Small-area Variation in Hypertension Prevalence among Black and White Medicaid Enrollees

Kellee White, PhD, MPH[1]; John E. Stewart, MS, MPH[2];
Ana Lòpez-DeFede, PhD, MEd, MA[2]; Rebecca C. Wilkerson, MSPH[2]

Objectives: To examine within-state geographic heterogeneity in hypertension prevalence and evaluate associations between hypertension prevalence and small-area contextual characteristics for Black and White South Carolina Medicaid enrollees in urban vs rural areas.

Design: Ecological

Setting: South Carolina, United States.

Main Outcome Measure: Hypertension prevalence

Methods: Data representing adult South Carolina Medicaid recipients enrolled in fiscal year 2013 (N=409,907) and ZIP Code Tabulation Area (ZCTA)-level contextual measures (racial segregation, rurality, poverty, educational attainment, unemployment and primary care physician adequacy) were linked in a spatially referenced database. Optimized Getis-Ord hotspot mapping was used to visualize geographic clustering of hypertension prevalence. Spatial regression was performed to examine the association between hypertension prevalence and small-area contextual indicators.

Results: Significant (alpha=.05) hotspot spatial clustering patterns were similar for Blacks and Whites. Black isolation was significantly associated with hypertension among Blacks and Whites in both urban (Black, b=1.34, P<.01; White, b=.66, P<.01) and rural settings (Black, b=.71, P=.02; White, b=.70, P<.01). Primary care physician adequacy was associated with hypertension among urban Blacks (b=-2.14, P<.01) and Whites (b=-1.74, P<.01).

Conclusions: The significant geographic overlap of hypertension prevalence hotspots for Black and White Medicaid enrollees provides an opportunity for targeted health intervention. Provider adequacy findings suggest the value of ACA network adequacy standards for Medicaid managed care plans in ensuring health care accessibility for persons with hypertension and related chronic conditions. *Ethn Dis*. 2016;26(3):331-338; doi:10.18865/ed.26.3.331

Keywords: Hypertension; Medicaid; Residential Segregation; Hotspot Mapping; Rural and Urban; Small-area Variation

Introduction

Hypertension is a highly prevalent chronic condition that underlies leading causes of cardiovascular disease (CVD) morbidity and mortality in the United States.[1] Geographic heterogeneity in hypertension across US states has been documented.[2] In South Carolina and other Southeastern states, the prevalence of hypertension is higher than national averages.[3] However, there may be substantial within-state variability in hypertension prevalence, making state averages difficult to interpret[4] and necessitating further differentiation of high- and low-risk areas for targeted health interventions. Hotspot mapping, a rigorous spatial analytic technique, can detect small-area clusters of high (hotspot) and low (cold-spot) disease prevalence. This method has been used to strengthen community-based disease prevention and management efforts by identifying areas of high need to guide resource allocation and inform health services policy, planning, and delivery.[5-8] Although hotspot analysis has the potential to identify areas and subpopulations at greatest risk for hypertension and related adverse health outcomes, few studies have applied this technique to examine whether hypertension clustering varies by race among high-risk groups. Recent empirical evidence indicates that such community contextual characteristics as poverty,[9] racial/ethnic residential segregation,[10] and health care accessibility[11] may contribute to small-area variation in hypertension. Further research is needed to achieve a clearer understanding

[1] Department of Epidemiology and Biostatistics, Arnold School of Public Health, University of South Carolina
[2] Division of Medicaid Policy Research Institute for Families in Society, University of South Carolina

Address correspondence to Ana Lòpez-DeFede, PhD, MEd, MA; Division of Medicaid Policy Research; Institute for Families in Society, University of South Carolina; 1600 Hampton Street, Suite 507; Columbia, SC 29208; 803.777.5789; adefede@mpr.sc.edu

of community-level factors contributing to within-state heterogeneity in hypertension prevalence among Blacks and Whites in urban and rural areas of the Southeastern US.

To address these gaps in the literature, the objectives of our study are two-fold. First, we identify and map race-specific spatial clusters of low- and high-hypertension prevalence among Black and White adult Medicaid enrollees in South Carolina.

We hypothesize hypertension prevalence among both Blacks and Whites will vary significantly across geographic space.

Medicaid, a publicly financed health insurance program, is the largest provider of insurance for low-income individuals in the US. Second, we examine potential associations between hypertension prevalence and small-area social, economic, and health care characteristics for Blacks and Whites in both urban and rural settings. The extent to which small-area contextual factors are associated with hypertension prevalence among Medicaid enrollees and whether such associations vary by race are not clearly understood. We hypothesize hypertension prevalence among both Blacks and Whites will vary significantly across geographic space. Further, we hypothesize that these spatial variations will be partially explained by social, economic and health care characteristics of local community environments. Using South Carolina Medicaid data, linked with Census-based small-area contextual measures, our study adds to a growing body of literature on localized spatial variation in health to inform targeted prevention efforts aimed at reducing the burden of hypertension and lessening health disparities in vulnerable communities.

Methods

We used South Carolina Medicaid Management Information System administrative claims data from July 1, 2012 to June 30, 2013, to identify Black and White Medicaid enrollees aged >19 years (nursing home residents were excluded).[12] Medicaid recipients were classified as having hypertension if one or more paid claims indicated an International Classification of Diseases, Ninth Edition, primary or secondary diagnosis of 401-405, excluding women with gestational hypertension or pre-eclampsia. Recipient address data limitations (eg, missing or incomplete street addresses) required that Medicaid enrollees be geocoded at the ZIP Code Tabulation Area (ZCTA) level. ZCTAs are Census enumeration units spatially approximating United States Postal Service ZIP Code service areas. Researchers have noted significant neighborhood associations with health at the ZCTA level,[13-15] suggesting these areas are statistically viable units of analysis in population health studies. There are 424 ZCTAs in South Carolina, with an average population of approximately 11,000 persons.[16] To achieve greater prevalence rate stability, ZCTAs with fewer than 25 adult Medicaid recipients per race category (a relatively conservative threshold) were excluded from analysis. Less than .25% of all Black and White adult Medicaid enrollees resided in these very small population ZCTAs. The final study population included 409,907 Medicaid recipients (216,062 Blacks in 360 ZCTAs and 193,845 Whites in 365 ZCTAs).

ZCTA-level data on rurality, socioeconomic disadvantage (poverty, educational attainment, and employment), racial residential segregation, and primary care provider (PCP) adequacy were calculated and integrated into a spatially referenced database. The percentage of persons living below the federal poverty level, the percentage of persons aged >25 years without a high school diploma, and the civilian unemployment rate were calculated using data from the US Census Bureau, American Community Survey 2012 5-Year Estimates (US Census 2013).[17] Census 2010 data were used to classify each ZCTA as rural or urban based on the percentage of total residents living in rural areas (>50% rural residents = rural; <50% rural residents = urban; US Census Bureau 2010). Residential segregation was operationalized using the Black isolation index, which has been used in prior studies examining health.[18-21] The Black isolation index is represented as:

$$bP_j = 100 \times \sum_{i=1}^{n} b_i/btotal_j \times b_i/T_i$$

where bP_j is the Black isolation index value for ZCTA j, n is the number of Census blocks, and i is the ith Cen-

sus block in ZCTA *j*, b_i is the number of Blacks in *i*, *btotal* is the total number of Blacks in *j*, and T_i is the total population in *i*. Black isolation index values range from 0 (no isolation) to 100 (complete isolation) and can be interpreted as the likelihood that Blacks have Black neighbors.[20]

By this method, a PCP adequacy score was calculated for each Census block in the study area. ZCTA-level PCP adequacy, defined as the average census block PCP adequacy score in each ZCTA, can be interpreted as the number of primary care providers per 1,000 persons.

Data representing individual primary care providers in Georgia, North Carolina, and South Carolina were obtained from the National Plan & Provider Enumeration System, National Provider Identifier Registry, 2013.[22] Primary care provider data were captured for Georgia and North Carolina to account for the possibility of interstate travel to care. PCP adequacy was measured using an enhanced 2-step floating catchment area (E2SFCA) method.[23,24] Briefly, this approach assesses spatial accessibility to PCPs relative to the distribution of the total population. The E2SFCA method incorporates multiple distance decay weights to account for travel impedance within variably sized catchment areas reflecting different provider supply and population demand characteristics across rural/urban settings. By this method, a PCP adequacy score was calculated for each Census block in the study area. ZCTA-level PCP adequacy, defined as the average Census block PCP adequacy score in each ZCTA, can be interpreted as the number of primary care providers per 1,000 persons. (E2SFCA formula and definitions are available from corresponding author.) E2SFCA spatial calculations were performed using ESRI ArcGIS Version 10.2;[25] other E2SFCA data processing was done with SAS Version 9.4.[26]

ZCTA-level age-standardized hypertension prevalence estimates (per 1,000) were calculated separately for Blacks and Whites. Optimized Getis-Ord hotspot mapping was conducted to visualize geographic clustering of low-hypertension prevalence (cold spots) and high-hypertension prevalence (hotspots) among adult Medicaid recipients at the ZCTA level. The optimized Getis-Ord statistic generates a Gi Bin score identifying statistically significant hot and cold spots corrected for spatial dependence and multiple testing effects. A hotspot map was generated to show clustering of low- and high-hypertension prevalence areas for Blacks compared to Whites. Hotspot analyses and mapping were performed using ESRI ArcGIS 10.2.[25]

Statistical Analysis

We fit a series of regression models to examine ZCTA-level associations between hypertension prevalence and community contextual factors. To assess potential urban/rural differences in these small-area associations, we stratified data by ZCTA rural/urban status. Four separate regression analyses were conducted: 1) Black hypertension prevalence: urban ZCTAs; 2) Black hypertension prevalence: rural ZCTAs; 3) White hypertension prevalence: urban ZCTAs; and 4) White hypertension prevalence: rural ZCTAs. Predictor variables were included in these models only if they were statistically significant (alpha = <.05) in univariate regression models. OLS regression analysis with spatial diagnostics (Moran's I) was conducted to evaluate spatial dependence in the data. Significant (P<.01) spatial autocorrelation was detected in all OLS models evaluated. To account for spatial dependence in the data, spatial linear regression models were evaluated. Robust Lagrange Multiplier test statistic diagnostics, which provide information about the type of spatial dependence distinct in each model, informed the selection of spatial lag versus spatial error regression estimates. Results of the spatial regression models are reported. OLS and spatial regression modeling were performed using GeoDa.[27]

Results

Overall, hypertension prevalence per 1,000 was higher among Blacks than Whites (227.9 vs 151.8, respectively). Moreover, prevalence rates for Blacks were higher than Whites in both urban and rural areas and across all age groups (Table 1). Compared with urban ZCTAs, rural ZCTAs were characterized by lower levels of PCP adequacy, higher levels of segregation, and greater socioeconomic disadvantage (Table 2).

Optimized Getis-Ord analyses revealed similar geographic patterns of hypertension prevalence clustering for Black and White Medicaid recipients. For both groups, statistically significant (alpha=.05) clustering of low-hypertension prevalence ZCTAs (cold spots) occurred in the northwest region of the state and along the coast. Statistically significant cluster-

ing of high-hypertension prevalence ZCTAs (hotspots) existed for Blacks and Whites in portions of the Lower Savannah region (eg, Allendale, Bamberg and Barnwell Counties) and Pee Dee region (eg, Chesterfield, Darlington, Dillon, Florence, and Marlboro Counties). If not directly overlapping, Black and White hypertension hotspots existed contiguously (Figure 1).

In race-specific multivariate spatial regression models, the Black isolation variable was positively associated with hypertension prevalence among urban Blacks (P<.01), urban Whites (P<.01), rural Blacks (P=.02), and rural Whites (P<.01). The greatest effect was among urban Blacks, for whom a one unit increase in Black isolation predicted a 1.34 increase in hypertension prevalence per 1,000 persons, adjusting for other neighborhood contextual factors. Smaller and similar effects were noted among rural Blacks and both urban and rural Whites, for whom a one unit increase in Black isolation was associated with about a .7 increase in hypertension prevalence per 1,000.

The small-area measure of poverty was positively associated with hypertension rates among urban Blacks only (P=.03). For this group a one unit increase in % poverty predicted a 1.25 increase in hypertension prevalence per 1,000. The low educational attainment small-area indicator was positively associated with hypertension prevalence only among rural Whites (P=.01), for whom a one unit increase in percent with no high school diploma predicted a 1.87 increase in hypertension prevalence. In urban areas, PCP

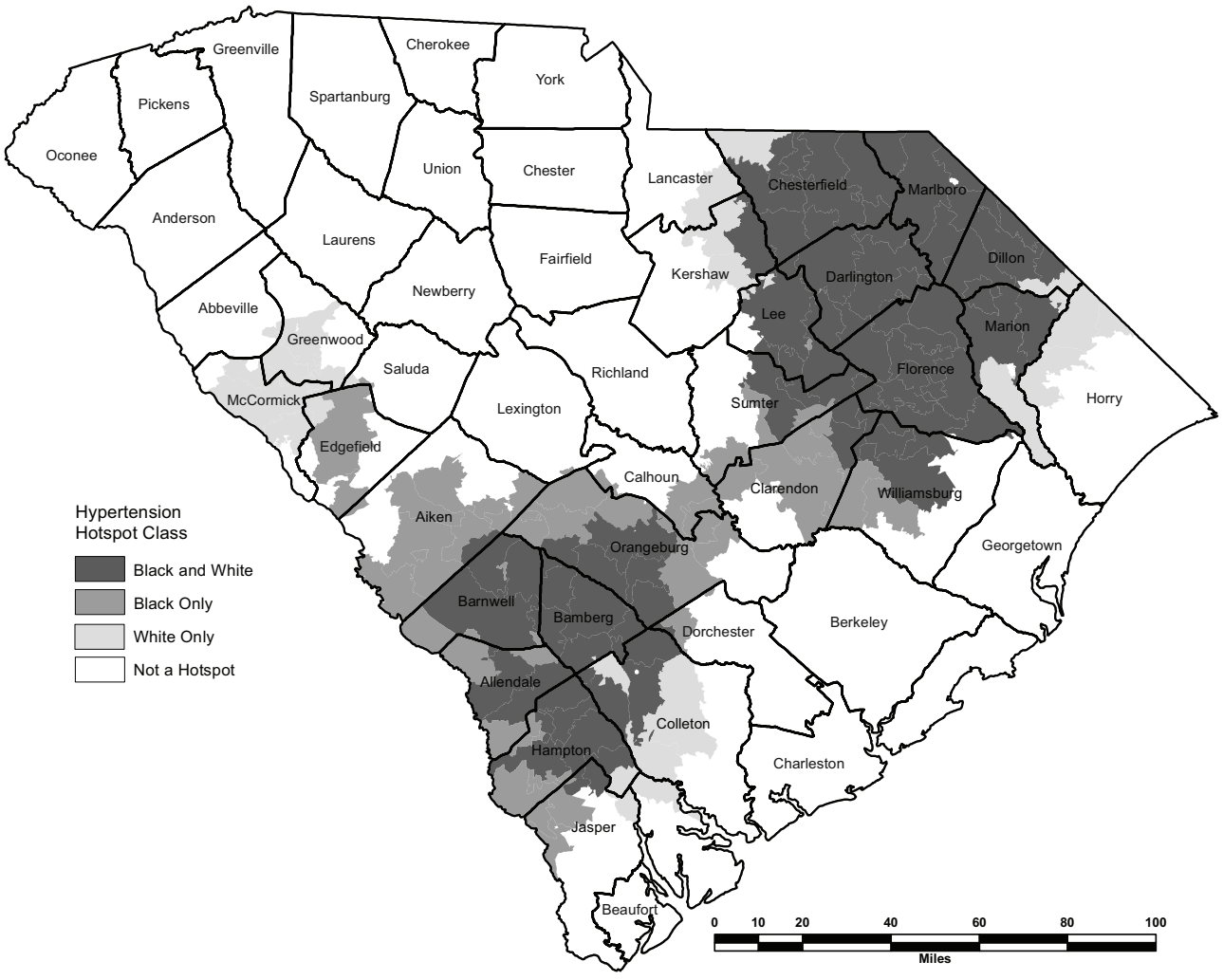

Figure 1. Hypertension prevalence hotspots[a] for adult Black and White Medicaid recipients
a. Getis-Ord Gi statistic hotspot analysis (95% CI).

Table 1: Hypertension prevalence among Black and White Medicaid enrollees by urban/rural residential status and age, South Carolina Medicaid Management Information System, 2012-2013

		Urban			Rural		
		Population	With hypertension	Rate per 1,000	Population	With hypertension	Rate per 1,000
Black		134916	26797	198.6	81146	22446	276.6
	Male	32281	7106	220.1	20912	6342	303.3
	Female	102635	19691	191.9	60234	16104	267.4
	19-24 years	33807	687	20.3	17627	445	25.2
	25-34 years	38613	3089	80.0	19496	2007	102.9
	35-44 years	20151	4580	227.3	11504	3035	263.8
	45-54 years	14542	5591	384.5	9267	4113	443.8
	55-64 years	12692	6436	507.1	9322	5382	577.3
	65-74 years	8006	3494	436.4	6708	3610	538.2
	75-84 years	4664	2022	433.5	4577	2469	539.4
	≥ 85 years	2441	898	367.9	2645	1385	523.6
White		117433	15601	132.9	76412	13824	180.9
	Male	30993	5559	179.4	21930	5144	234.6
	Female	86439	10042	116.2	54482	8680	159.3
	19-24 years	25868	342	13.2	16317	289	17.7
	25-34 years	34069	1523	44.7	19634	1266	64.5
	35-44 years	19613	2698	137.6	12966	2301	177.5
	45-54 years	14614	3715	254.2	9950	3138	315.4
	55-64 years	10943	3940	360.0	8050	3367	418.3
	65-74 years	7060	2013	285.1	5361	1939	361.7
	75-84 years	3571	938	262.7	2822	1055	373.8
	≥ 85 years	1695	432	254.9	1312	469	357.5

adequacy was negatively related to hypertension prevalence among both Blacks (P<.01) and Whites (P<.01). The greatest effect was among urban Blacks, for whom a hypertension prevalence decrease of 2.14 per 1,000 was expected for every additional primary care provider per 1,000. The effect among urban Whites was smaller, with a hypertension prevalence decrease of 1.74 per 1,000 expected for every additional PCP (Table 3).

Discussion

Among adult South Carolina Medicaid enrollees, hypertension rates were higher for Blacks than Whites in every age category and in both rural and urban settings. These results are consistent with numerous other studies demonstrating profound and persistent health disparities in the US.[18,19,21,28,29] The identification of spatial autocorrelation in regression models is in itself informative and supports our primary hypothesis that hypertension prevalence rates among Black and White Medicaid participants are not uniform across geographic space. Moreover, hotspot mapping indicated significant spatial heterogeneity in hypertension prevalence across the state. The greatest spatial clustering of high-hypertension prevalence among Black and White Medicaid enrollees occurred along the South Carolina Interstate-95 (I-95) corridor. This

Table 2. ZCTA characteristics by rural/urban residence, ACS 2012 5-year estimates; Census 2010

	Rural	Urban
Number of ZCTAs	243	148
Mean Black isolation index score	66.8	50.0
Mean PCP adequacy [a]	2.8	15.9
Mean % poverty	20.9	17.9
Mean % no high school	22.3	16.1
Mean % unemployed	13.8	11.4

ZCTA, ZIP Code Tabulation Areas are Census enumeration districts spatially approximating USPS ZIP Code service areas; PCP, primary care provider.
a. Number of primary care providers per 1,000 persons

Table 3. Spatial regression estimation[a] of the relationship between hypertension prevalence per 1,000 persons and neighborhood contextual factors stratified by race and urban/rural setting

	ZCTAs, n	Coefficient	SE	P
Black				
Urban (Spatial Error model)	136			
Constant		228.14	17.45	<.01
Black isolation		1.34	.29	<.01[c]
PCP adequacy[b]		-2.14	.63	<.01[c]
% Poverty		1.25	.59	.03[c]
% No high school diploma		-1.13	.69	.10
Rural (Spatial Error model)	224			
Constant		277.22	24.47	<.01
Black isolation		.71	.32	.02[c]
PCP adequacy[b]		-3.12	1.63	.06
% Poverty		.49	.48	.31
White				
Urban (Spatial Error model)	147			
Constant		167.52	11.25	<.01
Black isolation		.66	.15	<.01[c]
PCP adequacy[b]		-1.74	.47	<.01[c]
% Poverty		.68	.36	.06
% No high school diploma		-.10	.34	.76
% Unemployed		.26	.29	.37
Rural (Spatial Lag model)	218			
Constant		93.09	23.82	<.01
Black isolation		.70	.23	<.01[c]
PCP adequacy[b]		-1.55	1.43	.28
% Poverty		.11	.61	.85
% No high school diploma		1.87	.73	.01[c]
% Unemployed		-.92	.58	.11

PCP, primary care provider; SE, standard error; ZCTA, ZIP Code Tabulation Areas.
a. Multivariate model controls for other neighborhood contextual factors that were significant in the univariate regression analysis.
b. PCP adequacy measure represents the number of primary care providers per 1,000 persons.
c. P<.05.

geographic corridor, which includes portions of 17 counties, is home to approximately 1 million people living primarily in small towns and rural communities.[30] Our findings are consistent with observations of poor sexual health and high preventable hypertension hospitalization rates along the I-95 corridor.[31,32] The substantial overlap of hypertension hotspots for Blacks and Whites suggests there may be similarities in the socioeconomic and built environment of Black and White Medicaid enrollees. LaVeist and colleagues demonstrated that racial disparities in hypertension persist, albeit attenuated, when low-income Blacks and Whites share the same neighborhoods.[33] Identifying common geographic patterns of high-hypertension prevalence among Blacks and Whites underscores the need for policies to address the underlying living conditions that contribute to poor health.

Relatively few studies have examined associations between residential segregation and health outcomes in urban vs rural settings. Notably, we found higher hypertension prevalence among Blacks and Whites in both urban and rural communities characterized by high levels of Black segregation. In both settings, the magnitude of this association was greater for Blacks. Although recent estimates demonstrate declines in Black/White residential segregation, particularly in metropolitan areas, increasing population shifts to US southern states, including migration to non-metropolitan areas, warrant closer attention to the health consequences of segregation in the rural South.

Low PCP adequacy was significantly associated with higher hypertension prevalence for urban Blacks and Whites. This finding may reflect reduced opportunities to prevent hypertension and manage pre-hypertensive conditions among both Black and White Medicaid beneficiaries in urban communities lacking sufficient numbers of primary care providers. In rural areas, however, low PCP adequacy was not a significant predictor for either race category. This result might be attributed partly to the lesser geographic resolution of PCP adequacy measurement in relatively large rural ZCTAs and to the exclusion of predominantly rural, very small population ZCTAs from analysis. Alternatively, this finding might indicate that other access-to-care factors, including personal vehicle availability, public transportation, and hours of clinic operation, play a more salient role in health care accessibility for rural residents.

Small-area associations between hypertension prevalence and measures of socioeconomic disadvantage were inconsistent across rural/urban and race categories. Poverty was asso-

ciated with higher hypertension rates among urban Blacks, while low educational attainment was associated with greater levels of hypertension among rural Whites. The unemployment variable was not a significant predictor of hypertension prevalence in any of the models tested. Further research is needed to clarify associations between small-area deprivation and hypertension prevalence among Blacks and Whites in urban and rural areas.

This study has several limitations. Because it is an ecological, cross-sectional investigation, we are not able to demonstrate causality. Although there is the potential for ecological fallacy, this study primarily is focused on the association between small-area-level hypertension prevalence and community contextual measures. Hypertension prevalence rates were derived from Medicaid administrative claims data. More accurate prevalence estimates might be achieved using patient medical records. Medicaid recipient address limitations precluded analysis of hypertension prevalence at finer geographic resolutions (eg, Census tract or Census block group). Segregation was measured at the ZCTA level, where ZCTAs were the macro-units and Census blocks were the micro-units used in the calculation of Black isolation index scores. Although a metropolitan statistical area (MSA)/Census tract macro-unit/micro-unit operationalization of segregation is more common, other combinations of macro-/micro-units have been employed previously.[21] Our ZCTA-level results are not generalizable to very small population ZCTAs, because we excluded these areas from analyses. As noted, the exclusion of these predominantly rural ZCTAs may have lessened the observed association between PCP adequacy and hypertension prevalence in rural areas. For both rural Black and White Medicaid enrollees, the observed associations, although not statistically significant, were in the same direction noted in urban areas (ie, lower levels of PCP adequacy were associated with higher hypertension prevalence rates). These findings underscore the importance of ACA provisions establishing provider network adequacy standards for Medicaid managed care plans, especially as the majority of Medicaid beneficiaries now are enrolled in managed care. Our results further support efforts to develop and evaluate flexible provider adequacy standards in rural areas to optimize health care access in rural communities.[34]

Among adult South Carolina Medicaid enrollees, hypertension rates were higher for Blacks than Whites in every age category and in both rural and urban settings.

Conclusion

To our knowledge, this is the first geospatial analysis of Black/White hypertension across the South Carolina urban/rural continuum. The use of hotspot mapping to identify high-hypertension prevalence area clusters can inform state-level policy formation and decision making to improve population health.[6,32] Moreover, small-area analyses of hypertension prevalence can guide local place-based planning, health programming, and community resource development efforts.[35,36] The observed geographic overlap of hypertension prevalence hotspots for Black and White Medicaid enrollees in South Carolina provides an opportunity to target interventions to improve health outcomes in low-income populations. Our findings highlight the need to better understand and address racial residential segregation and its health consequences, and indicate the value of ACA provisions establishing provider network adequacy standards for Medicaid managed care plans in ensuring health care accessibility for urban and rural residents with hypertension and related chronic conditions.

Conflicts of Interest

No conflicts to report

Author Contributions

Research concept and design: White, Lòpez-DeFede, Stewart, Wilkerson; Acquisition of data: Lòpez-DeFede; Data analysis and interpretation: Stewart, Wilkerson; Manuscript draft: White, Lòpez-DeFede, Stewart; Statistical expertise: Wilkerson; Acquisition of funding: Lòpez-DeFede; Administrative: White, Lòpez-DeFede, Stewart; Supervision: Lòpez-DeFede

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