

A Spatial Analysis of the Food Environment and Overweight and Obesity Among Rhode Island Youth

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ABSTRACT

BACKGROUND: This study examined how proximity to food sources differed at the block group and town level, stratified by socioeconomic risk, and how the average distance to a food source was associated with child overweight and obesity rates in Rhode Island.

METHODS: Eight correlated variables from the 2014–2018 American Community Survey were used to measure high and low socioeconomic risk at the block group and town level. Linear regression models were used to assess the association between mean driving distance to food sources and prevalence of child overweight and obesity.

RESULTS: All food sources were closer to residences in the high-risk group than the low-risk group at the block group and town level. Convenience stores, sit-down restaurants, and snack and beverage stores showed the largest associations with prevalence of overweight and obesity.

CONCLUSION: Efforts to better understand the food environment are needed to address overweight and obesity among youth.

KEYWORDS: food environment, children, overweight and obesity, spatial analysis

INTRODUCTION

Childhood obesity is a major health issue that affects 18.5% of children and adolescents across the country.¹ Children with obesity have an increased risk of developing chronic diseases including diabetes and cardiovascular diseases, which can reduce life expectancy and affect quality of life.¹ Ethnic and racial minorities have higher rates of obesity and higher risks of becoming obese.¹ In Rhode Island, 36% of Hispanic children and 37% of Non-Hispanic Black children ages 2 to 17 are overweight or obese.²

Food accessibility has been shown to influence a person's dietary behavior and weight.^{3,4} Previous research has found that individuals without access to supermarkets near their homes are less likely to have healthy diets.³ Additionally, living in close proximity to convenience stores

was associated with low Healthy Eating Index (HEI) scores among children 11–14,⁵ and also associated with higher BMI among 8th and 10th graders.⁶ Moreover, children and adolescents have greater odds of obesity the shorter the distance from their home to a fast food establishment⁷ and are significantly more likely to be obese if they attend a school within a half mile of a fast food restaurant.⁸ However, other studies have shown no association between the food environment and obesity among children and adolescents.^{9,10}

Using Rhode Island statewide food environment data, we examined how distance to food source locations varied by high and low socioeconomic risk, at the block group and town level, using risk indices created from eight highly correlated variables. We also assessed whether the town level distance to food sources was associated with town levels of overweight and obesity rates among children 2–17.

METHODS

Overview

This study included a statewide analysis of the food environment using data from multiple online sources. Rhode Island childhood overweight and obesity rates were obtained through Rhode Island KIDS COUNT published data² and demographic characteristics were obtained from the American Community Survey (ACS). We examined the mean distance to the nearest food source from every residence at the block group and town level, stratified by socioeconomic risk.

Data

Residential addresses were extracted from the Rhode Island Enhanced 9-1-1 (E911) database.¹¹ The E911 database includes all known buildings and structures in the state. We limited the structures to those identified as primary residences, multifamily, mobile homes, other residential, and seasonal homes.

For each block group, a socioeconomic risk index was constructed using eight highly correlated measures obtained from the 2014–2018 ACS: percentage of adults without high school education, percentage of single-parent households, percentage of household crowding (>1 person per room), percentage of renter occupied housing units, percentage of vacant homes (excluding vacation homes), percentage of families below 100% of the federal poverty level, percentage

of non-white residents, and percentage of housing units built before 1950.¹² Quintiles were computed for each of the eight measures and summed, resulting in a scale ranging from 8-40, with higher scores indicating greater risk. Block groups were categorized as high (≥ 75 th percentile) and low risk (< 75 th percentile), a dichotomization we have implemented previously.¹² The same process was repeated for each town to create a town level risk index and classify towns as high and low risk.

Food environment data included food markets, restaurants, and Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) sites, accessed in 2019 from the Rhode Island Department of Health website (<https://health.ri.gov/licenses/index.php>). Additional food variables included community gardens, farmer's markets, food assistance providers, and Supplemental Nutrition Assistance Program (SNAP) locations, accessed from July-August 2019 and identified from website searches including the Rhode Island Community Food Bank, Southside Community Land Trust, Farm Fresh RI, Rhode Island Department of Human Services and the U.S. Department of Agriculture.

Food environment classification

Food markets were categorized based on the number of cash registers in the store and previous literature.^{13,14} Categories included supermarkets, grocery stores, convenience stores, specialty food stores and other. Supermarkets and grocery store categories were created to differentiate between big and small grocery stores. Supermarkets included well-known, large chain stores and stores with six or more cash registers. Grocery stores included smaller stores such as local, ethnic and non-corporate owned food markets with fewer than six cash registers.¹³ Convenience store establishments primarily sold limited amounts of food, mainly packaged snack foods, and the majority had one to two cash registers.¹⁴ Specialty food stores included stores that only sold fruits and vegetables, or meat and fish. All other food markets in the dataset were included in the category 'other' if they did not fall under any of the previous categories, including dollar stores, candy shops and pharmacies.

Restaurants were categorized into the following categories: fast food restaurants, sit-down restaurants, and snack and beverage stores. Fast food restaurants included places with a drive through, locations whose primary business was take-out or had take-out or express in the name; places that sold quick, ready-to-eat food and required customers to pay at the counter.^{15,16} Sit-down restaurants included locations offering full service dining.¹⁷ Snack and beverage stores included places such as donut, coffee, ice cream, tea shops and liquor stores.¹⁶

Businesses that held a retail food peddler license were excluded from the analysis sample since they were mainly catering companies. Food pantries with a market (non-profit) license were included under food assistance providers.

Restaurants with a vending unit license or a mobile food service license were excluded because they were vending machines or food trucks and not always in the same area. If it was required to pay a fee to have access to the food place, it was excluded (hotels, country clubs, bowling alleys).

Analyses

Food environment and residential addresses were geocoded using ArcGIS 10.7.1. All food environment variables were successfully geocoded, with a 100 percent match rate. A network database was created from 2019 TIGER/Line shapefiles maintained by the Census Bureau for Rhode Island, Massachusetts, and Connecticut.¹⁸ Network distances were calculated using an Origin Destination (OD) cost matrix in ArcGIS. The least-cost driving path for every residence to food source location was computed at the block group and town level. The network databases included information for one-way traffic flow and other traffic laws. Data were analyzed using Stata 16 and SAS 9.4. Descriptive statistics were calculated for variables included in the socioeconomic risk index and weighted mean driving distances to food sources at the block group and town level. Unadjusted and adjusted weighted linear regression analyses were conducted to assess the relation between mean driving distance to a food source location in each town and the prevalence of child overweight and obesity.

RESULTS

Socioeconomic characteristics and the food environment

Block group level analysis

The mean percentage for each of the factors in the socioeconomic risk index is shown in **Table 1**. As expected, the mean percentage for each factor is greater in the high-risk group. Nearly 25% of families in the high-risk block groups lived below the federal poverty level, compared to 5% in the low-risk block groups.

Table 1. Characteristics of Rhode Island block groups by block group level risk index

Block group characteristics (%)	Low Risk (N=609)		High Risk (N=199)	
	Mean	Standard deviation	Mean	Standard deviation
Non-white	15.53	15.17	63.82	25.04
Single parent households	10.58	11.19	31.25	15.23
Adults 25+ with no high school education	8.27	6.73	24.40	11.44
Families below 100% FPL	4.93	7.46	24.92	15.11
Renter-occupied households	30.05	22.19	70.32	15.62
Vacant homes	6.50	6.23	14.88	10.10
Household crowding	0.90	2.22	4.71	5.58
Housing units built before 1950	34.79	24.15	62.12	17.92

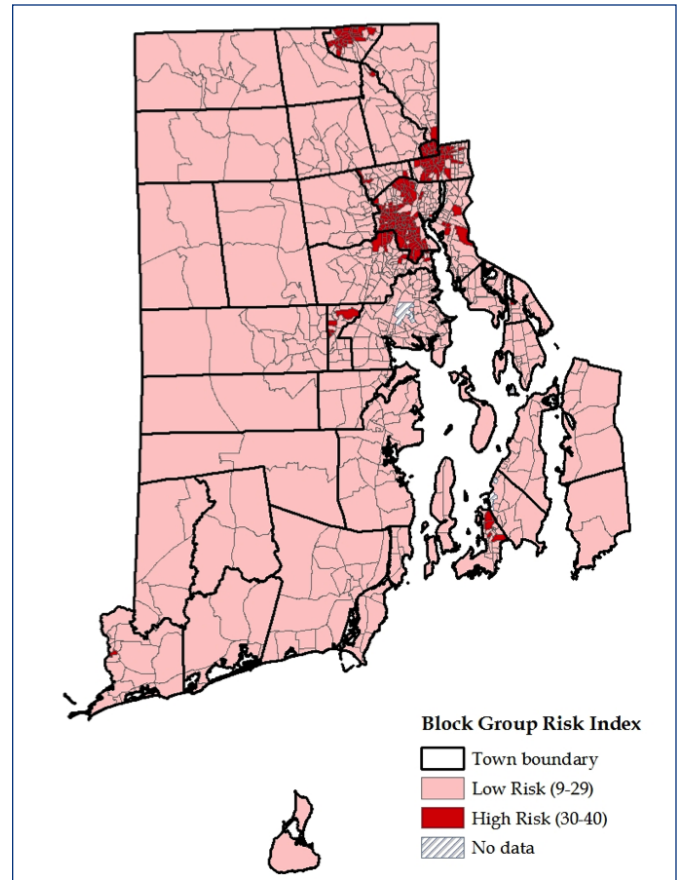
Table 2. Weighted average distance to a food source location by block group level risk index

Food Source	Low Risk (N=609)		High Risk (N=199)		p-value
	Distance (miles)	95% CI	Distance (miles)	95% CI	
Supermarket	2.32	2.12, 2.53	0.88	0.82, 0.95	<.0001
Grocery store	4.31	4.04, 4.57	0.78	0.62, 0.94	<.0001
Convenience store	1.11	1.04, 1.18	0.28	0.26, 0.29	<.0001
Specialty	2.76	2.57, 2.96	0.85	0.74, 0.97	<.0001
Other	1.28	1.23, 1.33	0.90	0.87, 0.93	<.0001
Sit down	1.00	0.92, 1.07	0.28	0.26, 0.31	<.0001
Fast food	1.16	1.07, 1.25	0.29	0.27, 0.31	<.0001
Snack and beverage	1.53	1.43, 1.63	0.60	0.56, 0.65	<.0001
Farmers market	3.21	3.02, 3.41	1.21	1.12, 1.30	<.0001
Community garden	13.28	12.37, 14.20	3.47	2.56, 4.37	<.0001
Food assistance provider	2.33	2.19, 2.47	1.21	1.15, 1.27	<.0001
WIC	4.53	4.21, 4.86	1.16	1.06, 1.26	<.0001
SNAP	7.28	6.85, 7.71	1.11	1.83, 2.38	<.0001

All food sources included in this study were closer to residences in the high-risk block groups than the low-risk block groups (Table 2). Mean distances for all food sources in the high-risk block groups ranged from 0.28 to 3.47 miles compared to food sources in the low-risk block groups whose mean distances ranged from 1.00 to 13.28 miles. For high-risk block groups, the average distance to a convenience store and sit-down restaurants were within 0.28 miles, compared to the low-risk block groups where the average distances were 1.11 and 1.00 miles, respectively. Fast food restaurants were 0.29 miles from residences in the high-risk block groups compared to 1.16 miles for the low-risk block groups. Supermarkets were, on average, 0.88 miles from residences in the high-risk block groups compared to 2.32 miles from residences in the low-risk block groups. For residences in the high-risk block groups, the average distance to a grocery store was 0.78 miles compared to 4.31 miles for the low-risk block groups.

Food sources offering the most energy dense foods including convenience stores, fast food restaurants and snack and beverage stores were the nearest places for both high-risk and low-risk block groups. High- and low-risk block groups had the furthest mean distances to food sources providing the healthiest food options. High-risk block groups were mainly located in urban areas of the state including Providence, Pawtucket, Central Falls and Woonsocket (Figure 1).

Figure 1. Location of high and low risk block groups



Town level analysis

The mean percentage for each of the factors in the town level risk index is shown in Table 3. As expected, the mean percentage for each factor is greater in the high-risk group. Almost 14% of families in the low-risk towns lived below the federal poverty level, compared to nearly 5% in the low-risk towns.

Table 3. Characteristics of Rhode Island towns by town level risk index

Town Characteristics (%)	Low Risk (N=29)		High Risk (N=10)	
	Mean	Standard deviation	Mean	Standard deviation
Non-white	8.49	3.55	35.27	23.16
Single parent households	9.05	3.88	19.81	7.24
Adults 25+ with no high school education	6.57	2.94	16.01	8.89
Families below 100% FPL	4.23	2.47	13.05	7.80
Renter-occupied households	23.39	9.35	52.26	15.10
Vacant homes	5.97	2.03	9.45	3.09
Household crowding	0.85	0.72	2.67	1.93
Housing units built before 1950	24.98	9.00	47.25	16.06

Table 4. Weighted average distance to a food source location by town level risk index

Food Source:	Low Risk (N=29)		High Risk (N=10)		p-value
	Distance (miles)	95% CI	Distance (miles)	95% CI	
Supermarket	2.92	1.94, 3.89	1.05	0.82, 1.29	.0006
Grocery store	5.48	4.40, 6.57	1.53	0.50, 2.56	<.0001
Convenience store	1.37	1.12, 1.63	0.47	0.30, 0.64	<.0001
Specialty	3.26	2.32, 4.20	1.43	0.64, 2.22	.0070
Other	1.37	1.19, 1.55	1.03	0.80, 1.26	.0154
Sit down	1.23	1.00, 1.46	0.44	0.30, 0.59	<.0001
Fast food	1.46	1.10, 1.83	0.46	0.32, 0.60	<.0001
Snack and beverage	1.86	1.48, 2.24	0.78	0.62, 0.93	<.0001
Farmers market	3.92	3.04, 4.79	1.59	1.15, 2.04	<.0001
Community garden	15.42	11.61, 19.23	6.98	0.00, 15.44	.0633
Food assistance provider	2.70	2.04, 3.36	1.46	1.11, 1.81	.0014
WIC	5.75	4.14, 7.36	1.77	1.24, 2.29	<.0001
SNAP	8.14	6.34, 9.95	4.28	0.68, 7.89	0.0516

Similar to the block group analysis, all food sources were closest to residences in high-risk towns (Table 4). Mean distances for all food sources in the high-risk towns ranged from 0.44 to 6.98 miles compared to food sources in the low-risk towns whose mean distances ranged from 1.23 to 15.42 miles. Additionally, residences in both high- and low-risk towns were closest to food sources with limited amounts of healthy food options. Fast food restaurants were within 0.46 miles and convenience stores were within 0.47 miles of residences in high-risk towns compared to 1.46 miles and 1.37 miles, respectively, of residences in low-risk towns. Sit-down restaurants were the closest food source to residences in the high- and low-risk towns (0.44 miles vs. 1.23 miles, respectively). For residences in the high- and low-risk towns, the furthest places were food sources offering a greater variety of healthy food options and food assistance programs (SNAP and WIC). Supermarkets and grocery stores were, on average, 1.05 miles and 1.53 miles from residences in the high-risk towns compared to 2.92 miles and 5.48 miles from residences in the low-risk towns. The high-risk areas were primarily the more densely populated cities in Rhode Island (Figure 2).

Food environment and childhood overweight and obesity

Table 5 displays the results of weighted linear regression models, which assessed the relationship between the

Figure 2. Location of high and low risk towns

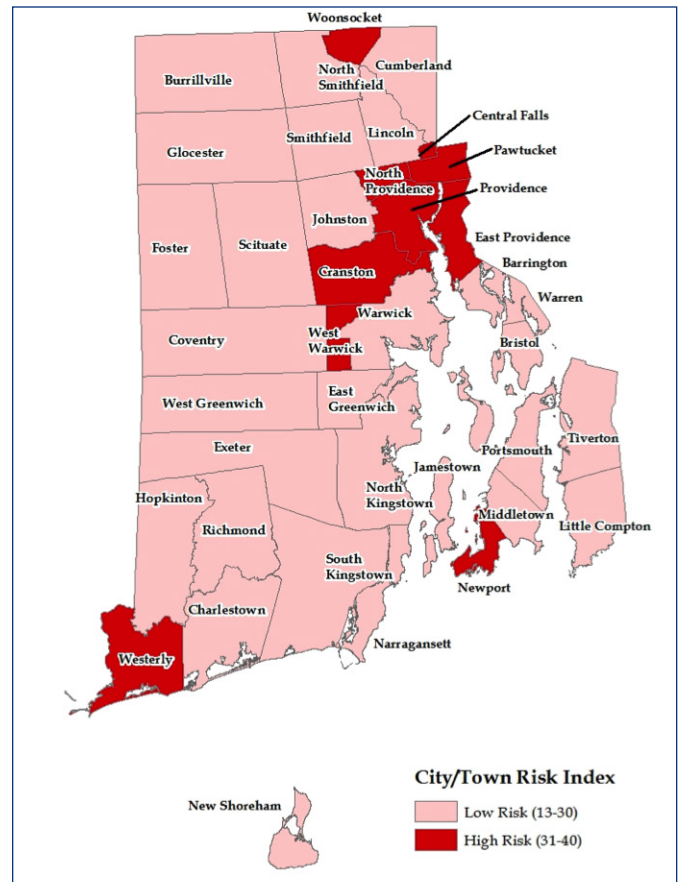


Table 5. Unadjusted and adjusted weighted regression models of town level overweight/obesity rates among Rhode Island children ages 2–17

Average distance to:	Unadjusted		Adjusted *	
	Beta (95% CI)	p-value	Beta (95% CI)	p-value
Supermarket	-1.21 (-2.11, -0.30)	.0102	-0.48 (-1.34, 0.38)	.2625
Grocery store	-1.23 (-1.79, -0.67)	<.0001	-0.65 (-1.34, 0.04)	.0639
Convenience store	-5.88 (-8.23, -3.53)	<.0001	-3.67 (-6.63, -0.71)	.0165
Specialty store	-1.32 (-2.20, -0.45)	.0039	-0.66 (-1.48, 0.16)	.1119
Other	-5.61 (-9.99, -1.23)	.0136	-2.52 (-6.50, 1.47)	.2086
Sit down	-6.45 (-9.15, -3.75)	<.0001	-3.85 (-7.17, -0.53)	.0185
Fast food	-3.87 (-5.90, -1.84)	.0004	-1.89 (-4.12, 0.34)	.0949
Snack and beverage	-4.16 (-5.95, -2.38)	<.001	-2.53 (-4.56, -0.49)	.0086
Farmers market	-1.43 (-2.31, -0.56)	.0021	-0.56 (-1.49, 0.37)	.2295
Community garden	-0.27 (-0.43, -0.11)	.0018	-0.16 (-0.31, -0.01)	.0325
Food assistance provider	-2.10 (-3.35, -0.84)	.0017	-1.15 (-2.34, 0.04)	.0576
WIC	-0.68 (-1.20, -0.17)	.0110	-0.16 (-0.68, 0.36)	.5432
SNAP	-0.65 (-1.00, -0.30)	.0005	-0.42 (-0.74, -0.10)	.0111

*Adjusted for town level risk index

average town level distance to each of the food environment variables and town level prevalence of child overweight and obesity. Unadjusted linear regression showed that mean distance to all food sources had significant inverse relations with prevalence of child overweight and obesity. After adjusting for the town level risk index, we found the shorter the average distance to a food source, the higher the rate of child overweight and obesity. However, most relationships were no longer statistically significant. Sit-down restaurants (adjusted beta: -3.85; 95% CI: -7.17, -0.53), convenience stores (adjusted beta: -3.67; 95% CI: -6.63, -0.71) and snack and beverage stores (adjusted beta: -2.53; 95% CI: -4.56, -0.49) showed the strongest associations with child overweight and obesity. Additionally, there was evidence that average distance to a food source that provides healthy options, such as community gardens, had a negative but small association with overweight and obesity (adjusted beta: -0.16; 95% CI: -0.31, -0.01).

DISCUSSION

Contrary to what was expected based on the concept of “food deserts,”¹⁹ our study found that Rhode Islanders living in high-risk block groups and towns, as defined by our socioeconomic risk indices, lived closer to all food sources than those living in low-risk areas. While high-risk areas may be closer to food sources, the distance may still be a barrier. Food sources offering an assortment of healthy food options including supermarkets and grocery stores were more than a half mile away at the block group level and over one mile at the town level for high-risk areas.

Additionally, we found that community gardens, which are created as an effort to address food deserts and improve access to healthy foods, were the farthest of all food sources, requiring residences in high-risk block groups to travel, on average, over 3 miles and nearly 7 miles for high-risk towns. Food assistance programs, like WIC and SNAP, which provide needy families with support to afford healthy foods were among the farthest food sources. These findings indicate the need to expand resources in high-risk areas.

When assessing the association between food source mean distance and prevalence of child overweight and obesity rates, we found the shorter the distance to a food source, the higher the prevalence of childhood overweight and obesity. Convenience stores had a large association with increased overweight and obesity rates, consistent with previous literature,⁶ as well as sit-down restaurants and snack and beverage stores. The reduction of overweight and obesity associated with SNAP locations and community gardens was significant but rather small. This suggests that proximity to unhealthy food sources may be more important than access to healthy food sources and more focus should be placed on limiting access to these places. Furthermore, additional factors may be contributing to the increase of

overweight and obesity, including the combination of proximity with abundance of places offering energy-dense foods that overtake the number of healthy food sources, a concept called “food swamp.”²⁰ Food swamps have been shown to increase overweight and obesity rates.²¹

LIMITATIONS

Our study had some limitations. When calculating distance, we only accounted for driving distance via motor vehicle and not for other modes of transportation such as public transit or walking. We also only examined the distance to the closest food sources, not the density of food sources in the block groups or towns. Additionally, KIDS COUNT overweight and obesity data were collected from electronic clinical and billing records and released publicly as town-level estimates. Although this is also a strength given it is not reliant on self-reported data that is more commonly available, the dataset did not account for all Rhode Island youth, potentially under- or overestimating the number of children ages 2–17 that are overweight or obese. Furthermore, given the data were only available as town-level summary statistics, individual characteristics could not be examined.

Our study provides evidence that suggests that distance to food sources may not be the only factor contributing to prevalence of overweight and obesity among Rhode Island youth. Further research should assess how additional factors may contribute to increased weight in children such as measuring distance to food sources using different modes of transportation, calculating the number or density of food sources in an area, assessing food prices, and other aspects of healthy food access. Lastly, policies need to address the issue associated with proximity to energy-dense food places and increased weight. Efforts to understand how people are interacting with their local environment, in addition to establishing interventions that encourage healthy eating could help reduce prevalence of child overweight and obesity.

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