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Geographic, Racial, Ethnic, and Socioeconomic Disparities in the Availability of Grocery Stores and Supermarkets Among Low-Income Women Across the Urban–Rural Continuum

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Disparities in the prevalence of obesity have been linked to differential access to grocery stores and supermarkets. The availability of convenience, grocery stores, and supermarkets within the census tract and a 1-, 3-, and 5-mile radius of residence was measured for women enrolled in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) (n = 21 203) in Kansas. Disparities in the availability of supermarkets were faced by women living in rural counties; however, within more urbanized areas, the presence of racial, ethnic, and socioeconomic disparities differed based on whether store availability was measured within tract or within a 1-mile radius of residence. These results highlight the need for greater specificity when examining the relationship between food environments and dietary outcomes.

KEYWORDS food environment, food desert, obesity, disparities

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INTRODUCTION

Within industrialized countries, access to grocery stores and supermarkets that carry healthy food items is a necessary, but not sufficient, condition for maintaining a healthy diet. A growing body of research suggests that there are significant geographic, racial, ethnic, and socioeconomic disparities in the availability of supermarkets and grocery stores[1–7] and that these structural disparities contribute to disparities in the prevalence of obesity among disadvantaged groups.[8–12] Attention to the availability of supermarkets and grocery stores, and concern over the local food environment, is central to socioecological approaches to health behaviors in which neighborhood environmental features are hypothesized to facilitate eating behaviors associated with appropriate weight maintenance and good health.[13]

To date, most of the studies examining supermarket availability in the United States have found a relatively consistent relationship between area deprivation, high percentages of racial/ethnic minorities, and reduced availability of supermarkets.[1,14] For instance, in a study in metropolitan Detroit, Michigan, Zenk et al[3]found that the nearest supermarket was 1.1 miles further in predominantly (>60%) African American census tracts compared to low-minority census tracts. Similarly, Morland et al[10] identified 5 times more supermarkets in low-minority tracts as compared to high-minority tracts in Maryland, North Carolina, Mississippi, and Minnesota. In a national study of supermarket and grocery store availability, Powell et al[15] observed that low-income ZIP codes had only 75% as many chain supermarkets as middle-income ZIP codes, and the availability of chain supermarkets in high-minority ZIP code areas was less than half of that observed in low-minority ZIP codes. Disparities in the availability of grocery stores and supermarkets by rurality have also been noted, as in a study in rural South Carolina in which 40% of very rural tracts had a supermarket compared to 67% of the more urbanized tracts.[6] In a study within 36 rural, high-poverty counties in the Mississippi Delta Region, Kaufman[16] reported that 70% of households eligible to receive food stamps had to travel in excess of 30 miles to reach a large grocery store or supermarket.

However, several recent studies suggest that these associations are neither as clear nor as universal as previously presumed. In one of the few detailed studies on food environments in rural areas, Sharkey and Horel[17] calculated network distances from population-weighted centers of census block groups within a 6-county rural region and determined that the most deprived neighborhoods with the highest percentages of minority residents had greater availability of both supermarkets and grocery stores compared to the more affluent and less racially diverse census block groups. Similarly, reports from the United Kingdom,[18,19] Canada,[20,21] New Zealand,[22] and Australia,[23,24] suggest relatively widespread availability of grocery stores and healthy foods for urban residents in socially disadvantaged communities.

One reason for this inconsistency in results may be associated with modifiable areal unit problems (MAUP), which arise when artificial units of categorization (like census tracts) are imposed on continuous geographic phenomenon. The result is the generation of erroneous relationships among spatial variables.[25,26] Most studies within the United States examining disparities in supermarket availability have examined relationships among food environments, sociodemographics, and health outcomes at the ecological level, using census tracts or ZIP codes as the administrative unit of analysis.[27] Implicit in these study designs is the assumption that census tracts (or ZIP codes) are appropriate units for examining grocery shopping behaviors. However, several recent studies suggest that most grocery shopping is not constrained by census tracts and that the location of nearby stores (which may not be in the same census tract) may be a critical factor in making decisions on where to shop. In a study in metropolitan Los Angeles, Inagami et al[28] reported that only 23% of whites and Hispanics, 13% of Asians, and 15% of African Americans conducted most of their grocery shopping within their own census tract. Qualitative studies investigating grocery shopping behaviors consistently report that cost, selection, and convenience of location (including proximity to work) are the primary factors influencing decision about where to shop.[29–31] Additionally, because census tract size is based on population, their use is likely to be inappropriate when examining local food environments across the urban–rural continuum.[32]

This study was undertaken to examine store availability at an individual level for women participating in (WIC) and to determine whether MAUP issues bias the associations between store availability and individual sociodemographic characteristics. The first hypothesis tested in this study is that WIC participants that live in rural areas, are African American or Hispanic, and have low educational and income levels would have fewer supermarkets and small grocery stores compared to WIC participants who are white, non-Hispanic, and have higher income and educational status. We further hypothesized that the store availability and associations between store availability and individual demographic characteristics observed within a 1-mile radius of WIC residence would parallel those obtained when examining availability and associations observed at the census tract level.

METHODS

Study Population—Women Participating in the WIC Program

The observational dataset used for this study included all Kansas women enrolled in WIC between October 10, 2004, and December 31, 2006. To be eligible for the WIC program a participant must be a pregnant, breastfeeding, or postpartum mother with children under 5 years of age and have a household income <185% of the federally designated poverty level. Certification

in the WIC program is automatic for women and children enrolled in the Supplemental Nutrition Assistance Program (SNAP), Temporary Assistance to Needy Families (TANF), and Medicaid programs. The initial study population included 25 032 unique cases. Cases were excluded if the street address was missing or incomplete. The final sample eligible for geocoding was 23 351. The street address was used to geocode each WIC mother's home residence within ArcGIS (Redlands, Calif). The final geocoded sample was 21 203 (90.8%). Cases were excluded if the mother was <18 or >50 years of age at the time of certification, and if postpartum body mass index (BMI) was recorded as < 15 or missing. There were no significant differences in WIC characteristics by geocoding status. The final sample included 21 166 unique cases. Selected characteristics of WIC mothers are presented in Table 1.

Study Setting—Kansas

The estimated population of Kansas in the 2000 Census was 2 688 418, residing within a land area of 81 815 square miles. Kansas has a relatively low population density, with an average of 32.9 persons per square mile, compared to a 79.6 persons per square mile average for the United States.[33] To differentiate between counties across the urban–rural continuum, county designations based on urban influence were obtained from the USDA-ERS Urban Influence Codes, which classifies counties based on population density, presence of population centers, and adjacency to a metropolitan area.[34] The 12 Urban Influence Codes (2 metropolitan UICs and 10 nonmetropolitan UICs) were collapsed into 3 categories: metropolitan (UICs 1, 2), micropolitan (UICs 3, 5, 8) and rural (UICs 4, 6, 7, 9, 10, 11, 12) based on groupings previously identified as relevant to employment and economic patterns in Kansas.[35] Rural counties in Kansas (n = 69) contain approximately 68% of the land area of Kansas but only 16% of the 2000 Kansas population, with an average population density of 76 persons per square mile. In contrast, metropolitan counties (n = 17) contain approximately 13% of the land area, 61% of the 2000 population, and have an average population density of 2407 persons per square mile. Micropolitan counties (n = 19) included population centers between 10 000 and 50 000 residents, contain 19% of the land area, 22% of the 2000 Kansas population, and have an average population density of 1081 persons per square mile.

A total of 727 census tracts were identified in the 2000 Census of Kansas, of which 7 tracts had fewer than 100 residents and were excluded from the analysis. Of the 720 census tracts, 422 were in metropolitan counties, 148 were in micropolitan counties, and 150 were in rural counties. Tract sizes varied widely along with urban–rural continuum, with a mean metropolitan tract size of 26.22 (SD = 74.54) square miles, mean micropolitan tract size of

TABLE 1 Selected Characteristics of WIC Mothers in Kansas, 2004–2006

	Full sample (n = 21 166)		Metropolitan (n = 12 247)		Micropolitan (n = 6248)		Rural (n = 2671)	
	%	Mean ± SD	%	Mean ± SD	%	Mean ± SD	%	Mean ± SD
Race								
White	84.99		78.40		92.38		97.87	
Black	11.83		17.29		5.60		.35	
All other races*	4.21		5.67		2.62		1.27	
Ethnicity								
Not Hispanic	72.02		69.50		70.04		88.24	
Hispanic	27.98		30.50		29.96		11.76	
Previous pregnancies		1.56 ± 1.73		1.58 ± 1.77		1.51 ± 1.57		1.57 ± 1.87
Age		24.80 ± 5.07		24.94 ± 5.13		24.67 ± 5.02		24.42 ± 4.89
Education (yrs)		11.46 ± 2.67		11.42 ± 2.67		11.46 ± 2.65		11.61 ± 2.76
Monthly household income ($)		1328 ± 1611		1300 ± 1812		1375 ± 1187		1346 ± 1487

*All other races includes American Indian (n = 427), Asian (n = 416), and Pacific Islander (n = 50) n the full sample. Sample sizes for these races/ethnicities were too small to allow for detailed analysis.

103.65 (SD = 181.89) square miles, and mean rural tract size of 369.30 (SD = 318.64) square miles.

Grocery Store and Supermarket Enumeration and Availability

A complete listing of food stores was obtained from the Kansas Department of Agriculture retail food licensure list for 2005. Under Kansas law, all stores selling food items are required to be licensed and inspected in compliance with Kansas Food Code[36]. Store license records included store type based on self-identification in 8 categories: bakery, bakery outlet, convenience store, fruit/vegetable market, grocery store, health food store, retail meat store, specialty shop, and variety shop. Stores were also classified by size: <5000 ft^2, 5000–15 000 ft^2, and >15 000 ft^2. The final geocoded stores were recoded into 5 categories based on store type and size. The final categories included (1) convenience stores; (2) small grocery stores (<15 000 ft^2); (3) supermarkets (grocery stores >15 000 ft^2); (4) specialty stores (bakery, bakery outlets, fruit/vegetable markets, health food stores, retail meat stores, and specialty stores); and (5) variety stores. Stores in the variety category included general merchandise stores (eg, dollar stores, pharmacies, and general merchandise stores without a specific grocery section). Super centers with substantial grocery sections (eg, Wal-Mart Super Centers, Target Super Centers) were coded as supermarkets.

The full listing of retail food stores licensed in 2005 (n = 2680) was geocoded by street address within ArcGIS (v. 9.2). A total of 2520 (94.90%) stores were successfully geocoded to the street address level. The majority (73%) of stores that were not geocoded were convenience stores. The number of stores by store type and urban influence category are presented in Table 2.

Euclidean buffers of 1-, 3-, and 5-mile radius were drawn around each WIC residence within ArcGIS using the Spatial Analyst Tool in the North American Datum (NAD) 1983 UTM Zone 14N Projection System. Hawth's Analysis Tool for ArcGIS Tools Point in Polygon function[37] was used to

TABLE 2 Number and Percentage of Stores by Type and Urban Influence Category

	Full sample		Metropolitan		Micropolitan		Rural	
Store type	N	%	N	%	N	%	N	%
Convenience stores	1184	47.38	531	43.85	325	51.02	328	50.38
Small grocery stores	361	10.44	125	10.32	85	13.34	151	23.20
Supermarkets	238	9.52	151	12.47	62	9.73	25	3.84
Variety stores	427	17.09	227	18.74	69	10.83	104	15.98
Specialty stores	289	11.56	177	14.62	96	15.07	43	6.61
Total stores	2499		1,211		637		651	

enumerate store types within census tract and within each radius around individual WIC mother's residences.

Statistical Analysis

All data were reduced and analyzed using SPSS software (v. 15.0, SPSS Inc, Chicago, Ill). Differences between store availability within census tracts and at each radius around WIC home residence were assessed by descriptive statistics and one-way analysis of variance. Multivariate count (Poisson) regression models, stratified by urban influence category, were used to estimate incidence rate ratios for the availability of different types of retail food stores within census tracts, and within a 1-, 3-, and 5-mile radius of WIC residence. Population density of census tract was controlled when estimating store availability by tract. In situations where count data were overdispersed, negative binomial models were run and contrasted with Poisson models using Akaike information critera (AIC). In all cases, Poisson models had equal or improved model fit as compared to negative binomial models.

RESULTS

Store Availability by Urban Influence

The number and percentages of store types, by store category and urban influence, are presented in Table 3. Convenience stores represented almost half of the stores available within all urban influence categories, with

TABLE 3 Number and Type of Retail Food Stores Within Census Tract and 1-, 3-, and 5-Mile Radius of WIC Residence by Urban Influence Category*

	Metropolitan (n = 12 263)	Micropolitan (n = 6248)	Rural (n = 2686)
Radius and store type	Mean ± SD	Mean ± SD	Mean ± SD
Tract convenience stores	1.50a ± 1.33	2.77b ± 2.07	2.80b ± 1.76
Tract small grocery stores	0.39a ± 0.67	0.91b ± 1.50	0.94c ± 0.89
Tract supermarkets	0.40a ± 0.64	0.55b ± 0.64	0.32c ± 0.52
1 Mile convenience stores	2.88a ± 1.93	3.63b ± 2.79	2.24c ± 6.18
1 Mile small grocery stores	1.03a ± 1.43	1.26b ± 1.58	0.61 ± 0.79
1 Mile supermarkets	0.84a ± 0.90	0.89b ± 0.99	0.22c ± 0.44
3 Mile convenience stores	17.67a ± 8.77	11.35b ± 6.91	3.17c ± 6.37
3 Mile small grocery	5.86a ± 5.16	3.09b ± 2.54	0.73 ± 0.84
3 Mile supermarkets	5.07a ± 3.19	2.83b ± 2.00	0.39c ± 0.56
5 Mile convenience stores	36.71a ± 17.99	13.65b ± 7.50	3.43 ± 6.36
5 Mile small grocery stores	11.01a ± 7.70	3.44b ± 2.63	0.81c ± 0.88
5 Mile supermarkets	10.83a ± 7.06	3.23b ± 2.04	0.41c ± 0.58

*Means within row followed by different letter are significantly different at the $p < 0.05$ level using Games-Howell post hoc procedures.

micropolitan areas having a higher percentage of convenience stores compared to metropolitan and rural areas. Rural areas had the highest percentage of small grocery stores and supermarkets (27.04%) as a percentage of total stores compared to metropolitan (19.96%) and micropolitan (22.79%) areas. However, supermarkets constituted less than 4% of the stores available in rural areas compared to 9.73% and 12.47% in micropolitan and metropolitan areas, respectively.

Table 3 includes the mean store availability, by urban influence category, of convenience, small grocery stores, and supermarkets within census tract and within a 1-, 3-, and 5-mile radius around the residence of each WIC mother in Kansas. Average store availability varied along the urban–rural continuum, with rural WIC mothers having consistently fewer stores available as contrasted to metropolitan and micropolitan WIC mothers. Rural WIC mothers had 52% and 75% fewer small grocery stores and supermarkets within a 1-mile radius of their residences compared to micropolitan WIC mothers and 41% and 74% fewer small grocery stores and supermarkets compared to metropolitan WIC mothers. These results contrast with those obtained when examining disparities at the tract level, in which rural WIC mothers had greater availability of small grocery stores compared to both metropolitan and micropolitan WIC mothers. However, rural WIC mothers had 20% fewer supermarkets available in their census tracts compared to metropolitan WIC and 42% fewer supermarkets compared to micropolitan WIC mothers. Disparities in the spatial availability of supermarkets grew more significant at larger distances from WIC residence, with 10.83 supermarkets available in a 5-mile radius for metropolitan WIC cases compared to 3.23 supermarkets in micropolitan areas and 0.41 supermarkets in rural areas.

Multivariate Analysis

Multivariate regression estimates of incidence rate ratios are presented in Table 4. Multivariate Poisson regression estimates are appropriate for count data, and the resulting parameter estimates can be interpreted as incidence rate ratios.[38] Within the metropolitan sample, when controlling for education and income, black WIC mothers had equal or greater availability of both grocery stores and supermarkets at all radial distances from their residence. Increases in the availability of supermarkets grew with distance from residence, with equal numbers available within a 1-mile radius, 20% more stores within a 3-mile radius, and 23% more stores within a 5-mile radius. Differences in the availability of small grocery stores were also evident, with black WIC mothers having 53% more small grocery stores compared to nonblack WIC cases within a 1-mile radius and 67% and 61% more small grocery stores within a 3- and 5-mile radius. These results contrast with those obtained when examining store availability within census tracts in which

TABLE 4 Incidence Rate Ratios From Multivariate Regression Count, Stratified by Urban Influence Category, of Availability of Convenience Stores, Grocery Stores, and Supermarkets by Race, Ethnicity, Income, and Educational Status Within Tract, 1-, 3-, and 5-Mile Radius of WIC Residence*†

Individual characteristic	(%)	1 Mile convenience β (t-value)	1 Mile grocery β (t-value)	1 Mile supermarket β (t-value)	3 Mile convenience β (t-value)	3 Mile grocery β (t-value)	3 Mile supermarket β (t-value)	5 Mile convenience β (t-value)	5 Mile grocery β (t-value)	5 Mile supermarket β (t-value)
Metropolitan counties (n = 12 263)										
Black	17.28	1.08§ (24.46)	1.53§ (289.05)	1.02 (0.33)	1.27§ (1658.09)	1.67§ (2581.77)	1.20§ (271.19)	1.29§ (3820)	1.61§ (4359)	1.23§ (763.56)
Hispanic	30.47	1.31§ (461.60)	1.93§ (984.17)	1.44§ (253.63)	1.35§ (3501.09)	1.78§ (4180.06)	1.34§ (940.58)	1.36§ (7544)	1.54§ (4429)	1.37§ (2318.23)
<12 yrs	34.81	1.08§ (37.70)	1.23§ (99.07)	1.00 (0.03)	1.08§ (242.21)	1.20§ (434.55)	1.04§ (15.28)	1.08§ (414.52)	1.14§ (407.47)	1.06§ (81.32)
>12 yrs	41.44	1.00 (0.029)	0.82§ (59.29)	1.09† (12.02)	1.00 (0.596)	0.91§ (75.06)	1.06§ (27.12)	1.00 (1.54)	0.95§ (54.60)	1.05§ (43.28)
<$10 000	34.40	0.99 (0.40)	1.01 (0.35)	0.99 (0.09)	1.05§ (79.03)	1.01 (1.70)	1.03 (11.00)	1.03§ (70.51)	1.03§ (18.87)	1.03§ (19.59)
$10 000–$15 000	17.04	1.03 (2.83)	1.06 (6.52)	1.00 (0.02)	1.07§ (119.44)	1.06§ (27.04)	1.07§ (40.53)	1.06§ (196.55)	1.06§ (66.60)	1.07§ (90.18)
Micropolitan counties (n = 6254)										
Black	5.60	1.05 (2.57)	1.01 (.009)	1.00 (.004)	1.15§ (75.44)	1.15§ (16.63)	1.00 (.003)	1.18§ (132.60)	1.14§ (18.50)	1.03 (1.11)
Hispanic	29.93	1.35 (385.49)	2.24§ (1,017)	1.46§ (149.51)	1.21§ (469.55)	2.00§ (1835.72)	1.34§ (276.29)	1.09§ (110.04)	1.87§ (1070)	1.25§ (178.28)
<12 yrs	34.07	1.07§ (19.27)	1.12§ (18.68)	1.08† (5.31)	1.08§ (65.76)	1.12§ (45.22)	1.10§ (28.60)	1.05§ (32.76)	1.10§ (35.02)	1.10§ (28.46)
>12 yrs	26.70	1.04† (5.10)	0.97 (0.90)	1.07 (3.46)	1.11§ (126.64)	1.10§ (22.42)	1.18§ (74.55)	1.09§ (107.84)	1.09§ (21.54)	1.15§ (58.46)
<$10 000	31.84	1.09§ (36.33)	1.10§ (14.51)	1.12§ (13.16)	1.09§ (111.62)	1.04† (5.17)	1.12§ (44.29)	1.02† (7.33)	1.01 (0.40)	1.09§ (30.63)
$10 000–$15 000	13.82	1.17§ (64.96)	1.06 (3.36)	1.19§ (19.22)	1.17§ (195.75)	1.09§ (16.02)	1.18§ (56.44)	1.08§ (56.48)	1.06† (6.92)	1.14§ (41.97)
Rural counties (n = 2686)										
Black	1.34	1.07 (0.36)	0.81 (0.75)	0.76 (0.44)	1.18 (3.69)	0.95 (.057)	0.92 (.096)	1.12 (1.71)	0.85 (0.66)	0.86 (0.30)
Hispanic	11.76	1.93§ (367.72)	1.65§ (54.27)	1.34† (5.81)	1.53§ (186.18)	1.67§ (68.81)	1.05 (.195)	1.42§ (135.44)	1.51§ (46.37)	1.00 (0.00)
<12 yrs	27.33	0.94 (3.48)	0.97 (0.31)	1.02 (0.05)	0.95† (4.41)	0.94 (1.13)	1.01 (0.03)	0.94 (6.62)	0.93 (1.83)	1.00 (.001)
>12 yrs	28.82	0.97 (0.76)	0.88† (4.26)	1.02 (0.03)	1.03 (1.63)	0.91 (3.02)	1.08 (1.05)	1.02 (0.56)	0.87† (6.70)	1.08 (1.07)
<$10 000	36.49	1.20§ (41.91)	1.09 (2.27)	1.09 (0.98)	1.21§ (63.50)	1.10 (3.74†)	1.13 (3.05)	1.17§ (48.03)	1.10† (4.12)	1.08 (1.17)
$10 000–$15 000	13.07	1.17§ (15.44)	1.10 (1.57)	1.11 (0.69)	1.16§ (20.79)	1.09 (1.35)	1.14 (1.80)	1.15§ (18.23)	1.07 (1.01)	1.11 (1.29)

*Referent categories are not black, not Hispanic, 12 years of education, and > $15 000 annual income.

Parameter estimates followed by the symbols †,‡, § and represent statistical significance at the $p < 0.05$, 0.01, and 0.001 levels.

black racial status was associated with 13% fewer supermarkets and 7% fewer small grocery stores available within their census tract, independent of income and education.

Hispanic ethnicity, controlling for income and education, was also associated with greater availability of both small grocery stores and supermarkets within their census tract and at every radius, with 93% more small grocery stores and 44% more supermarkets within a 1-mile radius compared to non-Hispanic WIC mothers. Differences in the availability of small grocery stores and supermarkets, independent of income and educational status, were also apparent when examining store availability at the tract level, with Hispanic WIC mothers having 28% and 10% more small grocery stores and supermarkets in their residence census tract. Metropolitan WIC mothers with the lowest category of education (<12 years) also had equal or increased availability of grocery stores and supermarkets, with the effect growing more pronounced as radial distances increased. Within a 1-mile radius, WIC mothers in the highest educational category (>12 years of education) had 18% fewer small grocery stores compared to WIC mothers with 12 years of education. There were no significant differences between the lowest and intermediate level of education at the tract level, but women with more than a high school education had 12% fewer small grocery stores and 8% more supermarkets as compared to WIC mothers with only 12 years of education. The effect of income was less consistent, but the lowest income categories were generally associated with equal or increased availability of small grocery stores and supermarkets compared to WIC mothers with annual incomes >$15 000. The availability of convenience stores was equal or greater among black, Hispanic, low educational status, and the lowest income group when examining availability using either a spatial metric or administrative unit within metropolitan areas.

Similar trends were apparent in the micropolitan sample, with equal or increased availability of all types of stores associated with black and Hispanic ethnicity among WIC mothers when examining store availability around WIC residence. The differences in availability were most pronounced for small grocery stores, with black WIC mothers having 15% more small grocery stores and Hispanic WIC mothers having more than 2 times the number of small grocery stores within a 3-mile radius of their residences. Black racial status was not associated with any difference in the availability of supermarkets at any distance from residence in the micropolitan sample. However, when we examine disparities across census tracts, black racial status was associated with 34% fewer small grocery stores and 17% fewer supermarkets. Hispanic ethnicity was associated with greater availability of supermarkets, with 45% more supermarkets within a 1-mile radius. The association of Hispanic ethnicity with store availability at the tract level was slightly attenuated, but Hispanic ethnicity was still significantly associated with increased availability of small grocery stores and supermarkets when

controlling for education and income level. As in the metropolitan sample, the lowest education and income categories were generally associated with equal or increased availability of small grocery stores and supermarkets.

Within the rural sample, multivariate results show that Hispanic ethnicity was associated with significantly greater availability of convenience and small grocery stores at every radial distance and at the tract level. Hispanic ethnicity was also associated with a 34% increase in the availability of supermarkets within a 1-mile radius and a 31% increase in availability of supermarkets at the tract level. There was no association between Hispanic ethnicity and supermarket availability at greater distances from residence. Very low income was associated with greater availability of convenience stores at every distance and equal availability of small grocery stores and supermarkets compared to WIC mothers with >$15 000 annual income. WIC mothers with less than 12 years of education had 5% fewer supermarkets within a 1-mile radius, and WIC mothers with >12 years of education had 12% fewer small grocery stores within a 1-mile radius and 13% fewer small grocery stores within a 5-mile radius compared to WIC mothers with a high school education.

DISCUSSION

The first set of hypotheses tested the presence of geographic, racial, and ethnic disparities in the availability of small grocery stores and supermarkets among WIC mothers in Kansas. In contrast to most previous research examining supermarket and small grocery store availability at the tract level, multivariate results from this research suggest that among low-income mothers participating in the WIC program in Kansas, racial and ethnic minorities and those with very low incomes and educational levels actually have equal or greater availability of small grocery stores and supermarkets within a 1-mile radius of residence compared to white, non-Hispanic, and WIC mothers of greater income and educational status.

However, consistent with our original hypothesis, significant geographic disparities in the availability of small grocery stores and supermarkets are faced by WIC mothers who reside in rural areas, with rural WIC mothers having 59% of the grocery stores and only 25% of the supermarkets within a 1-mile radius compared to metropolitan WIC cases. Interestingly, micropolitan WIC mothers had the greatest availability of both small grocery stores and supermarkets within a 1-mile radius of their residences, which is consistent with the hypothesis that concentration within the supermarket sector, combined with rural depopulation, have led to a loss of supermarkets in both urban and very rural areas.[39]

The second hypothesis tested in this study is that associations between WIC mothers' demographic characteristics and the availability of small grocery

stores and supermarkets observed within a 1-mile radius of residence would parallel those observed when examining store availability within their census tract. Contrary to our original hypothesis, we discovered estimates and observed associations differed substantially between those obtained at the tract level versus those obtained when we examined store availability within a 1-mile radius of residence. For example, when examining store availability within metropolitan areas, mean small grocery store and supermarket availability within a 1-mile radius of residence was 2 times greater than estimated at the tract level. A similar pattern emerged when examining store availability among micropolitan WIC mothers, with 37% more small grocery stores and 38% more supermarkets within a 1-mile radius as contrasted to mean store availability at the tract level. As expected due to the very large tract size in rural areas, these patterns were reversed with mean availability greater at the tract level compared to availability measured within a 1-mile radius of WIC residence.

Results from our multivariate regression analyses also indicate that associational patterns observed at the tract level differ from those observed within a 1-mile radius of residence. Within metropolitan and micropolitan areas, black racial status was associated with a 13% and 17% reduction in supermarket availability at the tract level, representing a significant disparity in the availability of supermarkets. In contrast, there were no significant differences when examining supermarket availability associated with black status when store availability was measured within a 1-mile radius of residence. Similarly, within micropolitan areas, black status was associated with a 34% reduction in the availability of small grocery store at the tract level but was not associated with significant differences when examining store availability within a 1-mile radius of residence.

It is worthwhile to examine some of the reasons why results obtained when examining small grocery store and supermarket availability within a 1-mile radius of individual WIC mothers' residences differ from those obtained when examining racial/ethnic disparities at a tract level. Within Kansas, high-minority and low-socioeconomic status (SES) census tracts are substantially smaller than low minority/high-SES census tracts, even within the same urban influence category. For instance, within metropolitan counties, high (>40%) black tracts average 0.85 square miles compared to 2.17 and 31.19 square miles in intermediate (15%–40%) and low (<15%) black tracts. As a result of these differences in tract size, large disparities in the availability at a tract level do not necessarily translate to disparities when examining availability within a 1-mile radius because stores may be available in adjacent tracts. The results obtained in this study highlight the key role that MAUP issues may play in biasing estimates of disparities in the availability of small grocery stores and supermarkets and suggest that future studies should explicitly address whether census tracts are an appropriate unit of analysis for examining food environments.[25,40,41]

The results from our study have important implications for policy initiatives designed to increase the availability of healthy foods through supermarket development. Recent efforts to site supermarkets within high-minority and low-income urban neighborhoods are largely premised on evidence that these tracts contain significantly fewer supermarkets than less ethnically and racially diverse and more affluent census tracts.[42–45] However, if grocery shopping is not bounded by census tract, and if supermarkets are available in nearby census tracts, the potential dietary impact of these interventions may be limited. Results from interventions to increase availability of supermarkets in the UK suggest that dietary improvements associated with increased supermarket availability in deprived areas are either nonsignificant or minimal.[46] However, there may be important nondietary benefits to supermarket interventions, including an enhancement of the perceptions of local food availability, improvements in the reputation of an area, and concomitant improvements in the psychological health of residents within an area.[47,48]

Another important consideration associated with these initiatives is whether healthy food availability and pricing is better in large, chain supermarkets as compared to smaller, independent grocery stores. Results examining pricing and healthy food availability by store type indicate significant differences in availability and pricing between supermarkets and convenience stores[6,49]; however, differences in the cost and availability between smaller grocery stores and chain supermarkets are less consistently reported.[50–54] For instance, within a rural environment in South Carolina, the availability of lean ground beef, skinless chicken, and frozen seafood was significantly greater in supermarkets compared to grocery stores, but differences in the average cost of items by store type were minimal and inconsistent.[6] In contrast, cost of food items associated with a Thrifty Food Plan market basket at small grocery stores within rural, upstate New York did not differ significantly as compared to the same market basket at supermarkets, suggesting that grocery stores in rural areas may offer similar pricing for major food items.[55] Further research on food availability and pricing, particularly in rural areas where small grocery stores predominate, is needed to better understand how geographic disparities in store availability might contribute to higher prevalence of obesity in rural areas.[56]

Most importantly, the results obtained in this study highlight the need for greater specificity in developing conceptual models examining the relationship between local food environments, grocery shopping, food choices, and diet. Specifically, most research on disparities in food environments suggest that a "spatial mismatch"[57] has arisen due to residential segregation, the flight of supermarkets from urban areas, and the loss of independent grocery stores from rural areas.[55] However, the results from this study suggest that disparities at the tract level do not necessarily correspond to spatial disparities in store availability and that women in metropolitan

and micropolitan areas have a multiplicity of supermarkets and grocery stores in which to shop within a relatively close distance of their residences. Future research should focus on identifying the factors that influence their choice of stores and examine whether store choice influences dietary quality. Two particularly promising approaches include structural equation modeling [58]and dietary mapping,[59] which can provide insight into the complex (and bidirectional) links between built, social, and cultural environments within localized areas.

Several limitations of this study must be noted. First, this study examined availability of stores among participants in the WIC program in Kansas, a sample that only included low-income women. Disparities in grocery store and supermarket availability would be expected to be more pronounced if we were examining store availability among individuals across a wider spectrum of socioeconomic status. Additionally, results from this study may not be transferable to other locations with different residential segregation and commercial patterns. A recent review of studies examining disparities in food store availability suggests that urban areas with high indices of segregation are likely to experience greater disparities in the availability of food stores.[1] This study also relied upon a statewide database of food stores from 2005. Though the use of historical state data sources has been validated in other studies,[60] recent ground-truthing studies suggest that nondifferential misclassification of food stores may be an issue.[6,17] There also may be significant differences in the quality and pricing of foods available at different stores that are not considered in our statewide database. Lastly, it is important to remember that spatial availability of grocery stores and supermarkets does not translate into functional accessibility and utilization of these stores. Utilization of stores that carry healthy foods is influenced by a multiplicity of factors, including pricing,[61,62] time constraints associated with shopping and food preparation,[63] nutrition and cooking knowledge,[64] and other social and cultural barriers that interact with structural barriers to healthy food purchasing.[22,58]

Despite these limitations, this study provides important information for understanding geographic, racial/ethnic, and socioeconomic disparities in the spatial availability of grocery stores and supermarkets. The finding that there are significant geographic disparities in the availability of grocery stores and supermarkets in very rural areas of Kansas is also significant, particularly for women who lack access to a vehicle or social networks that would facilitate grocery shopping. However, in contrast to most other reports on disparities in the availability of grocery stores and supermarkets, the results indicating that racial/ethnic minorities and very low-SES WIC mothers have equal or increased spatial availability of grocery stores and supermarkets within a reasonable distance of their residence is noteworthy. The second finding, that estimates of availability and associations observed at the census tract level are very different from those observed within a 1-mile

radius of residence, is noteworthy because it indicates that choice of the census tract as a unit of analysis may result in biased estimates and associations. Altogether, these results suggest that the spatial availability of healthy foods may play a less important role in determining dietary behaviors than previously hypothesized and that future research should address the interaction of spatial availability, functional accessibility, and utilization of food stores within local environments.

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