Food deserts: are we looking in the right places?

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ABSTRACT

Policymakers are targeting food deserts (lack of access to quality foods in underserved neighborhoods) in obesity reduction efforts, yet such strategies lack empirical evidence. Using a nationally representative sample (National Longitudinal Study of Adolescent Health 2001-02; n=13,995 young adults representing 7,588 U.S. block groups), we estimated cross-sectional relationships between availability of food resources and neighborhood poverty and racial minority population. Findings suggest that policies should address disparities in access to healthy foods in less urban areas (e.g., suburban and non-urban), in contrast to common assumptions that food deserts exist mainly in dense urban areas.

INTRODUCTION

At the national, state, and local levels, governments have begun to focus on what is termed food deserts. Food deserts are defined as areas with limited access to foods that help maintain a healthy diet and conversely, plentiful access to high fat, high calorie foods such as fast-food. [1, 2] Researchers have turned to food deserts for justification of lower quality diets and higher prevalence of obesity and other nutrition-related non-communicable diseases among low income and minority groups. [3-6]

However, much of the research on food deserts suffers from mismeasurement. That is, many studies use food resource availability measures that do not account for other environment factors, [7] such as population density and urbanicity, [8-12] that may be correlated with neighborhood sociodemographic characteristics and independently related to food resource availability. Furthermore, most studies have limited generalizability (small geographic range), and few have examined neighborhood disparities in food resources in rural or suburban settings, [1, 13-15] and limited sample sizes and insufficient variation of neighborhood characteristics often limit ability to make urbanicity or other subgroup comparisons within the context of a single study.

Racial disparities in food environments [3, 16, 17] may compound the detrimental effects of poverty. Individual level inequalities such as low quality health care, and higher morbidity and mortality in low socioeconomic status (SES) minorities compared to low SES white populations may extend to analogous inequalities in built and social environments. That is, impoverished neighborhoods with high minority populations may experience reduced access to high quality food resources than their white counterparts.

We used nationally representative data from 13,995 young adults, aged 18-24 years living throughout the U.S. and food resources within each respondent's neighborhood. We assessed whether individuals living in high poverty neighborhoods have lower availability of grocery/supermarkets and greater access to fast-food restaurants and convenience stores. Further, we examined how disparities in food resource availability might vary by neighborhood minority population and urbanicity.

METHODS

Study population and data sources

Our study sample is derived from respondents aged 18 to 24 years who participated in Wave III (2001-02) of the National Longitudinal Study of Adolescent Health (Add Health), a nationally representative, prospective cohort study of adolescents representative of the U.S. school-based population in grades 7 to 12 (11-22 years of age) in 1994-95 followed into adulthood. The survey design and sampling frame have been discussed elsewhere. [18, 19]

Using complex GIS techniques, we linked time-varying, community-level data to Add Health respondent Wave III home addresses geocoded with street-segment matches (n=13,039), global positioning system (GPS) measurements (n=1,204), and ZIP/ZIP+4/ZIP+2 centroid match (n=685) among 14,322 Wave III respondents with sample weights. The number of census block groups (n=7,588) represents 3.6% of census block groups included in the 2000 U.S. Census. Differences in individual-level and environmental measures across location sources were consistent with greater reliance on GPS or ZIP codes (compared to geocodes) among rural respondents, who often use Post Office Boxes or other addresses that cannot be geocoded. Attributes of circular areas of various radii surrounding each respondent location (Euclidean

neighborhood buffer) and block group, tract, and county attributes from time-matched U.S. Census and other federal sources were merged with individual-level Add Health interview responses.[20]

Of 14,322 Wave III respondents with sample weights, 327 (2.3%) with missing environmental data regarding food resources were excluded, leaving an analytic sample of 13,995.

Study variables

GIS-derived food resource data

Food resource data were obtained from a commercial dataset of U.S. businesses corresponding to the Wave III interview period (2001). Food resources were classified according to 4- and 8-digit Standard Industrial Classification (SIC) codes as described in Supplement. Briefly, fast-food restaurants included fast-food chain and non-chain restaurants, excluding food stands and cafeterias; sit down restaurants included restaurants with table or counter service such as ethnic, steak houses, and family-owned restaurants. Grocery stores and supermarkets included independent and chain grocery stores and supermarkets of all sizes, and convenience stores included variety & convenience stores and food stores attached to filling stations.

We examined several measures of food resource availability within 3 kilometer Euclidean neighborhood buffers to address different dimensions of resource allocation (absolute availability, relative availability, and density) and variation in measures used in the literature. We chose the 3 kilometer buffer because it exhibited analogous associations between physical

activity facilities and physical activity behaviors, [21] and we theorized that food resources within the same area would influence diet behaviors. For restaurants, measures included (1) absolute availability (raw counts) of fast-food and sit down restaurants, (2) relative availability of fast-food restaurants (count of fast-food restaurants as a percent of all restaurants [fast-food/(sit-down+fast-food)]), and (3) fast-food restaurant density (fast-food restaurant counts per 10,000 population, derived from 2000 US Census block-group population count weighted according to the proportion of block-group area within the neighborhood buffer). Analogously, we examined absolute availability and densities of grocery and convenience stores, but not relative availability of grocery/supermarket stores since it could not be compared within the universe of all available food stores.

GIS-derived neighborhood sociodemographics

We examined several common neighborhood sociodemographic measures from the 2000 U.S. Census. We used Census block groups to define neighborhoods because smaller units more likely adhere to individually perceived neighborhood boundaries [22, 23] and are more sociodemographically homogeneous. Using the federal definition of "poverty area," [24, 25] we dichotomized neighborhood poverty into >20% or ≤20% of population below the federal poverty level. We defined neighborhood minority population as percent of persons of non-Hispanic white race/ethnicity and neighborhood-level education as percent of persons ≥25 years with college or greater education.

Urbanicity

U.S. Census-defined urbanized areas (UA) were used to classify residential locations as non-urban (outside UA) or urban (inside UA). Within urban, we used Fragstats [26] software with U.S. Geologic Survey National Landcover Data to distinguish: 1) low density [≤95% (75th percentile) developed land cover] and 2) high density [>95% developed land cover] urban areas based on the area of developed land as a proportion of total area within 3k after excluding water and ice. Our measure of developed land cover provides an indicator of urban development that is independent of population density and correctly classifies areas as within or outside of a UA (Receiver Operating Characteristic curve area=0.937).

Statistical analysis

Descriptive analysis. Availability of restaurants and food stores and sociodemographic characteristics were compared across urban strata. To address skewness, we report median and interquartile range. All statistical analyses were weighted for national representation and corrected for complex survey design using Stata 10.1.

Multivariate regression analysis. We fit multivariable regression models to predict food resource availability (negative binomial regression models were used for absolute availability and linear regression models were used for relative availability and density) as a function of neighborhood poverty. Absolute and relative availability models controlled for population density (dichotomized at urbanicity-specific medians; Exhibit 1). Relative fast-food availability models controlled for count of total restaurants (fast-food and sit down).

All models were weighted for national representation, corrected for clustering on our primary sampling unit (schools) and controlled for continuous neighborhood-level education. Given that schools and census block groups are not geographically nested, we did not use multi-

level analysis. Further, multi-level analysis of unbalanced, sparse data within census block groups can result in biased estimates. [27]

Food resources and neighborhood sociodemographics varied dramatically across urbanicity, making comparability across sociodemographic and geographic subpopulations difficult. We examined urbanicity-specific tertiles of neighborhood minority population (Exhibit 1) to address non-linear associations with food resource availability measures. In addition, we tested interactions between neighborhood minority population and neighborhood poverty; where interactions were statistically significant ($p<0.10$), we present comparisons of food resource availability in high versus lower poverty areas within each of the three minority strata. To aid interpretation of the model results, we used the estimated model coefficients to predict food resource density for selected levels of neighborhood-level poverty and minority population within the non-urban stratum, in which the strongest disparities were observed.

RESULTS

Neighborhoods captured in our large, nationally representative sample of 13,995 young adults provide substantial variability of food resource measures, neighborhood sociodemographics, and development characteristics across levels of urbanicity (Exhibit 2).

In multivariate analysis, high poverty neighborhoods had higher absolute fast-food availability than lower poverty neighborhoods in low and high density urban areas, but not in non-urban areas (Exhibit 3). In high density urban areas, this relationship was no longer statistically significant after accounting for population and commercial clustering by using density and relative availability measures, respectively. The direction of associations was similar for each of the three fast-food restaurant availability measures in non-urban and low density

urban neighborhoods (due to different scaling across models, the magnitude of associations were not comparable). Associations between relative fast-food availability and neighborhood poverty were strongest in low or medium minority neighborhoods in non-urban and low density urban areas. A negative association between absolute sit down restaurant availability and neighborhood poverty was observed only in non-urban areas.

Neighborhood poverty was not significantly related to food store availability in high and low density urban areas. Yet, we observed significantly fewer food stores (grocery/supermarkets and convenience stores) in high (versus low) poverty areas in the non-urban stratum, which was most apparent in medium minority areas (Exhibit 4).

To illustrate, Exhibit 5 presents predicted food resource density in non-urban, high and low poverty and high and low minority population neighborhoods. For example, we predicted an average of 3.6 convenience stores per 10,000 population in the most disadvantaged neighborhoods (high minority, high poverty), compared to 0.9 in the least disadvantaged neighborhoods (low poverty, low minority).

Discussion

We assessed inequities in fast-food restaurant and food store availability by neighborhood poverty in a large, nationally representative sample of young adults representing 7,588 census block groups (3.6% of 2000 U.S. Census block groups). Our findings suggest that food deserts do exist, though not where prior research suggests. Disparities in food resources were far more apparent in low density urban and non-urban areas than in high density, poor, urban areas, where food deserts are typically assumed to exist. Prevailing assumptions regarding food resource availability are not supported by patterns observed in the neighborhoods

throughout the U.S. captured in our study and indicate higher risk among lower density urban and non-urban areas.

Our analysis explored a series of important measurement issues related to food deserts. We found that density measures of fast-food and supermarkets appear to help to isolate counts of such food establishments from population density. Likewise, relative availability measures may help to correct for geographic clustering of food resources, as is seen in food districts with many restaurants of all types. Therefore, we focus our remaining discussion on findings using relative availability and density measures, rather than the absolute (raw count) measures. Our findings further suggest that identification of areas with food resource disparities should use appropriate measures that account for the surrounding environment and capture characteristics that are likely to influence diet and obesity.

Our findings contradict the assumption that food deserts are very common in poor, urban neighborhoods, as supported by many studies conducted in small study populations [28, 29] as well as other national U.S. studies conducted at larger aggregations [12, 30]. Instead, our study uses national data at a small geographic scale reflective of local residential areas (within 3 km of each respondent's residential location), and incorporates complex, layered spatial data linked to individuals and their local neighborhoods. Using these unique data, we observed expected disparities in fast-food availability in non-urban and low density urban areas. Associations were most consistent in the low density urban stratum, which includes the largest proportion of our nationally representative sample and theoretically captures suburban America. While we observed expected disparities for grocery/supermarkets in non-urban neighborhoods, our results also suggest that high poverty areas have lower availability of many types of food stores including convenience stores. In sum, our findings suggest that rural and suburban areas should

be targeted for access to healthy foods. While this idea has been suggested by a small study in Texas, [14] our national study further supports more focus on rural and suburban food environments.

In the US, we also note that the distribution of poverty has shifted away from the dense inner cities. The most recent analysis of the face of poverty in the US suggests that counter to the assumption of "White Flight" out of inner cities, racial minorities, foreign-born, and low income people were more likely to live in metropolitan suburbs than their primary cities in 2008 [31]. Thus, the disparities in availability of healthy foods observed in non-urban and low density urban areas in our 2001 data may become much more important as poor and minority populations increasingly reside in these neighborhoods.

Strengths and limitations

This study did not look at extreme poverty nor consider a large array of other factors linked with dense urban areas and even possibly low-density urban areas. It is possible that disparities in food resources in dense, urban areas may be evident only under extreme neighborhood poverty that we did not examine in our analysis. More refined analyses of dynamic effects among social and economic environments and food resources are beyond the scope of the present analysis though they certainly warrant further attention. Moreover, other factors such as crime, [32, 33] aesthetics, [32] or proximity to other resources [32, 33] could also relate to actual or perceived food resource access.

The benefit of business record data, which provide comparative national food resource data, must be balanced with their limitations. Neighborhood audits (street-by-street data collection by researchers) may better capture food environment features that contribute to

healthy food access, but they are not feasible for large national samples across thousands of census blocks groups. These intense audits are generally performed in smaller geographic areas, and thus preclude broad comparisons across neighborhood type and sociodemographics. In addition, ours is a cross-sectional study and thus does not capture changes in food environments over time. Further, due to lower participation of illegal immigrants in the census, U.S. census data may underestimate neighborhood minority population and poverty by as much as half. [34] Finally, our 3 km Euclidean neighborhood buffer may not accurately reflect food purchasing areas for different urban settings and sociodemographic subgroups.

Despite these limitations, our study is an essential step in understanding the allocation of theoretically healthy and less healthy food resources across social and geographic space over the entire US, and our findings can inform measurement and design in future individual-level and longitudinal studies. Our study benefits from the variation in neighborhoods of a large, nationally representative population that enables comparisons across multiple sociodemographic and urban strata within a single study. Further, our study capitalizes upon national data with alternative measures of availability of fast-food and sit down restaurants as well as grocery and convenience stores within 3 km residential buffers for each individual. By using more detailed measures of urbanicity derived both from U.S. census and landcover data, we use a more refined urban/rural classification than the traditional urban/rural dichotomy. In sum, our study benefits from several innovations and depth of coverage that has been heretofore unaddressed in a large, geographically diverse study.

Our study does not address the question of whether improving access to healthful eating options will improve dietary intake and overall health of residents living in food deserts. [2, 35, 36] Our focus was on relative accessibility rather than effects of adding a supermarket or sit-down

restaurant to any poor area – be it non-urban, low density or high density urban – on diet behaviors. This is itself the subject of extensive debate, as evident by a recent Congressional mandate for a study on "food deserts". Despite this lack of evidence, many state and national efforts are focused on providing healthy eating options for poor inner-city neighborhoods, many with high minority populations. Strategies include providing produce carts in low income neighborhoods in New York City, [37] directly or indirectly subsidizing supermarkets [38-43], banning fast-food restaurant construction in selected urban areas, [44] as well as legislation considered at the national level. [45]

Our findings suggest that common assumptions regarding income and race-ethnic subpopulation disparities in food resources are not universally true. We observed an association between greater neighborhood poverty with greater availability of fast-food restaurants in low density and non-urban areas. Conversely, we observed less availability of food stores in non-urban areas. Regardless of minority population, in high density, urban areas with high poverty, the concern about reduced access to supermarkets does not seem to be as substantial as heretofore assumed. Overall our findings suggest the need for careful targeting of food resources with greater focus on low income and minority populations from low density urban and rural areas.

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Exhibit 1. Urbanicity-specific neighborhood minority population and population density quantiles[a]

	Non-urban	Low density urban	High density urban
Count (census block groups)	1,606	4,048	1,934
Count (Add Health respondents)	3,939	6,511	3,548
% Non-Hispanic White population			
Low	0-72.6	0-71.3	0-31
Medium	72.7-96	71.4-90.6	31.1-63.7
High	96.1-100	90.7-100	63.8-100
Population density (persons/km^2)			
Low	0.2-90.8	15.4-960.6	555.2-2651.2
High	90.9-5749.8	961.5-26514.7	2651.5-22952.4

[a]National Longitudinal Study of Adolescent Health Wave III (young adulthood; 2001-02), corrected for clustering and weighted for representation. Urbanicity based on U.S. Census-defined urbanized areas (UA; non-urban or urban); locations within a UA with ≤95% (75th percentile) and >95% developed land cover were classified as "low density urban" and "high density urban," respectively.
[b]Census block group
[c]3k Euclidean neighborhood buffer

Exhibit 2. Availability of restaurants and food stores and neighborhood SES characteristics, by urbanicity[a]

	Non-urban		Low density urban		High density urban	
	mean (SE)	median (25th, 75th percentile)	mean (SE)	median (25th, 75th percentile)	mean (SE)	median (25th, 75th percentile)
Absolute fast-food restaurant availability (raw counts)[b]	5.5 (1.1)	1 (0, 6)	19.0 (0.8)	16 (8, 25)	50.1 (5.5)	33 (22, 50)
Absolute sit down restaurant availability (raw counts)[b]	1.6 (0.7)	0 (0, 0)	12.5 (1.3)	3 (0, 18)	51.0 (7.8)	27 (10, 54)
Absolute total restaurants (fast +sit down raw counts)[b]	7.0 (1.8)	1 (0, 7)	31.5 (2.0)	21 (10, 40)	101.0 (13.2)	60 (36, 100)
Relative fast-food availability (#fast-food/#total restaurants)[b]	51.3 (2.8)	64 (0, 100)	73.2 (1.7)	70 (51, 100)	61.3 (2.9)	53 (46, 69)
Fast-food restaurant density (count per 10,000 population)[b]	6.1 (0.3)	4 (0, 10)	6.5 (0.2)	6 (4, 8)	5.6 (0.2)	5 (4, 7)
Absolute grocery/supermarket availability (raw counts)[b]	1.5 (0.8)	0 (0, 0)	8.0 (0.9)	2 (0, 9)	45.0 (11.8)	16 (6, 35)
Absolute convenience store availability (raw counts)[b]	2.3 (0.9)	0 (0, 0)	10.7 (1.1)	4 (0, 17)	36.8 (5.6)	26 (13, 39)
Grocery/supermarket density (count per 10,000 population)[b]	0.5 (0.1)	0 (0, 0)	1.8 (0.2)	1 (0, 3)	3.1 (0.3)	3 (1, 4)
Convenience store density (count per 10,000 population)[b]	1.5 (0.5)	0 (0, 0)	2.8 (0.2)	2 (0, 5)	3.8 (0.3)	4 (2, 6)
% College educated or above[c]	16.7 (0.8)	13.6 (8.3, 20.8)	25.6 (1.1)	20.8 (11.5, 35.8)	22.2 (1.8)	15.7 (7.2, 30.7)
% White/Non-Hispanic[c]	78.6 (2.9)	92.0 (70.8, 97.7)	76.1 (1.6)	84.6 (65.2, 93.7)	58.9 (3.4)	62.9 (36.4, 85.5)
% Below poverty[c]	16.7 (1.1)	12.5 (7.3, 22.7)	13.5 (0.5)	9.2 (4.1, 17.7)	18.4 (1.0)	15.7 (8.0, 25.3)
Population density[b]	292.6 (92.9)	84.5 (22.8, 236.1)	1,148.8 (63.4)	927.5 (514.1, 1,399.4)	3,604.5 (562.3)	2,125.4 (1,650.3, 3,533.6)

[a]National Longitudinal Study of Adolescent Health Wave III (2001-02), corrected for clustering and weighted for representation. Urbanicity based on U.S. Census-defined urbanized areas (UA; non-urban or urban); locations within a UA with ≤95% (75th percentile) and >95% developed land cover were classified as "low density urban" and "high density urban," respectively.
[b]3k Euclidean neighborhood buffer
[c] Census block group

Exhibit 3. Association between high neighborhood poverty and restaurant availability measures, by urbanicity-specific neighborhood minority population tertile [beta coefficient (95% CI)][a]

Food resource outcome	Neighborhood minority population	Neighborhood poverty status	Non-urban	Low density urban	High density urban
Absolute fast-food restaurant availability (raw counts)					
	Low	Low	---	---	1.00
		High	---	---	0.04 (-0.13, 0.22)
	Medium[e]	Low	1.00[e]	1.00[e]	1.00
		High	0.15 (-0.15, 0.46)	**0.21 (0.12, 0.31)**	**0.22 (0.09, 0.34)**
	High	Low	---	---	1.00
		High	---	---	**0.34 (0.19, 0.49)**
Absolute sit down restaurant availability (raw counts)					
	Low	Low	1.00	---	---
		High	0.08 (-1.25, 1.41)	---	---
	Medium[e]	Low	1.00	1.00[e]	1.00[e]
		High	**-1.83 (-2.78, -0.88)**	-0.08 (-0.34, 0.17)	0.09 (-0.13, 0.31)
	High	Low	1.00	---	---
		High	-0.29 (-1.08, 0.51)	---	---
Relative fast-food availability (#fast-food/#total restaurants)					
	Low	Low	1.00	1.00	---
		High	-4.77 (-14.38, 4.84)	**10.43 (5.82, 15.03)**	---
	Medium[e]	Low	1.00	1.00	1.00[e]
		High	**18.31 (9.99, 26.63)**	**12.07 (7.71, 16.42)**	4.66 (-0.73, 10.05)
	High	Low	1.00	1.00	---
		High	9.78 (-0.28, 19.85)	**4.93 (1.14, 8.72)**	---
Fast-food restaurant density (count per 10,000 population)					
	Low	Low	1.00	1.00	---
		High	0.41 (-1.29, 2.11)	**5.10 (1.16, 9.03)**	---
	Medium[e]	Low	1.00	1.00	1.00[e]
		High	**3.97 (2.48, 5.45)**	**2.76 (0.82, 4.70)**	3.87 (-1.17, 8.91)
	High	Low	1.00	1.00	---
		High	1.91 (-0.28, 4.11)	0.52 (-0.09, 1.13)	---

[a] National Longitudinal Study of Adolescent Health Wave III (young adulthood; 2001-02), corrected for clustering and weighted for representation. Estimated from urbanicity-stratified regression modeling restaurant availability (within 3k Euclidean buffer) as a function of neighborhood poverty status (>20% population below federal poverty level, compared to ≤20% of population below federal poverty level), with neighborhood poverty*neighborhood minority interactions.
[b] Negative binomial regression models, controlling for population density (urbanicity-specific high vs low), neighborhood-level education, and total restaurant count

[c]Linear regression models, controlling for population density (urbanicity-specific high vs low), neighborhood-level education, and total restaurant count
[d]Linear regression models, controlling for neighborhood-level education
[e]No significant neighborhood poverty x minority population interactions ($p<.10$), estimates reported across all levels of neighborhood minority population

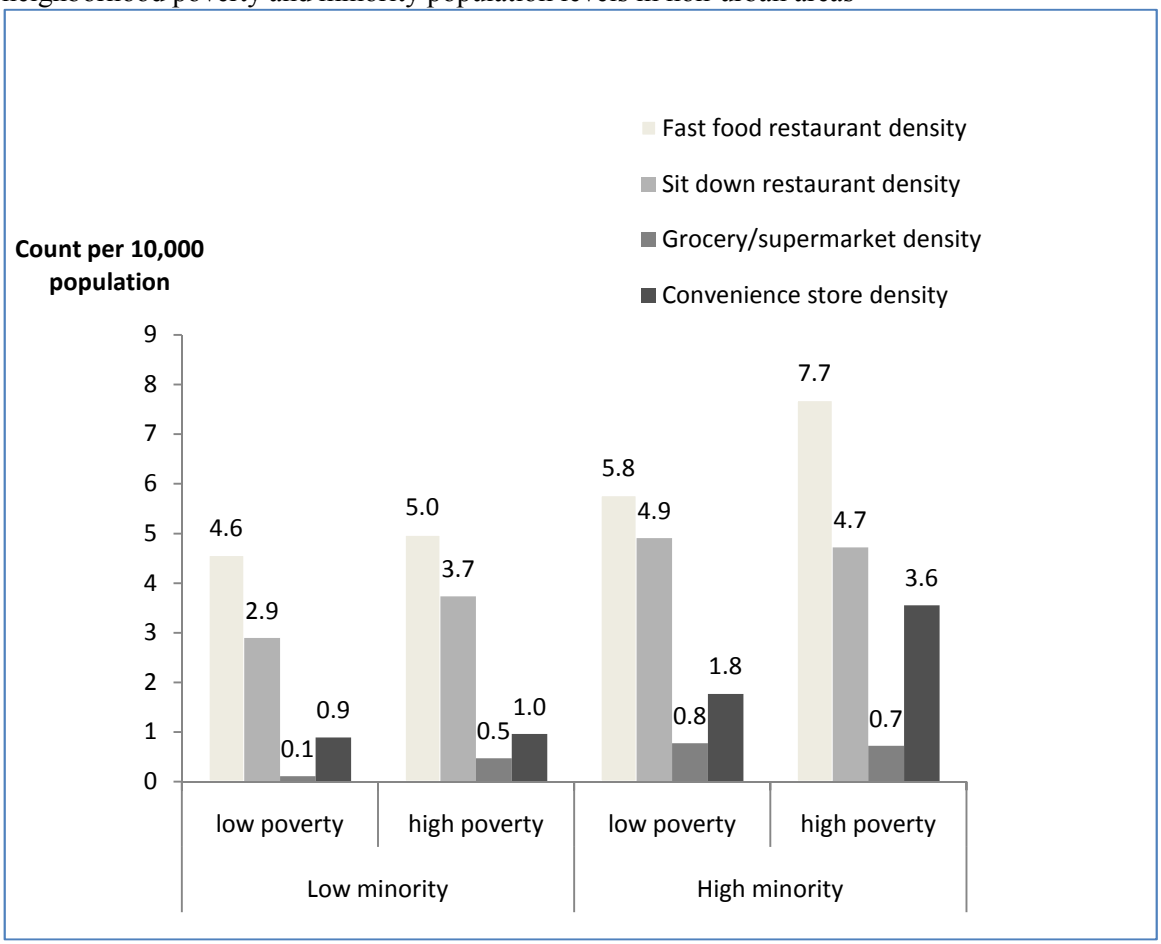
Exhibit 4. Association between high neighborhood poverty and food store availability measures, by urbanicity-specific neighborhood minority population tertile [beta coefficient (95% CI)][a]

Food resource outcome	Neighborhood minority population	Neighborhood poverty status	Non-urban	Low density urban	High density urban
Absolute grocery/supermarket availability (raw counts)					
	Low	Low	1.00	---	---
		High	0.29 (-0.98, 1.55)	---	---
	Medium[e]	Low	1.00	1.00[e]	1.00[e]
		High	**-1.94 (-2.77, -1.11)**	0.02 (-0.21, 0.26)	0.23 (-0.01, 0.47)
	High	Low	1.00	---	---
		High	-0.41 (-1.28, 0.45)	---	---
Absolute convenience store availability (raw counts)					
	Low	Low	1.00	---	---
		High	-0.21 (-1.12, 0.70)	---	---
	Medium[e]	Low	1.00	1.00[e]	1.00[e]
		High	**-1.58 (-2.47, -0.69)**	-0.09 (-0.30, 0.12)	0.07 (-0.12, 0.26)
	High	Low	1.00	---	---
		High	0.24 (-0.63, 1.12)	---	---
Grocery/supermarket density (count per 10,000 population)					
	Low	Low	1.00	---	---
		High	**0.36 (0.10, 0.61)**	---	---
	Medium[e]	Low	1.00	1.00[e]	1.00[e]
		High	**-0.48 (-0.81, -0.14)**	-0.07 (-0.42, 0.29)	0.69 (-0.08, 1.46)
	High	Low	1.00	---	---
		High	-0.05 (-0.73, 0.62)	---	---
Convenience store density (count per 10,000 population)					
	Low	Low	1.00	---	---
		High	0.07 (-0.59, 0.73)	---	---
	Medium[e]	Low	1.00	1.00[e]	1.00[e]
		High	**-0.93 (-1.57, -0.29)**	-0.26 (-0.68, 0.15)	-0.19 (-0.88, 0.51)
	High	Low	1.00	---	---
		High	1.79 (-1.21, 4.78)	---	---

[a] National Longitudinal Study of Adolescent Health Wave III (young adulthood; 2001-02), corrected for clustering and weighted for representation. Estimated from urbanicity-stratified regression modeling restaurant availability (within 3k Euclidean buffer) as a function of neighborhood poverty status (>20% population below federal poverty level, compared to ≤20% of population below federal poverty level), with neighborhood poverty*neighborhood minority interactions.
[b] Negative binomial regression models, controlling for population density (urbanicity-specific high vs low), neighborhood-level education, and total restaurant count
[c] Linear regression models, controlling for population density (urbanicity-specific high vs low), neighborhood-level education, and total restaurant count

[d]Linear regression models, controlling for neighborhood-level education
[e]No significant neighborhood poverty x minority population interactions ($p<.10$), estimates reported across all levels of neighborhood minority population

Exhibit 5. Predicted neighborhood food resource density (count per 10,000 population) for various neighborhood poverty and minority population levels in non-urban areas[a]



[a]National Longitudinal Study of Adolescent Health Wave III (young adulthood; 2001-02), corrected for clustering and weighted for representation. Estimated from urbanicity-stratified regression modeling food resource availability (within 3k Euclidean buffer) as a function of neighborhood poverty status (>20% population below federal poverty level, compared to ≤20% of population below federal poverty level), with neighborhood poverty*neighborhood minority interactions. For simplicity, predictions for medium neighborhood minority population are not reported; low and high neighborhood minority population are 0-71% and 91-100% non-Hispanic white, respectively.

Supplement

Detailed food resource definitions based on 4- and 8-digit Standard Industrial Classification (SIC) codes

Food Resource Type	SIC subgroup	SIC	SIC definition
Grocery/Supermarkets	Grocery/Supermarkets (5411)	54110200	Convenience stores
		54110201	Convenience stores, chain
		54110202	Convenience stores, independent
		54110100	Supermarkets
		54110101	Supermarkets, chain
		54110102	Supermarkets, greater than 100,000 square feet (hypermarket)
		54110103	Supermarkets, independent
		54110104	Supermarkets, 55,000 - 65,000 square feet (superstore)
		54110105	Supermarkets, 66,000 - 99,000 square feet
		54110000	Grocery stores
		54119900	Grocery stores, nec
		54119903	Frozen food and freezer plans, except meat
		54119904	Grocery stores, chain
		54119905	Grocery stores, independent
		54119902	Delicatessen stores
		54119901	Cooperative food stores
	Other grocery sources (5399)	53999903	Country general stores
		53999906	Warehouse club stores
Convenience stores	Convenience Stores (5331)	53310000	Variety stores
		55410000	Gasoline service stations
		55419900	Gasoline service stations, nec
		55419901	Filling stations, gasoline
Fast-food restaurants	Away-from-home (5812)	58120300	Fast-food restaurants and stands
		58120301	Box lunch stand
		58120302	Carry-out only (except pizza) restaurant
		58120303	Chili stand
		58120304	Coffee shop
		58120305	Delicatessen (eating places)
		58120306	Drive-in restaurant
		58120307	Fast-food restaurant, chain
		58120308	Fast-food restaurant, independent
		58120309	Food bars
		58120310	Grills (eating places)

	58120311	Hamburger stand
	58120312	Hot dog stand
	58120313	Sandwiches and submarines shop
	58120314	Snack bar
	58120315	Snack shop
	58120600	Pizza restaurants
	58120601	Pizzeria, chain
	58120602	Pizzeria, independent
Sit down restaurants	58120100	Ethnic food restaurants
	58120101	American restaurant
	58120102	Cajun restaurant
	58120103	Chinese restaurant
	58120104	French restaurant
	58120105	German restaurant
	58120106	Greek restaurant
	58120107	Indian/Pakistan restaurant
	58120108	Italian restaurant
	58120109	Japanese restaurant
	58120110	Korean restaurant
	58120111	Lebanese restaurant
	58120112	Mexican restaurant
	58120113	Spanish restaurant
	58120114	Sushi bar
	58120115	Thai restaurant
	58120116	Vietnamese restaurant
	58120117	Pakistani restaurant
	58120700	Seafood restaurants
	58120701	Oyster bar
	58120702	Seafood shack
	58120800	Steak and barbecue restaurants
	58120801	Barbecue restaurant
	58120802	Steak restaurant
	58129904	Chicken restaurant
	58120500	Family restaurants
	58120501	Restaurant, family: chain
	58120502	Restaurant, family: independent