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Associations of Built Food Environment with Dietary Intake among Youth with Diabetes

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Abstract

Objective: To evaluate the associations of supermarket and fast food outlet accessibility and availability with dietary intake among youth with diabetes.

Design: Individual's residential location and dietary intake was obtained from the SEARCH for Diabetes in Youth study. Food outlets data obtained from the South Carolina Department of Health and Environmental Control and InfoUSA were merged based on names and addresses of the outlets. The comprehensive data was then used to construct accessibility and availability measures for each participant.

Setting: State of South Carolina.

Participants: 359 youths with diabetes (10 years and above) from the SEARCH study.

Phenomena of Interest: Supermarket and fast food outlet accessibility and availability; dietary intake represented by Dietary Approaches to Stop Hypertension (DASH) score.

Analysis: Generalized estimating equations analyses.

Results: Increased availability and accessibility of supermarkets was significantly associated with higher DASH score, even after adjusting for individual-level correlates, urbanicity and fast food outlet accessibility or availability. Fast food accessibility, however, was only associated with specific food groups (meat, sweets and low-fat dairy intake), not with the DASH score.

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Conclusions and Implications: Efforts to promote environments conducive to healthy eating may significantly improve the overall dietary intake and reduce diet-related health complications among youth with diabetes.

Keywords

Built food environment; DASH adherence score; supermarket; fast food outlet; accessibility/availability

INTRODUCTION

Previous studies have documented the poor dietary intake among youth[1,2], with almost 95% of adolescents failing to meet the Healthy People 2010 recommendations for fruits, vegetable or nutrient-rich vegetable servings[2]. A study among youth with diabetes has reported higher intake of total (37%-38% of energy) and saturated fat (13% of energy)[3] than recommended level (<30% of energy from total fat and <10% from saturated fat) for healthy children and adolescents by the American Heart Association.

Dietary modification is a crucial factor in the management of obesity, hypertension, blood lipids[4] and diabetes[5], and to achieve optimal health outcomes. Further, diet is an integral component of medical nutrition therapy for individuals with diabetes in order to maintain optimal metabolic outcomes, and to prevent and treat chronic complications[6]. Given the evidence that children and youth with diabetes have poor dietary behavior[3] despite the higher likelihood of various cardiovascular disease risk factors[7], it is important to understand factors influencing children's dietary consumption.

Several studies have demonstrated that the presence[8,9] and proximity[10] to supermarkets in neighborhoods was associated with increased fruit/vegetable intake, with some exceptions[11,12]. In contrast, increased fast food outlet accessibility and availability was associated with poor dietary intake[11,12]. Most of these studies, however, focused either on an environment supporting a healthy diet (e.g., supermarkets), or an environment supporting an unhealthy diet (e.g.,fast food outlets) rather than both simultaneously. Furthermore, most studies assessed individual dietary components (e.g.,fruit intake)[8,11,12] rather than overall diet quality, which can be measured by diet indices such as the Dietary Approaches to Stop Hypertension (DASH)[4,13].

The purpose of this study was to explore the associations of the accessibility and availability of supermarkets (proxies for healthy food) and fast food outlets (proxies for unhealthy food) with dietary intake among youth with diabetes (type 1 and type 2 diabetes) from South Carolina (SC). Distance to nearest food outlets from youth's residence represented accessibility, and number and density of food outlets around residence represented availability. This study evaluated the associations of supermarket and fast food outlet accessibility and availability with dietary intake separately as well as simultaneously.

RESEARCH DESIGN AND METHODS

STUDY DESIGN

Details on the SEARCH for Diabetes in Youth Study, hereafter called the SEARCH study have been published[14]. SEARCH is a multi-center, multi-ethnic, population-based observational study that ascertained prevalent non-gestational cases of physician-diagnosed diabetes in youth aged <20 years in 2001 and continues with the ascertainment of incident cases through the present. This analysis is limited to the Carolina SEARCH site, which is one of the six clinical sites. Youth with prevalent diabetes were ascertained in four counties and statewide ascertainment was conducted of newly diagnosed cases in 2002 and beyond. Data were collected during the initial patient survey and in-person clinic visits. Specifically, dietary data was collected during baseline clinic visit for prevalent cases, and baseline and follow-up 1 visit (12 months) for incident (2002-2005) cases by trained and certified SEARCH staff.

Youth with diabetes who participated in the Carolina site between 2001 and 2005 and had at least one time point of dietary data were eligible for this study. This study was reviewed and approved by University of South Carolina's Institutional Review Board.

DIETARY ASSESSMENT, DASH ADHERENCE SCORE, AND OTHER INDIVIDUAL-LEVEL CHARACTERISTICS

Details of dietary assessment in youth aged 10 years and above can be found elsewhere[3]. The overall dietary intake quality was evaluated using the DASH index (comprised of eight food groups: grains, vegetables, fruits, dairy, meat, nuts/seeds/legumes, fats/oils, and sweets)[15], as described in detail[13]. A maximum score of 10 could be achieved for each food group when the intake met the recommended level. Following the DASH eating plan guidelines[15], each individual was assigned a distinct energy-level closest to his/her estimated energy requirement on the basis of age, sex, and physical activity[13] i.e. some youth were evaluated based on the DASH 1,600 kcal/day plan, some based on the DASH 2,300 kcal/day plan, and so on. To calculate their DASH adherence score, individuals' intake were then compared to the distinct goals for this energy level. To more closely reflect the recommendations of DASH, the grains and dairy components consisted of 2 items (grains:total and high-fiber grains, each worth 5 points; dairy:total and low-fat dairy, each worth 5 points) and addressed a qualitative goal in addition to a quantitative one. The overall DASH score combined the resulting scores from all food groups, which could range from 0 to 80.

Age at in-person clinic visit, race/ethnicity, gender and parental education were considered. Race/ethnicity was categorized as non-Hispanic white (NHW) and African American (AA)/ Others. Physician-diagnosed diabetes was categorized into type 1 and type 2 diabetes.

BUILT FOOD ENVIRONMENT DATA

Supermarkets included large corporate-owned franchised food stores selling groceries, including fresh produce and meat (e.g.,Bi-lo, Publix, Wal-Mart, IGAs). Fast food outlets included nationally or internationally known franchised limited-service restaurants that sell inexpensive, quickly served foods with payment made prior to receiving food, and had limited or no wait staff. Fast food outlets included Bojangles', McDonald's etc.

Data on food outlets including latitude and longitude were obtained from SC Department of Health and Environmental Control, SCDHEC (August 2008) and InfoUSA Inc. (February 2009). After performing substantial data cleaning to remove spelling errors and duplicate entries, 686 supermarkets and 2624 fast food outlets were identified in SC.

GEOCODING AND BUILT FOOD ENVIRONMENT MEASURES

Addresses of youth with diabetes were geocoded to street address-level with an automated process using Topographically Integrated Geographic Encoding and Referencing road files: TIGER 2000 and 2006 in ArcGIS 9.3 software. The remaining addresses were geocoded to street address level using "World Imagery" layer in ArcGIS. Out of a total 406 youth with diabetes, 380 had street address information. A total of 359 (94%) youth with street address were successfully geocoded.

Five measures of availability of and accessibility to supermarkets and fast food outlets for each participant were calculated[16] using ArcGIS 9.3 and R 2.9.1 software. Accessibility was defined as travel distance in miles using the shortest network distance to the nearest food outlet and as the average distance to the three nearest food outlets. Availability was defined as the number or density of food outlets within a specified network buffer around youth's residence, and included three measures: number (i.e.count), crude density (number per square mile) and kernel density (number per square mile).

This study used network buffers of 4- and 6-mile as reasonable driving distances for supermarkets. Fast food availability, however, was assessed only in close proximity (1-mile) to the residential locations, with the assumption that youth are more likely to walk or bike to nearby outlets[17]. The crude density of food outlets around residence was calculated by dividing the number of outlets within specified network buffer by the area of the buffer. The kernel density calculation proceeded in 2 steps: first a smoothed map to represent densities of outlets was generated using Gaussian kernel density function. Bandwidths of 4-mile and 1-mile were selected to generate the density surface for supermarkets and fast food outlets, respectively. The densities of food outlets were then estimated by overlaying residence locations of participants on the kernel density map.

Census tract-level four-tier consolidated Rural-Urban Commuting Area (RUCA) system representing urban core, sub-urban, large rural town, and small town/ isolated rural[18], was assigned to each participant based on his/her tract of residence.

STATISTICAL ANALYSIS

Generalized estimating equations (GEE) analyses were used to quantify the associations of supermarket and fast food outlet accessibility and availability with the DASH adherence score, while adjusting for the potential dependence of the dietary measures taken repeatedly over time on each individual. First, stratified analyses were conducted to determine associations by diabetes type, and found similar results. Hence, we proceeded with analyses which combined youth with type 1 and type 2 diabetes. Associations of supermarket and fast food outlet measures with dietary intake were assessed both separately and simultaneously. All analyses were adjusted for age at clinic visit, gender, race/ethnicity, diabetes type, diabetes duration and cohort year. Variables such as parental education and census tract-level urbanicity (RUCA) were included in sequential models. P-value of 0.05 was used as a cut-off point for level of significance. All statistical analyses were performed in SAS version9.2 (SAS Institute Inc.,Cary,NC,2008). Since the results for 4- or 6-mile buffers were extremely similar, results are presented for supermarket availability only in 4-mile buffer.

RESULTS

PARTICIPANT PROFILE

The average age of this study sample was 14.5 years and the majority was female (54.3%) and non-Hispanic white (57.7%) (Table 1). Approximately two-thirds had parents with more than a high school education (68.3%), and more than one-third of the youth lived in household with income of $50,000 and more (38.4%). Majority of youth lived in urban census tracts (61.6%) and tracts with median household income around $50,000.

The study participants exhibited a fairly poor dietary intake (Table 2). The DASH adherence score in this study was fairly poor (Median score=37.1). Only a small percentage of youth met the recommended daily levels for total grains(13%); whole grains(0%); vegetables(17%); fruit(9%); total dairy(22%); low-fat dairy(15%); meat, poultry, fish, eggs(44%); nuts, seeds, legumes(31%); fats, oils(41%); and sweets(30%) (data not shown).

ACCESSIBILITY AND AVAILABILITY OF FOOD OUTLETS

Half of the study population resided at the distance of 2.0 miles or less from the nearest supermarket (1.6 miles from the nearest fast food outlet), and at the average distance of 2.8 miles from the three nearest supermarkets (1.9 miles from three nearest fast food outlets). The median value for crude density and kernel density of supermarkets were 0.2 and 0.8 per square mile, respectively (fast food 0.0 and 1.0 per square mile). For all measures of availability and accessibility, substantial amount of variations were observed across the study population (Table 3).

ASSOCIATIONS OF FOOD OUTLETS ACCESSIBILITY AND AVAILABILITY WITH DASH ADHERENCE SCORE

The DASH adherence score significantly decreased by 0.29 for every mile increase in distance to a nearest supermarket, after adjusting for individual-level correlates (estimated difference:−0.29,95%CI:−0.57,−0.02,p<:0.05;Table 4,Model 2). Adjustment for urbanicity slightly attenuated the association (Table 4,Model 3). Similarly, the DASH score significantly decreased by 0.30 for every mile increase in distance to three nearest supermarkets, even after adjusting for individual-level correlates and urbanicity (estimated difference:−0.30,95%CI:−0.59,−0.008, p<0.05;Table 4,Model 3). Further adjustment for fast food accessibility strengthened the associations between supermarket accessibility measures and the DASH score.

The DASH score increased for each additional supermarket within 4-mile network buffer around the residence; however the association did not reach statistical significance (Table 4,Model 1-3). Further, the DASH score significantly increased for each additional supermarket per square mile, represented by crude density, even after adjustment for individual-level correlates and urbanicity (estimated difference:5.25,95%CI:0.51,9.98,$p<0.05$;Table 4,Model 3). Further adjustment for fast food availability slightly strengthened the associations between supermarket availability measures and the DASH score, and the association with kernel density also became significant (estimated difference:2.04,95%CI:0.03,4.06,$p<0.05$,Table 4,Model 4).

None of the fast food outlet accessibility/availability measures were significantly associated with the DASH score (Table 4). However, the direction of associations was in the expected direction after adjustment for supermarket accessibility/availability.

ASSOCIATIONS OF FOOD OUTLETS ACCESSIBILITY WITH FOOD GROUPS

Fruits, vegetables and low-fat dairy intake decreased as an individual resided at greater distance to the three nearest supermarkets (fruits:estimated difference:−0.06,95%CI: −0.12,−0.003, $p<0.05$; vegetables:estimated difference:−0.03,95%CI:−0.08,−0.01,$p<0.05$; low-fat dairy;estimated difference:−0.04,95%CI:−0.07,−0.01,$p<0.01$;Table 5). This implies that an individual's fruit serving was reduced by almost half for every 10-mile increase in distance to three nearest supermarkets. In contrast, the intake of low-fat dairy increased, and meat and sweets decreased as an individual resided at greater distance to the three nearest fast food outlets (low-fat dairy:estimated difference:0.03,95%CI:0.01,0.06,$p<0.05$; meat:estimated difference:−0.04, 95%CI:−0.08,−0.01,$p<0.05$; sweets:estimated difference: −0.04,95%CI:−0.08,−0.003,$p<0.05$;Table 5).

DISCUSSION

The findings from this study suggest that increased accessibility and availability of supermarkets may significantly improve the overall dietary intake and support increased intake of fruits, vegetables and low-fat dairy. This may be due to the availability of a variety of healthful foods in chain supermarkets compared to other food stores[19]. These findings are consistent with previous studies that have shown that individuals with supermarket in their neighborhoods[8,9], or supermarkets at closer proximity to home[10] have a better diet. For instance, a lower diet quality was observed among pregnant women living greater than 4-mile from a supermarket[10]. Similarly, participants with no supermarkets within 1-mile of their home were 25-46% less likely to have a healthy diet compared to participants who had the most stores[9].

Fast food outlet accessibility and availability in this study was not associated with the DASH score (the overall measure of dietary quality) and is consistent with Moore et al. (2009) where alternate healthy eating index was not associated with fast food outlet availability[20]. The lack of association in this study may be the result of very low DASH score or inability to account for fast food environment around potential locations (e.g.,schools). This could have resulted in underestimation of the true associations of fast food measures with dietary intake. Furthermore, the direction of associations of fast food outlet accessibility and availability with the DASH score was unexpected and contrary to the hypothesis. The direction changed once adjusted for supermarket accessibility/availability. This may be due to the fact that a large proportion of supermarkets (78%) had one or more fast food outlets at close proximity (one half mile).

When specific food groups were analyzed, this study provided some support for a negative influence of fast food accessibility. Specifically, increased distance to fast food outlet from residence location was associated with a significantly decreased intake of meat and sweets and increased intake of low-fat dairy. This finding is consistent with finding from Moore et al. (2009) where increased fats and processed meat dietary pattern was associated with increased fast food outlet availability[20].

This study showed comparatively lower accessibility and availability of supermarkets and fast food outlets compared to previous studies[9–11,20].The study population in these previous studies were from urban cities and counties and hence lived in closer proximity to supermarkets (1.0-1.5 miles) and fast food outlets (0.5-1.0 mile), and had higher density of supermarkets and fast food outlets (1.5 and 2.0 per square mile, respectively), which was not expected in this study encompassing rural state.

There are a few potential sources of error in this study. First, the addresses are the contact addresses and may not represent the residence location. Another concern is that the built food environment data was collected several years after the individual-level data were collected, a major limitation of secondary analysis of existing data on the built food environment. It is likely that some change in food environments (closing or opening of outlets) occurred during the study period, however, these changes would most likely be occurring independently of dietary intake of the study population. This non-differential misclassification thus would lead to bias towards null. The fact that this study found significant results despite the possible changes in the years between the diet and the environment assessment shows the strength of the relationship. One of the major concerns in previous epidemiologic studies exploring the impact of food environment has been the validity of food outlet data from secondary sources[21]. However, our recent validation work in SC showed better sensitivity and positive predicted values (PPV) for both supermarkets/grocery stores (sensitivity-86% and PPV-86%) and limited service restaurants category (sensitivity-93% and PPV-93%), when the combination of SCDHEC and InfoUSA datasets were used[22]. Hence, consideration of these two data sources would have minimized the count error in this study. Furthermore, for error in the food outlet database to bias the results, it would have to be correlated with the individual dietary intake quality, which is highly unlikely. This study considered only franchised grocery and fast food outlets as proxies for healthy and unhealthy food availability because of high chances of misclassification of other small stores (i.e.convenience stores providing unhealthy food classified as small grocery stores providing healthy food by databases). Finally, the use of a food frequency questionnaire relies on participants' perception of frequency and portion size and may not capture the overall diet variability[23]. In addition, this and several other studies used administratively defined buffers around home addresses to quantify the food accessibility/availability. This is based on the assumption that individuals do their food shopping in their local neighborhoods. Even if this assumption is not met, the local food environment may be representative of the actual shopping environment of youth and their families in this study.

This study contributes to the literature in several ways. First, it quantified the accessibility and availability of food outlets at the individual-level, an approach that has been described as ‘cutting edge’ in built food environment study. Secondly, it included youth from the entire state encompassing urban, sub-urban, large town and small town/rural areas. Third, it explored the impact of food environment on dietary intake by considering both obesogenic environmental components (i.e.fast food outlets) and those conducive of healthy eating (i.e.supermarkets). Only a few studies have explored the associations of both healthy and unhealthy food environments with dietary intake[8,11,12]. This two-fold approach can be an important aspect to consider in SC and other states which lack specific land-use zoning and are typified by clustering of retail locations around arterial roads with high traffic volume[24]. Finally, it included five different measures that allowed us to capture different dimensions of the food environment such as immediate proximity, variety and diversity. Only one existing study of the influence of the built food environment on dietary intake has explored multiple dimensions of accessibility and availability[12].

IMPLICATIONS FOR RESEARCH AND PRACTICE

The results from this study suggest that the built food environment may be a key contextual factor that influences dietary intake among the youth with diabetes. These results have potential implications for public health interventions. Given the findings of extremely poor dietary intake, efforts to promote environments conducive to healthy food choices may provide better opportunities for healthy eating and hence may reduce diet-related health complications among youth with diabetes. Particularly, efforts to support farmers markets and small stores to offer fruits/vegetables and other healthy food options may be a better solution in rural areas, where residents travel large distances to supermarkets/grocery stores, a factor that has been identified to have impact on fruits/vegetables intake beyond affordability[25]. Increasing awareness about the role of the neighborhood food environment among dieticians and diabetes educators working with youth with diabetes also seems an important component of improving health practice. Understanding the individual patient’s perception of his/her local food environment in the context of nutrition counseling seems an important first step towards offering advice on ways to make healthier choices, especially in limited-resource settings.

This study, like several other studies, has used the residential food environment as the proxy of individual’s shopping environment. Nevertheless, future studies should also consider several other food shopping venues located close to home, work, schools etc. Furthermore, an individual’s shopping environment can also be affected by factors such as individual’s purchasing behaviors, perceptions of the availability and prices of foods, and social perceptions, along with the actual food environment in individual’s neighborhood[26]. Hence, future studies integrating individual, social and environment factors can provide better understanding of the factors that influence an individual’s choice of their food environment and their dietary behavior.

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Table 1.

Baseline characteristics of youth with diabetes (N=359;type 1 diabetes:274 and type 2 diabetes:85).

Characteristics	Variables	Mean(SD) or %	Range
Individual	Age at clinic visit	14.5(2.9)	9.1,21.5
	Gender(Female)%	54.3	-
	Race/ethnicity%		
	Non-Hispanic white	57.7	-
	African American or Others	42.3	-
	Highest parental education * %		
	Less than HS graduate	6.7	-
	HS graduate	24.0	-
	Some College thru Assoc Degree	32.9	-
	Bachelors degree or more	35.4	-
	Household income * %		
	<$25K	26.5	-
	$25-49K	20.1	-
	$50-74K	18.9	-
	$75K+	19.5	-
Neighborhood	Median household income($)	40,939(12,893)	13,020,91,459
	Population density(per sq.mile)	961.5(1,206.2)	11.9,12,042.9
	Urban/Rural		
	Urban	61.6	-
	Suburban	20.9	-
	Large towns	14.5	-
	Small towns and rural	3.1	-

* % does not add up to 100 due to missing information on few participants.

Table 2.

Estimated daily intake of selected food groups and DASH adherence score for youth with diabetes (N=359;type 1 diabetes:274 and type 2 diabetes:85).

Diet characteristics	Median(25th,75th percentile)	Range
DASH score	37.1(31.0,43.8)	11.2,64.3
Energy, kcal/day	1558.9(1174.1,2197.4)	399.8,5790.1
Food groups, servings per 1,000 kcal		
Total grains	2.1(1.7,2.6)	0.3,6.6
High-fiber grains	0.0(0.0,0.1)	0.0,1.2
Vegetables	1.1(0.7,1.7)	0.0,6.9
Fruit	0.7(0.3,1.2)	0.0,5.9
Total dairy	0.7(0.4,1.1)	0.0,3.7
Low-fat dairy	0.2(0.0,0.6)	0.0,3.3
Meat	1.4(1.0,1.8)	0.2,3.9
Nuts and seeds	0.1(0.0,0.4)	0.0,4.3
Fats and oil	2.0(1.1,3.1)	0.0,8.2
Sweets	0.7(0.3,1.2)	0.0,4.5

DASH:Dietary Approaches to Stop Hypertension

DASH-recommended servings per 1000 kcal per day:≥3 servings of total grains; having at least 50% whole grains of daily servings;≥2 servings of vegetables;≥2 servings of fruits;≥1 serving of total dairy; having at least 75% low-fat dairy of daily servings;≤1 serving of lean meats, poultry, or fish;≥0.3 servings of nuts, seeds, or legumes;≤1.5 servings of fats and oils;≤0.3 servings of sweets and added sugar.

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Table 3.

Food outlets accessibility/availability for youth with diabetes (N=359; type 1 diabetes:274 and type 2 diabetes:85).

Food outlet types	Accessibility/availability measures	Median (25^{th},75^{th} percentile)	Range
Supermarket	Distance to nearest(miles)	2.0(1.1,3.7)	0.2,14.8
	Average distance to three nearest(miles)	2.8(1.8,4.9)	0.6,17.3
	Number in 4-mile buffer	3.0(1.0,6.0)	0.0,18.0
	Crude density in 4-mile buffer(per sq.mile)	0.2(0.04,0.4)	0.0,1.1
	Kernel density(per sq.mile)	0.8(0.3,1.5)	0.0,2.5
Fast food	Distance to nearest(miles)	1.6(0.8,3.3)	0.0,15.7
	Average distance to 3 nearest(miles)	1.9(1.0,4.0)	0.2,15.7
	Number in 1-mile buffer	0.0(0.0,1.0)	0.0,17.0
	Crude density in 1-mile buffer(per sq.mile)	0.0(0.0,1.3)	0.0,25.8
	Kernel density(per sq.mile)	1.0(0.03,3.2)	0.0,9.8

Table 4.

Associations of supermarket and fast food outlet accessibility/availability with DASH adherence score for youth with diabetes.

Food outlet types/Accessibility and availability measures	Model 1[a]		Model 2[b]		Model 3[c]		Model 4[d]	
	Estimated difference	95% CI	Estimated difference	95% CI	Estimated difference	95% CI	Estimated difference	95% CI
Supermarket								
Distance to nearest(miles)	−0.326*	−0.595,−0.057	−0.294*	−0.569,−0.020	−0.294	−0.592,0.004	−0.411	−0.913,0.091
Average distance to three nearest(miles)	−0.310*	−0.557,−0.061	−0.285*	−0.533,−0.038	−0.302*	−0.595,−0.008	−0.703*	−1.278,−0.128
Number in 4-mile buffer	0.218	−0.035, 0.471	0.189	−0.064,0.442	0.182	−0.103,0.467	0.217	−0.074,0.508
Crude density in 4-mile buffer(per sq.mile)	5.459**	1.309, 9.609	4.775*	0.523,9.028	5.246*	0.514,9.978	5.524*	0.607,10.441
Kernel density(per sq.mile)	1.344*	0.101, 2.587	1.112	−0.137,2.362	1.380	−0.222,2.982	2.042*	0.026,4.058
Fast Food Outlet								
Distance to nearest(miles)	−0.229	−0.560,0.102	−0.191	−0.512,0.131	−0.131	−0.536,0.274	0.166	−0.474,0.806
Average distance to three nearest(miles)	−0.176	−0.485,0.133	−0.148	−0.444,0.148	−0.081	−0.468,0.305	0.517	−0.197,1.231
Number in 1-mile buffer	−0.002	−0.345,0.341	−0.012	−0.369,0.344	−0.039	−0.410,0.331	−0.169	−0.612,0.275
Crude density in 1-mile buffer(per sq.mile)	0.008	−0.242,0.257	0.012	−0.248,0.272	−0.012	−0.285,0.260	−0.083	−0.392,0.227
Kernel density(per sq.mile)	0.148	−0.234,0.529	0.082	−0.310,0.474	0.018	−0.427,0.462	−0.301	−0.856,0.255

[a] adjusted for age at clinic visit, race/ethnicity, gender, cohort year, diabetes type, diabetes duration

[b] Model 1+parental education

[c] Model 2+urbanicity

[d] Model 3+fast food outlet accessibility/availability in supermarket model or supermarket accessibility/availability in fast food model

* p-value: <0.05

** p-value: <0.01

*** p-value: <0.0001

Table 5.

Associations of supermarket and fast food outlet accessibility with food groups for youth with diabetes.

Food Groups (servings per day per 1,000 kcal)	Average distance to three nearest(miles)	
	Supermarket[a]	Fast food outlet[a]
	Estimated difference (95% CI)	Estimated difference (95% CI)
Total grains	0.003(−0.058,0.064)	−0.016(−0.077,0.044)
High-fiber grains	−0.001(−0.010,0.008)	0.002(−0.009,0.013)
Vegetables	−0.033(−0.083,−0.006) *	0.018(−0.040,0.076)
Fruits	−0.056(−0.116,−0.003) *	0.046(−0.016,0.109)
Total dairy	−0.032(−0.072,0.007)	0.023(−0.024,0.070)
Low fat dairy	−0.042(−0.072,−0.011) **	0.027(0.007,0.061) *
Meat, poultry, fish, eggs	0.027(−0.016,0.069)	−0.036(−0.079,−0.006) *
Nuts, seeds, legumes	0.011(−0.028,0.051)	−0.014(−0.056,0.029)
Fats, Oils	0.043(−0.061,0.147)	−0.003(−0.117,0.111)
Sweets	0.005(−0.035,0.045)	−0.037(−0.076,−0.003) *

[a]Fully adjusted model:adjusted for age at clinic visit, race/ethnicity, gender, cohort year, diabetes type, diabetes duration, parental education, urbanicity, supermarket or fast food outlet accessibility

*p-value: <0.05

**p-value: <0.01

***p-value: <0.0001