income and education, with reduced frequency of patient-provider contacts, reduced early and correct diagnosis and treatment, ineffectual follow-ups and hence poorer control of the disease.⁴⁰⁻⁴³ Specifically, individuals are less likely to have regular checkups for IHD risk factors⁴⁴ and there may be lower compliance by health care providers to standardized therapies for these diseases.^{41,45} Notably, despite the greater representation of rural residents, the majority of REGARDS participants in high IHD or stroke counties were nevertheless urban residents, suggesting that rural residence alone is unlikely to be responsible for our findings. In addition, rural residence was included in the multivariable models and did not fully explain our observations.

Our finding that those participants with poor control of hypertension were likely to be living in a county in the high rather than the low stroke mortality tertile is in

keeping with the well-known association between hypertension and stroke (e.g., a 20/10 mm Hg increase or decrease in blood pressure is associated with a corresponding two-fold difference in the risk of stroke).⁴⁶

The low correlation between high IHD and stroke mortality counties is noteworthy given the similarity in the identified risk factors for both diseases. This observation suggests that although there are overlapping risk factors responsible for both IHD events and stroke, there are probably other distinct environmental or social factors which influence mortality from each disease. Although our analysis was at the county level, prior reports at the state level demonstrate a similar lack of correlation between stroke and IHD mortality.⁴⁷

The mis-match between the counties in the high IHD or stroke mortality tertile and HPSA counties buttresses the concern that current HPSA designation may not consistently be given to areas of need for health care service prioritization. Although steps have been taken by successive government health agencies to bridge the gap in health care access between rural and urban areas and between geographical areas and populations, our finding that areas not designated as HPSAs experienced a higher CVD mortality and also demonstrated worse control of CVD risk factors raises several issues that warrant further exploration. It is possible that HPSA designation has not consistently been provided to counties that warrant it, including many counties with high CVD mortality. By the same token, some areas that may no longer need HPSA designation may continue to have it. Given the known challenges of applying for HPSA designation by departments of health and other health organizations, and delays experienced in updating this status to reflect current health needs of the population, it is possible that the current process of HPSA designation may not be capturing the health services required by many areas or population groups.

It is worth noting that the host of characteristics we had available in our models did not explain the lower odds of control of risk factors we observed in the high mortality areas. While it is possible that residual confounding may play a role, alternative explanations for high IHD and stroke mortality regions should be sought, and are the subject of ongoing investigation in REGARDS.⁴⁸⁻⁴⁹

This study has several potential limitations, the most obvious being its inability to draw causal associations as a result of its cross-sectional design. Second, the use of self-reported data may introduce reporting bias. However, self-reporting of many of the variables used here has been validated.^{22,50-53} Third, county level IHD and especially stroke mortality estimates may not be stable for all counties because of sparse population density. We note that infant mortality rates, one of the current criteria used for HPSA designation, are even lower than IHD mortality rates and may therefore be less stable. Another limitation of the study design is that the REGARDS population may not be representative of residents in either HPSA or non-HPSA areas, as demonstrated by the high awareness of diabetes and hypertension. It is possible that the control differences we observed in this possibly more health-conscious study population may be less than those that would be observed among more general population. Last, the study was not able to define the mechanisms that led to lower odds of risk factor control in high mortality regions. Future study of access to care and health services utilization may shed light on these important issues.

In summary, we found little evidence of differences in awareness and treatment of hypertension, diabetes or high cholesterol across tertiles of IHD and stroke mortality at the county level. However, we found less control of diabetes and cholesterol in the counties in the highest IHD mortality tertile, and less control of hypertension in the counties in the highest stroke mortality tertile. Because successful control of CVD risk factors requires access to high quality medical care, these findings suggest that additional resources in these areas may be needed if the goals of the *Healthy People 2020*¹⁷ objectives are to be achieved. The lack of overlap either between counties in the high IHD and stroke mortality tertile or HPSA counties suggests that county-level CVD mortality rates may be informative in making resource allocation decisions.

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