CHAPTER 3

The Interaction of Neighborhood and Household Characteristics in Explaining Areas With Limited Access

The food deserts literature suggests that those who have better access to supermarkets tend to have healthier diets and lower levels of obesity and related diseases (Laraia et al., 2007; Larson et al., 2009). However, the extent to which limited access to supermarkets and other differential aspects of the food environment contribute to known economic and racial health disparities remains unclear. That lack of clarity stems in part from conflicting findings with regard to access to supermarkets for low-income, minority, and racially mixed neighborhoods. Some researchers have found economically disadvantaged populations and neighborhoods with high concentrations of racial minorities to have better access than their counterparts (e.g., Moore and Diez Roux, 2006), while others have found the reverse (e.g., Burns and Inglis, 2007). There is substantial literature showing that low-income and minority populations are disproportionately at risk when it comes to major public health concerns (e.g., Diez Roux et al., 2001; Odoms-Young et al., 2009). But critical gaps remain in the understanding of the associations between the neighborhood food environment and indicators of health. Investigators have made considerable gains in the development of approaches to better characterize neighborhood food environments and thus identify the mechanisms that underlie those associations between the food environment and poor health outcomes (e.g., Moore et al., 2008; Sharkey, 2009), but doing so continues to be a major challenge.

This chapter uses physical distance to the nearest supermarket as a measure of access, but also extends the analysis to include distance to the third nearest supermarket, which serves as a proxy for variety (Apparicio et al., 2007). Access in relation to the neighborhood and household socioeconomic environment is also explicitly examined. Examining areas of low-access to food from a socioeconomic perspective as such is both theoretically and empirically important. In theory, those with the lowest incomes, living in the most disadvantaged places, will have limited provisional access in general, whether in reference to food, health care, transportation, or other services and resources. Further, households that lack access to a vehicle (particularly in rural areas) or have very few financial resources may have difficulty purchasing affordable and nutritious food, which in turn may translate into poor health (Bostock, 2001). Lack of access to food and poor health could be amplified if the same households live in a disadvantaged neighborhood, such as one where public transportation options are nonexistent and food retail choices are limited (Ford and Dzewaltowski, 2008).

There are a number of phrases used in the health inequalities literature to capture the relationship between household and neighborhood risk factors (e.g., pathways of disadvantage). The one utilized in this study is "deprivation amplification" (Macintyre et al., 2008). Deprivation amplification is best explained as a process that could impact an individual's health whereby, for example, risk factors for obesity, such as low-income, combined with limited knowledge about nutrition are intensified by exposure

to a food retail environment that offers too few choices for nutritious food and/or too many options for less nutritious alternatives. Thus, the food environments of low-income populations require special consideration due to the vulnerability of the individuals as well as that of the unique social and physical setting in which they live (Gittelsohn and Sharma, 2009).

Empirical evidence suggests that deprivation amplification may be more of a problem in the United States than in the United Kingdom and elsewhere where food desert research has been conducted. That is, while research on food deserts in the United States is in its infancy, research completed to date shows that in comparison to other country studies (e.g., Pearce et al., 2009) complex social and physical contexts are greater determinants of health outcomes for the low-income population of the United States than for the European counterparts. Cummins and Macintyre (2006) suggest that one explanation for this uniquely U.S. "contextual effect" may be that "residential segregation along socioeconomic and racial lines may be more pronounced in the USA and planning regulations less focused on compensating for such segregation than in the UK, continental Europe, or Australia." A number of studies lend support to this notion (e.g., Franco et al., 2008; Galvez et al., 2008; Morland et al., 2002). Thus, while the main objective of this analysis is to determine the characteristics that best differentiate groups with dissimilar levels of supermarket access (i.e., low, medium, or high), the secondary objective is to examine segregation based on race and income inequality as a determinant of low supermarket access in comparison to other neighborhood and household contextual risk factors.

Research Method and Indicators

The research method applied to this study is referred to as multiple discriminant analysis, or MDA. This approach is useful to understand the differences between groups, to identify which variables best capture those differences, to describe the dimensionality of groups, or to test theories or taxonomies (Huberty and Lowman, 1997).[26] In health geography and inequality research it is often used to discover the variables that contribute to group separation and to describe grouping variable effects. For example, Hemphill et al. (2008) used discriminant analysis to explore the relationship between the placement of fast food outlets and neighborhood-level socioeconomic variables, where neighborhoods were classified as high-, medium-, or low-access based on the number of fast food opportunities available to them. The study found significant differences between the three levels of fast food accessibility across the socioeconomic variables, with successively greater percentages of unemployment, low-income, and renters in neighborhoods with increasingly greater access to fast food restaurants. Several of these variables were also found to be predictive of greater access to fast food restaurants.

Similarly, discriminant analysis is used here to capture the characteristics that best differentiate urban and rural neighborhoods grouped into low-, medium-, and high-access categories given distance to first and third nearest supermarkets (i.e., supermarket proximity and variety). Those relative accessibility measures were determined based on the criterion given in the previous chapter (i.e., with low-access defined by a distance greater than 1 mile for walking and 20 miles for driving, medium-access defined by a

[26]Discriminant analysis is conceptually and mathematically analogous to multiple regression analysis. Both techniques involve calculating from a set of continuous predictor variables to a criterion. The primary difference is that the dependent variables in discriminant analysis are linearly combined mathematically to maximally discriminate between the groups, thereby emphasizing group differences and deemphasizing group similarities. In other words, multiple discriminant analysis calculates a linear equation using standardized discriminant function coefficients, which are analogous to beta weights in regression. As such, similar to regression, these coefficients identify the relative importance of each continuous variable in predicting the criterion. However, unlike regression analysis, the dependent variables are linearly combined to create a synthetic or composite dependent variable that separates or maximally differentiates the groups.

distance between one-half and 1 mile for walking and between 10 and 20 miles for driving, and high-access defined by a distance less than one-half mile for walking and 10 miles for driving). However, for this analysis, the geographic area of interest is neighborhoods, for which Census tracts are commonly used proxies. As such, the grid-defined distance measures used in Chapter 2 were aggregated to the Census tract for this study.[27]

As with the area-based analysis in Chapter 2, little variation was found among subpopulations with respect to distance measures and access levels. For example, based on distance alone, the low-income population was found to be no worse off than female-headed households with children, or the African-American population, the severely poor (50 percent of the poverty income threshold), or any other vulnerable population. Likewise, non-White and low-income populations were found to have better access than their counterparts, and lack of access to a vehicle within the household did not emerge as a defining characteristic of low access. With respect to the latter, walking distance to a variety of supermarkets proved to be the greatest access barrier for low-income households with or without a vehicle, in either urban or rural neighborhoods. Yet, the same was determined for all neighborhoods regardless of whether they were low-income or not, leading us to conclude that low access in general is not specifically a low-income area phenomenon.

FFor this reason, this study does not limit the discriminant analysis to low-income areas; it includes all neighborhoods in the analytical models. In keeping with the geography applied to the area-based analysis, the study categorizes those neighborhoods as being located in metro core, micropolitan or small town core, and rural tracts, which are census tract-level equivalents of urbanized areas, urban clusters, and rural areas, respectively.[28] Using that geography in association with the access groups (a dependent variable), 12 independent discriminant analyses are conducted—one for each of the three geographic groups given walking and driving distances to first and third nearest supermarkets (see table 3.1 for group frequencies).

A number of factors were included in each analysis in addition to a select set of socio-economic indicators believed to be potential predictors of group membership given existing literature on vulnerable people and places.[29] The factors consisted of indicators of neighborhood and household composition that have previously been associated with deprivation, such as householder age and race/ethnicity, income and education levels, household structure, area population density, and degree of rurality. The predictor variables consisted of indicators of neighborhood context that are hypothesized to be associated with deprivation amplification, such as depth and persistence of poverty, housing values and vacancy rates, area unemployment and labor force participation rates, low-income concentration, and segregation based on race and income. Most of these variables are straightforward and require little explanation, but there are a few exceptions for which additional details are provided below. Summary statistics for each are given in table 3.2.

- *Dissimilarity index of segregation*: This variable captures dissimilarity by race or the evenness with which one racial population group is located (or segregated) within an area with respect to another racial group. The dissimilarity statistic is interpreted as the proportion of one racial group that would need to relocate to another neighborhood (census tract) in

[27]Specifically, tract-level distance measures were calculated by first assigning grids to 2000 Census defined tracts. Then median distances for all grids within a tract were computed, including total tract population and population-specific distances to the nearest and third closest supermarket based on income, age, race/ethnicity, and various household characteristics (e.g., households without a vehicle and female-headed households with children).

[28]These tract-level geographic designations are based on ERS 2000 Rural-Urban Commuting Area (RUCA) Codes, which were developed using the same theoretical concepts used by the Office of Management and Budget to define county-level metropolitan and micropolitan areas. Metropolitan cores (code 1) are defined as census tract equivalents of urbanized areas. Micropolitan and small town cores (codes 4 and 7) are tract equivalents of urban clusters. And, rural tract (code 10) designation is defined by a primary commuting flow that is local or to another rural tract.

[29]All factor and predictor variable data stem from RAND's Center for Population Health and Health Disparities Data Core (http://www.rand.org/health/centers/pophealth/data.html). The RAND data include a range of census-based variables tabulated to capture various characteristics known to be correlated with health disparities, such as standard measures of socio-economic disadvantage (e.g., unemployment, poverty, and education), disability by type and population, cost of living, segregation, unevenness, and inequality by race and/or income, alternative measures of environmental pollution by level and type, and various forms of physical access based on extent of roadway connectivity and complexity. The full range of potential factor and predictor variables from the RAND data were initially considered for analysis and selection of variables was based on a standard variable reduction process (e.g., univariate analysis to determine significance and elimination of redundant or overlapping variables).

Table 3.1

Access Category Variables and Corresponding Percent Frequency: Metro Core, Micropolitan / Small Town Core, and Rural Tracts

Access category variables	Percent of metro core tracts	Percent of micropolitan or small-town core tracts	Percent of rural tracts
		Percent	
Walking--1 store (proximity)			
High access	31.5	12.4	1.3
Medium access	42.6	46.9	8.6
Low access	25.9	40.7	90.1
Driving--1 store (proximity)			
High access	100.0	99.8	75.8
Medium access	0.0	0.1	17.8
Low access	0.0	0.1	6.4
Walking--3 stores (variety)			
High access	0.0	0.0	0.0
Medium access	12.8	3.3	0.3
Low access	87.2	96.7	99.7
Driving--3 stores (variety)			
High access	100.0	84.5	32.5
Medium access	0.0	11.0	45.5
Low access	0.0	4.5	22.0

Source: USDA, ERS estimations based on 2006 ERS-compiled directory of supermarkets and RAND's Center for Population Health and Health Disparities Data Care.

order to be evenly distributed across the county (or metro area) with respect to other racial groups. A dissimilarity statistic value of 0 reflects absolute integration while a value of 1 reflects absolute segregation.

- *Gini index of segregation*: This variable represents income inequality by race. The Gini statistic is understood much like the dissimilarity statistic. It ranges in value from 0 to 1 with 0 indicating complete equality and 1 indicating complete inequality. In other words, higher values indicate that the study area is more unequal in terms of how income is distributed among racial groups while lower values mean that income is more equally distributed.

- *Roadway connectivity (alpha):* This measure is used to examine connectivity with respect to the availability of alternative travel routes within a tract. The alpha value represents the ratio of the actual number of complete loops to the maximum number of possible loops given the number of tract intersections. A higher alpha value indicates a greater degree of roadway complexity and connectivity, and thereby serves as an indicator of access to supermarkets given the extent of the area's physical transportation infrastructure.

- *Index of disadvantage:* This is a normalized socioeconomic status measure for all census tracts developed from six measures understood to represent disadvantage: percent of adults older than age 25 with less than a high school education; percent male unemployment; percent of households with income below the poverty line; percent of households

Table 3.2

Summary Descriptives; Factor and Predictor Variables: Metro Core, Micropolitan / Small Town Core, and Rural Tracts

	Rural core		Micro/Small-town core		Metro core	
Variable	Mean	Std. deviation	Mean	Std. deviation	Mean	Std. deviation
Region (NE, MW, S, W)	2.59	0.91	2.6314	0.91390	2.5416	1.09064
Segregation by Race (dissimilarity)	0.24	0.15	0.29	0.12	0.44	0.14
Segregation by income (Gini)	0.29	0.17	0.37	0.15	0.57	0.16
Land area of tract in miles	452	2146	50	238	4	22
Roadway connectivity (alpha)	0.11	0.06	0.17	0.07	0.17	0.08
Median value of owner-occupied housing	$72,056	$53,004	$85,896	$50,248	$153,295	$123,395
Percent rural population	95.6%	18.2%	18.3%	20.5%	3.3%	10.8%
Percent Black or African-American population	5.5%	13.8%	10.4%	18.5%	15.6%	25.3%
Percent Hispanic population	4.8%	11.4%	8.6%	16.2%	13.5%	20.1%
Percent linguistically isolated households	5.8%	10.5%	5.7%	7.3%	11.2%	10.4%
Percent of tract poverty population who are 65+ years old	14.2%	8.4%	12.7%	8.1%	11.8%	12.2%
Percent of tract poverty population who are children	31.4%	10.3%	32.2%	10.5%	29.7%	14.6%
Percent vacant housing units	20.2%	15.3%	10.5%	8.4%	6.6%	6.6%
SES index of disadvantage	74.94	13.14	75.7635	6.24350	78.0322	9.80811
Percent persistent poverty county	14.8%	35.5%	9.9%	29.9%	1.7%	13.0%
Valid N (listwise)	N = 4141		N = 6392		N = 40436	

Source: USDA, ERS estimates based on 2006 ERS-compiled directory of supermarkets and RAND's Center for Population Health and Health Disparities Data Care.

receiving public assistance; percent of female-headed households with children; and median household income. The index is scaled such that the values fall between 0 and 100, with the lower number indicating a greater degree of tract disadvantage than a tract with a higher number.

- *Linguistically isolated households*: A linguistically isolated household is defined as one in which no member age 14 or older speaks only English or speaks a non-English language while also being able to speak English well. In other words, for a household to be declared linguistically isolated then at least one member age 14 or older must have some difficulty with the English language.

- *Persistent poverty counties*: This designation is based on the ERS 2004 County Typology, which classifies all U.S. counties according to six non-overlapping categories of economic dependence and seven overlapping categories of policy-relevant themes. Persistent poverty counties belong to the latter group and are defined as such if 20 percent or more of their populations were living in poverty over the last 30 years (measured by 1970, 1980, 1990, and 2000 decennial censuses).

Discussion of Results

MDA yields two types of output that are particularly useful for this investigation. The first is the structure coefficients, which are useful for determining the characteristics that contribute the most to group separation (i.e., low-, medium-, and high-access groups). The second is the set of standardized discriminant coefficients (similar to beta coefficients in regression analysis), which are useful for identifying the characteristics that best predict group membership and can thereby be thought of as indicators of associated risk. That output for all 12 discriminant analyses, and, therefore, the three geographies (metro core, micropolitan/small-town core, and rural core), are summarized in two typology tables.

Table 3.3 provides information on the characteristics of supermarket accessibility walking proximity and variety, while table 3.4 provides similar information for driving proximity and variety. Both tables give corresponding structure coefficients (access group separation) and standardized discriminant coefficients (access group predictors) with the top three most influential (on the basis of absolute value) highlighted. Those values can be interpreted following an example for rural core neighborhoods from table 3.3.

Considering walking proximity, roadway connectivity has the strongest correlation with the grouping variable (.797), followed by percent of vacant housing units (-.356) and percent rural population (-.289). This means that the extent and complexity of the road system contributes most to groupings of low-, medium-, and high-access. Its relative contribution can be understood by taking the square of the coefficient (.635), which indicates that 63.5 percent of the variance in the composite grouping variable is explained by the roadway connectivity variable. In other words, roadway connectivity is the characteristic that best discriminates among groups of neighborhoods categorized as having low-, medium-, or high-access to the nearest supermarket given walking distance. It also happens to be the strongest predictor of group membership (.913).

The second and third most powerful predictors for rural core neighborhoods were found to be the index of disadvantage (-.311) and the percent of the tract poverty population who are 65 years of age or older (.252). This finding implies, for example, that limited access is associated with a combination of indicators of socioeconomic disadvantage. This reinforces the need to give greater consideration to the notion of deprivation amplification in access and related health inequalities research. Further, the relevance of the elderly poverty population highlights that some people may face multiple barriers to access. Thus, continued efforts to improve measurement and advance multivariate techniques are needed.

The discriminant analysis results presented in tables 3.3 and 3.4 offer evidence in support of the hypothesis that segregation by race and income are associated with limited access. Segregation by race and income inequality are the dominant predictors among all neighborhood and household context variables that predict low-, medium-, and high-access levels. This was particularly true for access based on driving distances in rural core and micro/small-town core neighborhoods. However, some variability in

Table 3.3

Group Separation and Predictor Variables for Low-, Medium-, and High-Access to Supermarkets: Walking Proximity and Variety for Metro Core, Micropolitan / Small Town Core, and Rural Neighborhoods

	Walking proximity			Walking variety		
Access group separation	Rural core	Micro/Small-town core	Metro core	Rural core	Micro/Small-town core	Metro core
Region (NE, MW, S, W)	-0.125	0.114	0.115	0.218	0.062	-0.035
Segregation by race (dissimilarity)	0.072	-0.002	0.232	-0.296	-0.110	0.294
Segregation by income (Gini)	0.061	0.006	0.245	-0.323	-0.137	0.303
Land area of tract in miles	-0.181	0.208	-0.266	0.091	0.207	-0.126
Roadway connectivity (alpha)	0.797	-0.740	0.582	0.019	-0.717	0.465
Median value of owner-occupied housing	-0.227	0.189	0.035	0.204	-0.024	0.204
Percent rural population	-0.289	0.901	-0.677	0.878	0.833	-0.253
Percent Black or African-American population	-0.065	0.046	0.130	0.066	0.045	0.108
Percent Hispanic population	0.093	-0.079	0.379	0.068	-0.155	0.506
Percent linguistically isolated households	-0.118	-0.020	0.489	0.089	-0.188	0.778
Percent of tract poverty population who are 65+ years old	0.201	-0.027	-0.062	0.258	0.091	-0.091
Percent of tract poverty population who are children	-0.129	0.039	-0.038	0.456	0.188	-0.026
Percent vacant housing units	-0.356	0.184	-0.027	0.207	0.135	-0.046
SES index of disadvantage	-0.234	0.159	-0.304	0.834	0.318	-0.327
Persistent poverty county	-0.120	0.047	-0.070	0.071	0.022	-0.055

	Walking proximity			Walking variety		
Access group predication	Rural core	Micro/Small-town core	Metro core	Rural core	Micro/Small-town core	Metro core
Region (NE, MW, S, W)	-0.026	0.046	0.211	0.340	0.030	-0.050
Segregation by face (dissimilarity)	0.197	-0.604	0.322	0.167	0.532	0.554
Segregation by income (Gini)	-0.168	0.696	-0.228	-0.291	-0.600	-0.463
Land area of tract in miles	-0.251	0.046	-0.070	-0.112	0.002	-0.024
Roadway connectivity (alpha)	0.913	-0.387	0.478	-0.098	-0.512	0.388
Median value of owner-occupied housing	0.105	-0.046	0.096	-0.104	-0.382	0.353
Percent rural population	-0.061	0.728	-0.501	0.387	0.479	0.014
Percent Black or African-American population	-0.075	0.088	0.067	0.080	0.171	0.175
Percent Hispanic population	0.050	0.051	0.117	0.025	0.120	0.258
Percent linguistically isolated households	-0.190	-0.004	0.390	0.139	-0.102	0.605
Percent of tract poverty population who are 65+ years old	0.252	-0.097	-0.031	0.044	0.022	-0.089
Percent of tract poverty population who are children	0.014	-0.013	-0.172	0.069	0.155	-0.173
Percent vacant housing units	-0.054	0.121	-0.113	0.117	0.127	-0.108
SES index of disadvantage	-0.511	0.153	-0.171	0.582	0.451	-0.241
Persistent poverty county	-0.052	-0.045	-0.150	0.044	-0.071	-0.141

Source: ERS estimates based on 2006 ERS-compiled directory of supermarkets and RAND's Center for Population Health and Health Disparities Data Care.

Table 3.4

Group Separation and Predictor Variables for Low-, Medium-, and High-Access to Supermarkets: Driving Proximity and Variety for Metro Core, Micropolitan / Small Town Core, and Rural Neighborhoods

	Driving proximity			Driving variety		
Access group separation	Rural core	Micro/Small-town core	Metro core	Rural core	Micro/Small-town core	Metro core
Region (NE, MW, S, W)	0.263	0.130	n/a	0.256	0.255	0.075
Segregation by race (dissimilarity)	-0.027	0.026	n/a	-0.125	-0.271	-0.013
Segregation by income (Gini)	-0.085	0.033	n/a	-0.190	-0.358	-0.008
Land area of tract in miles	0.725	0.900	n/a	0.640	0.584	0.693
Roadway connectivity (alpha)	0.334	-0.063	n/a	0.374	0.202	-0.154
Median value of owner-occupied housing	-0.313	-0.033	n/a	-0.266	-0.211	0.113
Percent rural population	-0.005	0.105	n/a	0.099	0.071	0.483
Percent Black or African-American population	-0.173	-0.041	n/a	-0.178	-0.134	-0.060
Percent Hispanic population	0.191	0.055	n/a	0.147	0.307	-0.086
Percent linguistically isolated households	0.323	0.265	n/a	0.194	0.178	0.182
Percent of tract poverty population who are 65+ years old	-0.056	-0.025	n/a	0.035	0.081	0.122
Percent of tract poverty population who are children	0.003	0.073	n/a	0.069	0.137	-0.080
Percent vacant housing units	0.182	0.133	n/a	0.179	0.257	0.413
SES index of disadvantage	-0.077	-0.187	n/a	0.036	-0.092	0.040
Persistent poverty county	0.072	0.052	n/a	0.018	0.106	0.350

	Driving proximity			Driving variety		
Access group prediction	Rural core	Micro/Small-town core	Metro core	Rural core	Micro/Small-town core	Metro core
Region (NE, MW, S, W)	0.222	0.045	n/a	0.351	0.198	0.208
Segregation by race (dissimilarity)	1.251	-0.870	n/a	1.742	2.558	-0.362
Segregation by income (Gini)	-1.316	0.958	n/a	-1.921	-2.893	0.462
land area of tract in miles	0.591	0.953	n/a	0.514	0.529	0.575
Roadway connectivity (alpha)	0.356	-0.007	n/a	0.479	0.242	-0.048
Median value of owner-occupied housing	-0.373	0.045	n/a	-0.374	-0.258	0.050
Percent rural population	-0.032	-0.088	n/a	0.095	0.017	0.309
Percent Black or African-American population	-0.158	-0.271	n/a	-0.232	-0.107	-0.114
Percent Hispanic population	-0.035	-0.340	n/a	-0.075	0.166	-0.393
Percent linguistically isolated households	0.350	0.237	n/a	0.243	0.156	0.455
Percent of tract poverty population who are 65+ years old	-0.052	0.111	n/a	0.058	0.187	0.088
Percent of tract poverty population who are children	-0.169	0.101	n/a	-0.037	0.071	0.020
Percent vacant housing units	0.302	0.032	n/a	0.401	0.283	0.429
SES index of disadvantage	-0.016	-0.385	n/a	-0.145	0.017	-0.034
Persistent poverty county	0.104	0.016	n/a	0.046	0.043	0.327

Source: ERS estimates based on 2006 ERS-compiled directory of supermarkets and RAND's Center for Population Health and Health Disparities Data Care.

predictors was found; for example, in rural core areas segregation was not among the top predictors of walking accessibility. This finding lends some support to the need for situation-specific research and policy.

Summary

The findings of this study indicate that low-access to supermarkets is most heavily influenced by characteristics of neighborhood and household socioeconomic environments, such as the extent of income inequality, racial segregation, transportation infrastructure, housing vacancies, household deprivation, and rurality. This lends support to the notion that there is indeed a socioeconomic "contextual effect" that should be considered when designing food access policy. In that vein, there is growing evidence that documents the success of non-health interventions that have had a positive impact on health (e.g., improvements to road networks and investments in public transportation options), particularly for those living in deprived areas (e.g., Cassady and Mohan, 2004; Wrigley et al., 2003).

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