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Food Availability en Route to School and Anthropometric Change in Urban Children

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ABSTRACT *This study examined food availability along children's paths to and from elementary school, and associations with change in body mass index (BMI) and waist circumference over 1 year. Secondary data from 319 children aged 8–13 years from the "Multiple Opportunities to Reach Excellence" Project was used. Child anthropometry and demographic variables were obtained at baseline (2007) and 1 year follow-up. Food outlet locations (n=1,410) were obtained from the Baltimore City Health Department and validated by ground-truthing. Secondary data on healthy food availability within select food stores in Baltimore City in 2007 were obtained via a validated food environment assessment measure, the Nutrition Environments Measures Study. Multilevel models were used to examine associations between availability of healthy food and number of various food outlets along paths to school and child anthropometric change over 1 year. Controlling for individual-, neighborhood-, and school-level characteristics, results indicated that higher healthy food availability within a 100 m buffer of paths to school was associated with 0.15 kg/m*^{2} *lower BMI gain (p= 0.015) and 0.47 cm smaller waist circumference gain (p=0.037) over 1 year. Although prior research has illuminated the importance of healthy food choices within school and home environments, the current study suggests that exposure to the food environment along paths to school should be further explored in relation to child health outcomes.*

KEYWORDS *Obesity, Healthy food, Weight, Body weight changes, Adiposity, Abdominal, Youth, Food environment, Anthropometry, Overweight*

INTRODUCTION

Approximately 17 % of youth in the USA are obese (body mass index (BMI) at or above the 95th percentile for age and gender).[1] Obesity and dietary intake among children

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have been associated with the availability of certain types of foods at home, school, and in the community.[2,3] Although numerous studies have examined food availability within and surrounding schools, no peer-reviewed, published research to date has described children's exposure to various food sources along paths to school.

Limited evidence suggests that children frequently purchase food en route to and from school. One study examined the frequency with which 833 elementary school aged children (grades 4–6) in Philadelphia purchased food from corner stores before or after school.[4] Over half of the children (53.3 %) reported purchasing food items daily at corner stores and another 21.9 % shopped two to four times per week.[4] On average, children spent $1.07 per day, which bought an average of 356 calories (typically in the form of chips, candy, and sugar-sweetened beverages).[4] Similarly, a study of Black youth (ages 10–14 years) in Baltimore City reported that they spent an average of $3.96 per day at corner stores, carryouts, and fast-food outlets, typically purchasing chips, candy, and soda.[5] These findings are significant because over half of elementary school children in Baltimore City walk to school,[6] providing numerous opportunities for exposures to unhealthy food sources.

Previous research is limited by the use of cross-sectional data and one-dimensional assessments of the food environment. Only two prospective studies to date have examined the relationship between food outlet density and changes in BMI among young children. Fast-food outlet density (but not other types of food outlets) at baseline was marginally related to greater rates of 5- to 8-year-old children's weight gain over 3 years ($p<0.10$).[7] An analysis of 6- to 7-year-old girls indicated that a greater density of convenience stores within 0.25 miles of participants' homes was associated with higher risk of obesity and greater increase in BMI z-score over 3 years, while the availability of farmer's markets was associated with a lower risk of obesity.[8] Few studies to date have measured both within-store healthy food availability and distance or diversity of food sources.[9,10] The current study examines whether the spatial density and diversity of various food sources, and within-store availability of healthy food items along children's paths to school is associated with change in child anthropometry. We hypothesized that higher availability of healthy food along paths to school would be associated with smaller gains in BMI and waist circumference (WC) over 1 year.

METHODS AND PROCEDURES

Study Population

Data on child anthropometry and demographic variables were drawn from the "Multiple Opportunities to Reach Excellence" (MORE) Project,[11] an observational, 3-year cohort study of elementary school children in Baltimore, MD, USA. The MORE Project was designed to examine the impact of urban children's exposure to community violence on their emotional and behavioral health, substance use, and academic functioning. Following institutional review board approval, child assent and written informed consent was obtained from parents/caregivers. The MORE Project participants include 748 students in six urban public elementary schools (grades 3–5) in three Baltimore City communities with low, moderate, and high levels of crime. Two schools were selected from each community. Baltimore City is a large metropolitan area with approximately 640,000 residents, two thirds of whom identify as Black, and a large proportion of residents living below the poverty level (21 %).[12] The inclusion criteria for the MORE Project were: (1) enrolled as a full-time student in the fall of 2006 or 2007; (2) aged 8–12 years, inclusively; and (3) speak English and live with an Englishspeaking guardian. Exclusion criteria included: (1) presence of serious medical or neurological illness or mental retardation that precluded completion of interviews or (2) does not reside with a parent or guardian.

The first cohort (assessed in spring 2007) consisted of 490 eligible families who consented to participate. Of these, 427 (87 %) children and 282 (66 %) parents/caregivers completed interviews. In the fall of 2007, 258 additional families consented and comprised cohort 2. Across both cohorts, there were a total of 1,406 eligible students (consent rate of 53 %). Data for baseline and 1 year follow-up were only available for cohort 1; we restricted analysis to that group. We further restricted the sample to students who had address data available for geocoding and for whom anthropometric data were available at baseline (N=319). Of these, 237 (74 %) had anthropometric measurements taken at year 1 follow-up. This loss-to-follow-up rate is comparable to other cohort studies.[13,14] Children with missing follow-up data were not different from those included on baseline characteristics, including waist circumference and BMI z-score.

Data Sources

The MORE Project. Separate interviews with children and caregivers were conducted in 2007 and 2008 by the MORE Project staff. All demographic questions in the current study were self-reported, and trained interviewers measured each child's height, body weight, and WC. To protect confidentiality, children's addresses were coded as the centroid of street block of residence (e.g., 6000 West 30th St) instead of individual residential address.

The Local Food Environment. The Center for a Livable Future (CLF) at the Johns Hopkins Bloomberg School of Public Health maintains a Geographic Information System (GIS) mapping project that includes data on food retail outlet locations for Baltimore City.[15] Food retail outlet locations were obtained from the Baltimore City Health Department (BCHD), which uses a list of retail outlets for inspection purposes.[16,17]

For 149 stores (e.g., corner, convenience, small grocery, and supermarkets) in Baltimore City, data were collected on within-store food availability of healthy food in 2007[9] using a modified version of a validated food environment assessment measure, the Nutrition Environments Measures Study (NEMS)[2] which is based on the US dietary guidelines.[18] The modified NEMS collected information on the availability of eight food groups (skim milk, fruits, vegetables, low-fat meat, frozen foods, low-sodium foods, whole wheat bread, and low sugar cereals) and is very similar to the original but altered slightly to capture local brands and dietary patterns.[9] The presence of food items within each of these eight groups is tallied to generate an overall Healthy Food Availability Index (HFAI) for each food outlet based on the amount of healthy foods presented for sale. The HFAI scores range from 0 to 27, where 0 indicated the complete absence of any healthy food and 27 indicated the presence of all healthy foods on the NEMS. For all markets and convenience stores in Baltimore City that were not previously assessed using the NEMS as part of the Multi-Ethnic Study of Atherosclerosis (MESA)[9,19], HFAI scores were imputed by CLF using a process that matched the outlets to stores of a similar size and type, in similar neighborhoods (i.e., tracts with a similar racial and ethnic composition), and taking the mean HFAI of those measured stores.[13] This matching process has been described and utilized in prior studies.[20]

Food outlets were categorized by BCHD and CLF into several categories including: corner store, supermarket/grocery store, convenience stores, and restaurants. Restaurants were categorized as full-service or carryout (including fast-food and counter-service restaurants). Fast food restaurants were extracted from the carryout category to include outlets that were part of a major chain and offered primarily counter-service (e.g., McDonalds, Subway, Burger King, KFC). Gas stations were coded separately. Full-service restaurants were excluded from the analysis because children are unlikely to visit full service restaurants en route to school. Additionally, the following types of outlets were excluded due to seasonality, lacking a permanent address, being mobile, or low likelihood of children utilizing the facilities: market stalls, caterers, soup kitchens, food stands, push carts, festivals, outlets within closed facilities (e.g., hotels, universities), vending machines, farms, food processing facilities, hospitals, churches, specialty stores (e.g., seafood shops, butchers, confectionaries), food pantries or soup kitchens, bar/taverns, and liquor stores. Results from a data validation study of the BCHD list found sensitivities of 0.85–0.95 compared to ground-truthing and false-positive rates of 9–15 %.[21]

US Census Data. The US Census provides estimates of sociodemographic characteristics for census tracts within Baltimore City.[22] Street maps of Baltimore City (TIGER/Line files) were also obtained from the US Census.

Measures

Body Mass Index. Child weight (in kilograms) and height (in meters was measured annually by a member of the MORE Study research team. Age- and gender-adjusted BMI *z*-scores were calculated according to the Center for Disease Control 2000 growth charts.[23] Obesity is defined as a BMI *z*-score greater than 95th percentile for age and sex, and overweight is defined as a BMI *z*-score greater than 85th percentile.[23] BMI *z*-score was used because it demonstrates high correlations with measured body fat in children.[24] Change in weight status over 1 year was calculated by subtracting baseline BMI from follow-up BMI. Absolute change in BMI is a better measure of change over time in children because change in BMI *z*-score tends to correlate with weight status and violate the assumption of constant variance and change in absolute BMI provides greater power than change in BMI *z*-score.[25,26]

Child Waist Circumference. Child WC (in centimeters) was measured annually by a member of the MORE Study research team. WC correlates with a number of cardiovascular disease risk factors among children, independent of BMI.[27] WC change was calculated by subtracting baseline WC from follow-up WC. There are no published guidelines on the use of WC change over time among children, so absolute change was used, similar to the absolute change in BMI.

Demographic Variables. Individual-level characteristics included child age (years), gender, self-reported race or ethnicity (Black, White, Asian American, Hispanic, Native American, or Biracial), number of siblings, and whether the child received free or reduced price lunch (FRPL) at school. Due to a high level of missing parent/caregiver SES data (e.g., highest level of education attainment, self-reported household yearly income, employment status), FRPL status was used as an indicator of family SES.

School. Routes to school were identified for each individual by mapping school and child street block of residence and selecting the most direct (shortest) route along streets (meter). Along these routes, mean HFAI and the numbers of different food outlet types within various buffers (e.g., 100, 400, and 800 m) were quantified. The school attended by each participant was included in all analyses as a random intercept to control for school-specific variations and policies that may affect child weight (e.g., mandatory physical education classes, vending machine availability). The violence strata (i.e., high, medium, or low) for each school were also included.

Neighborhood Sociodemographic Characteristics. An index of deprivation capturing the domains of education, employment, housing, and poverty was used to increase model parsimony, and because these census variables are typically highly collinear.[28] The following variables were standardized and summed to create a neighborhood deprivation index: percent of adults over 25 years with less than a high school education, percent males over 16 years who are unemployed, percent of families below the federal poverty level, percent of households receiving public assistance, percent of female headed households with children, and median household income. Variables were transformed for normality and direction, and z-scores were summed and divided by 6, higher values indicate greater material and social deprivation.

Statistical Tools

Street blocks of residence and school addresses were geocoded and mapped using ArcGIS software.[29] The 2007 TIGER/Line shapefiles containing roads and streets for Baltimore City were used to identify routes to and from school for each individual using the "as the person walks" method,[30] which calculates the shortest distance along roads, using ArcGIS network analyst.[31]

Buffers of various sizes (e.g., 100–800 m) were drawn around the identified paths to school and the number of various types of food outlets and mean HFAI scores were quantified using ArcGIS. Buffers of 400 m are typically used because they represent a distance that can be walked in approximately 5 min[32]; however, the size of typical activity spaces in urban settings and among children is an area of ongoing research.[32] Thus, analyses included smaller and larger buffers (100 and 800 m) to address uncertainty related to the fact that children may not travel along the most direct street–network path. Too narrow of a buffer may underestimate the influence of the food environment along paths to school, as children may deviate from the most direct path in order to patronize food outlets nearby (but not directly on the path). Wider buffers may better capture the uncertainty of children's paths, but they may introduce additional noise to the data as many outlets are captured that children may not be exposed to. A portion of the study area depicting projected paths to school and food outlets within 100 m buffers of these paths can be seen in Figure 1.

Statistical Analyses

Mixed effects models were used to examine the association of variables related to the local food environment and child weight status and gain over time. Weight status of children is a function of individual level covariates (e.g., age, sex, race or ethnicity, SES, and food availability along paths to school) plus school and neighborhood level covariates (e.g., violence strata, area deprivation index). Preliminary analyses

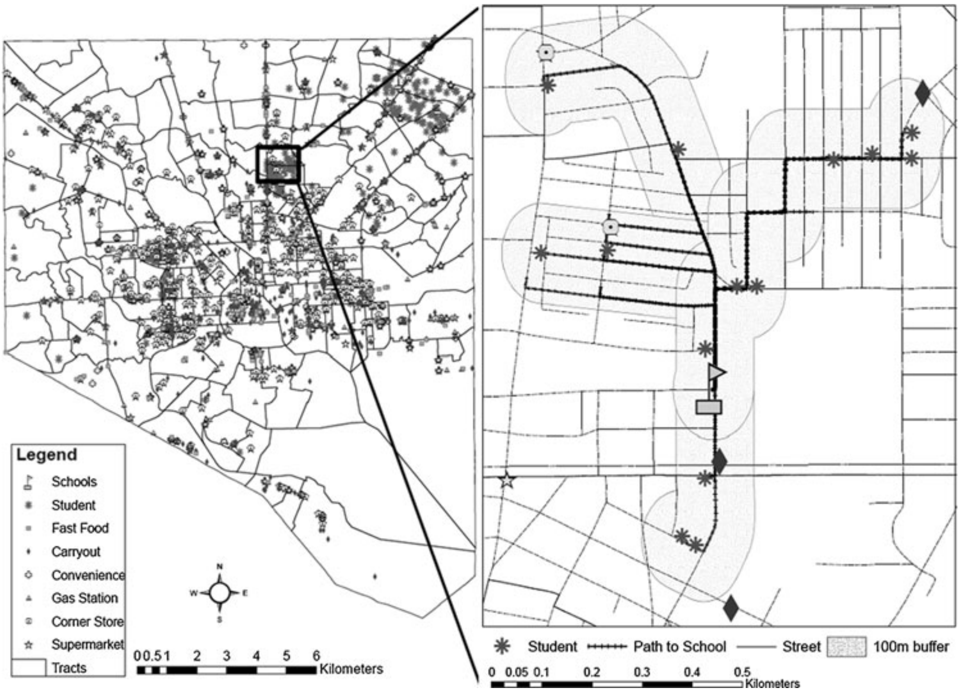

FIGURE 1. Map of food outlets, student's home, and school locations for 319 elementary school children from the MORE Project in Baltimore City, MD, USA. Zoomed in map on the right depicts the food outlets and paths to school with 100 m buffers for an example set of students in the highlighted region.

examined weight status and WC at baseline and year 1 as outcomes. Cross-sectional outcomes were not significantly associated with any covariates of interest. Since many studies have reported on cross-sectional associations between the food environment and weight status, those results are not reported here.

Because the data were not purely hierarchical (i.e., nested) and children were cross-classified into both schools and census tracts, cross-classified random effects models were explored.[33,35] Before developing the cross-classified models, preliminary analyses were conducted to examine two-level models where children were nested within either schools or census tracts, to determine if there was significant clustering at either of these levels. Likelihood ratio testing indicated that the random intercepts for census tract were not statistically significant ($\chi^2(1)>0.15$). The tract-level fixed effect of area deprivation index was retained in the models to account for neighborhood SES, and models were reduced to two-level multilevel models where children were nested within schools.

Statistical analyses for multilevel models were conducted using STATA 11.[35] Using STATA's xtmixed commands,[36] the models were estimated using maximum likelihood estimation. Covariates (grand mean centered) at the various levels were then added to the models, and variance components were examined to ascertain whether the covariates of interest reduced the unexplained variance at different levels. Due to the spatial nature of the outcome and covariate data, residuals from all final models were checked for spatial dependence using variograms.[30]

RESULTS

Baseline child characteristics are presented in Table 1. The sample was 87 % Black and 46 % male, with a mean age at baseline of 9.60 years (SD 1.03, range=8–13 years). Children traveled an average of 1,263 m to and from school each day, and 54 % of children reported walking to school most days. Within 100 m of these routes, children passed one carryout and one corner store, on average. Children passed far fewer fast-food outlets, supermarkets, gas stations, and convenience stores en route to school. Mean HFAI score within 100 m of children's paths to school was 2.18 (range, 0–24).

Anthropometric measurements at baseline and 1 year can be seen in Table 2. On average, BMI increased by 0.28 kg/m^2 (SD 2.01) over 1 year among children who completed follow-up assessments. Approximately 22 % of children were obese and 17 % of children were overweight. Of the children who were normal weight at baseline, 6 % became overweight by 1 year follow-up and none became obese. Of the children who were overweight at baseline, 34 % became normal weight, 59 % remained overweight, and 7 % became obese by 1 year follow-up. Of the children who were obese at baseline, 4 % became normal weight, 16 % became overweight, and 80 % remained obese at 1 year follow-up.

BMI Change

Table 3 describes the regression model results for BMI change. Baseline BMI *z*-score was included in the adjusted models to account for the baseline weight status of children because change in weight status over time is associated with baseline adiposity.[22,23] After the inclusion of violence strata in the multilevel model, the random intercept for school was no longer significant (but kept in the model),

TABLE 1 Baseline sociodemographic characteristics of elementary school children in the MORE Project (n=319) in Baltimore, MD, USA

Child characteristics	*n* (%)	Mean (SD)	Min–max
Race and ethnicity[a]			
Black	277 (86.83)		
Other	42 (13.17)		
Male	148 (46.39)		
Free/reduced price lunch	264 (85.44)		
Walks to school	173 (54.23)		
Age (years)		9.60 (1.03)	
Distance to school (m)		1,262.93 (1,507.31)	
Number of siblings		3.32 (1.98)	
Food environment (100 m)			
Fast food		0.13 (0.59)	0–7
Carryout		0.98 (2.32)	0–14
Convenience		0.24 (0.75)	0–6
Gas station		0.14 (0.43)	0–4
Corner store		1.09 (1.69)	0–11
Supermarket		0.04 (0.19)	0–1
HFAI		2.18 (2.68)	0–24

[a] The "other" race/ethnicity category was largely comprised of children identifying as biracial or white

TABLE 2 Child anthropometric measurements at baseline and year1 for elementary school children in the MORE Project (n=237), in Baltimore, MD, USA

	Baseline	Year1
	Mean (SD)	Mean (SD)
Weight (kg)	40.04 (13.38)	45.25 (15.27)
Height (m)	1.43 (0.10)	1.51 (0.11)
Waist (cm)	72.50 (12.06)	69.97 (12.55)
BMI (kg/m^2)	19.31 (4.69)	19.52 (5.31)
BMI z-score	0.54 (1.26)	0.39 (1.29)
BMI percentile	64.03 (31.61)	59.83 (32.58)

indicating that the strata accounted for the significant portion of school-level variability in BMI change.

Compared to Black children, BMI change over 1 year was 0.79 kg/m^2 lower for children identifying as other races or ethnicities (p=0.045), for the average child in the average school. A 1 year, increase in age was associated with a 0.02 kg/m^2 higher BMI change (p=0.043) for the average child in the average school. Lastly, having one additional healthy food item available within the 100 m buffer along paths to school was associated with a 0.15 kg/m^2 smaller BMI change (p=0.015), for the average child in the average school.*

WC Change

Table 3 describes regression model results for WC change. After the inclusion of violence strata, the random intercept for school was no longer significant (but kept in the model), indicating that there was no longer any school-level variance in WC change to be explained. For the average child within the average school, a 1 cm higher WC at baseline was associated with a 0.17 cm smaller change in WC change (p<0.001). Having one additional healthy food item available within the 100 m buffer along paths to school was associated with a 0.47 smaller WC change (p= 0.037).

Estimates of the random effects for the above multilevel models indicated that while all of the school-level variance was explained by the included covariates, there was a substantial amount of residual (unexplained) individual-level variance in BMI and WC change. Final models presented did not exhibit any residual spatial variation based on estimated variograms and thus there was no need to adjust the regression inference due to lack of spatial independence.

Mode of Transportation to School as an Effect Modifier

Mode of transportation to school (i.e., walking vs. driving or taking the bus) was explored as a potential effect modifier of the associations between HFAI scores along paths to school and child anthropometric outcomes. Children who walk to school likely have a greater exposure to the food environment along paths to school, and therefore associations between availability of healthy food

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*A 0.15 kg/m^2 difference in BMI is approximately 0.5 lb per year for the average 9 year old and 0.7 lb per year for the average 12 year old, though these estimates would vary by sex, height, and age.

TABLE 3 Estimates of association between covariates and BMI change (in kilograms per meter squared) and WC change (in centimeters) over 1 year among elementary school children in the MORE Project (n=237) in Baltimore, MD, USA

	BMI change[a]				WC change[a]		
	b	95 % CI	*p*		*b*	95 % CI	*p*
Baseline BMI *z*-score	*−0.22*	*−0.42* to *−0.02*	*0.028*	Baseline WC	*−0.17*	*−0.25* to *−0.10*	*<0.001*
Age (year)	*0.02*	*0.00* to *0.04*	*0.043*	Age (year)	0.05	−0.04 to 0.13	0.263
Race and ethnicity				Race and ethnicity			
Black	1.00			Black	1.00		
Other	*−0.79*	*−1.57* to *−0.02*	*0.045*	Other	−0.03	−2.87 to 2.81	0.984
HFAI score	*−0.15*	*−0.26* to *−0.03*	*0.015*	HFAI score	*−0.47*	*−0.91* to *−0.03*	*0.037*

[a] Adjusted models included sex, number of siblings, free and reduced price lunch receipt, walking to school status, distance to school (log kilometer), census-tract deprivation index, violence strata, and number of food outlets (i.e., carryouts, corner stores, fast food, convenience stores, supermarkets, and gas stations) within 100 m of paths to school. These covariates were not significantly associated with BMI change or waist circumference change, and are subsequently not reported in the table. Additionally, these models did not include the interaction term between walking to school status and HFAI score. Full model results can be seen in the supplementary material Appendix A

along paths to school and anthropometric outcomes may be stronger among this group than children who drive or take a bus to school. To explore this effect modification, interaction terms between mode of transportation and HFAI scores were added to each of the models. The interaction between walking to school and HFAI scores was not statistically significant in any of the models ($p>0.05$). However, the effect modification was in the expected direction for all models; for children who walked to school, higher HFAI scores along paths to school were associated with smaller gains over time in BMI and WC, compared to children who do not walk to school. The interaction between HFAI scores along paths to school and walking versus passive transport can be seen in Figure 2.

Sensitivity analyses including larger buffers (e.g., 400 and 800 m) demonstrated no significant associations between features of the food environment (i.e., number of various outlets passed en route to school, and HFAI scores) and the outcomes of interest.

DISCUSSION

This study of predominantly Black children from low-income, urban settings, examined whether features of the food environment along paths to schools were associated with BMI change and WC change over 1 year. Results from multilevel models where children were nested within schools suggest that one additional healthy food item available along paths to school (i.e., within 100 m) was associated with smaller gains in BMI and WC over 1 year. Contrary to prior cross-sectional studies, no associations were seen between the numbers of food outlets of various types and child anthropometric outcomes.

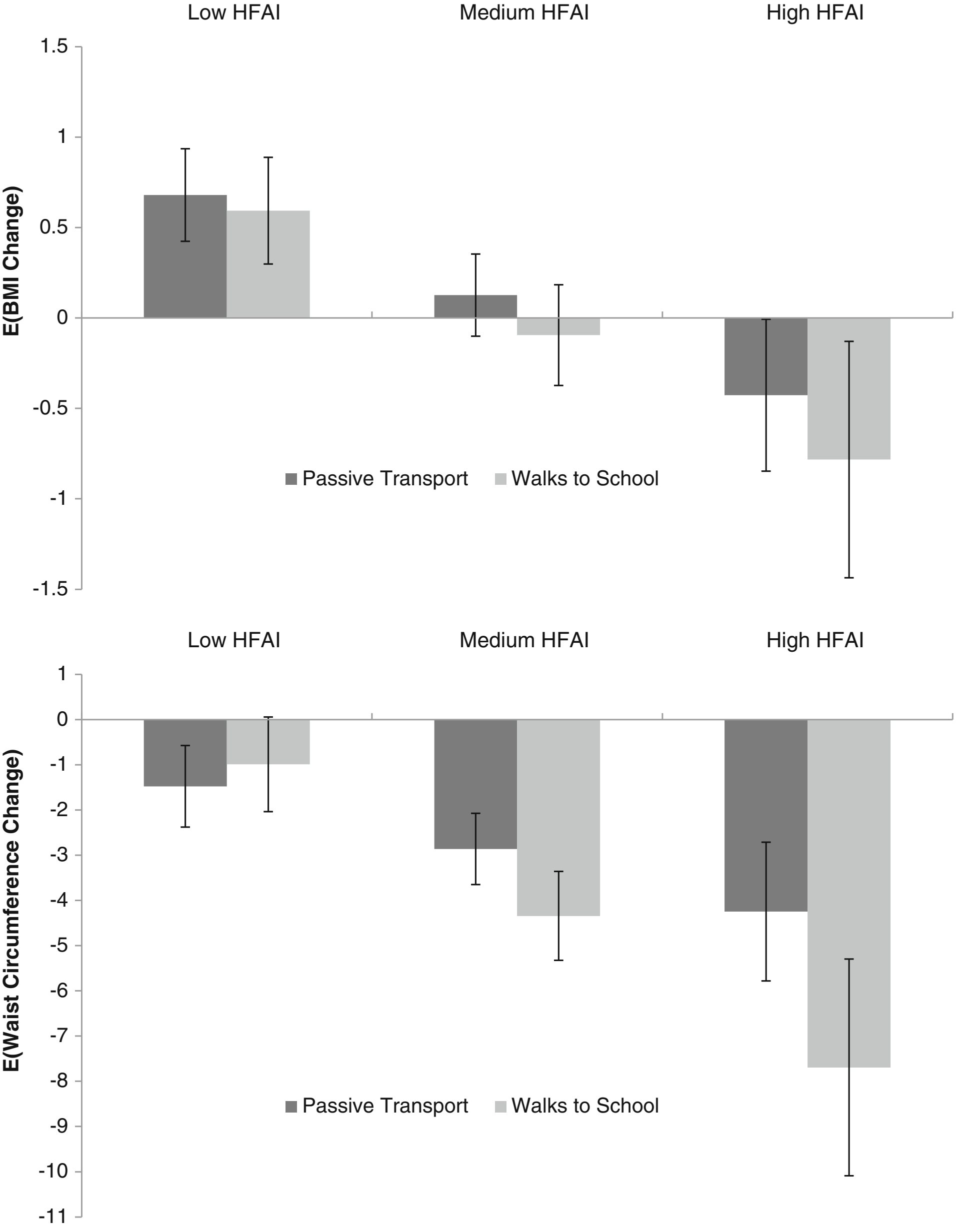

FIGURE 2. Interactions between mode of transportation to school (walking or passive transportation such as car or bus) and HFAI scores along paths in relation to change in BMI (*top*) and change in waist circumference (*bottom*), among 237 elementary school children from the MORE Project, in Baltimore, MD, USA. Positive values indicate that BMI or waist circumference increased over time; negative values indicate that BMI or waist circumference decreased over time.

Finally, mode of transportation to school was not a statistically significant effect modifier of the association between food availability along paths to school and anthropometric outcomes. However, the direction of effects was in the expected direction, whereby for children who walk to school, a stronger association between healthy food availability along paths to school and anthropometric outcomes was seen compared to children who do not walk to school.

Results from this study that are contrary to previous research could, in part, be a consequence of the study sample and methodological strengths vis-à-vis prior studies. This study involved a group of primarily Black children from a low-income, urban setting, while previous studies have not focused specifically on this population. Very few previous studies have examined associations longitudinally between the food environment and weight outcomes among children or used multidimensional assessments of the food environment that capture the within-store availability of food.[10] This research addressed these gaps in the literature and presented a novel exploration of the food environment along paths to school, which yielded some results not shown in prior research.

Although this study generated novel findings, there are a number of limitations. First, without randomization of individuals to neighborhood, we cannot establish causality. Given the difficulty of randomizing children and families to neighborhoods, we are reliant on associational designs to examine relationships between environmental factors and health outcomes. Although several individual and neighborhood level variables were controlled for in the analyses, there may be residual confounding, which could bias the results in either direction. The most important potential confounder is likely the availability of unhealthy food products. The NEMS does not assess the availability of unhealthy food items; subsequently, it may be that areas with low-HFAI scores also have an abundance of unhealthy food. Future studies are needed to examine the differential influences of healthy and unhealthy food availability.

Second, although missing data was not associated with baseline BMI *z*-score or WC, it is possible that children who were lost to follow-up differed from those included with respect to change in BMI and WC over time. Additionally, information bias, or "cartographic confounding" may result when geocoded data are missing not at random, but differentially by urbanization or some other important predictor variable.[35] For example, if data on food outlets were missing disproportionately from low-income neighborhoods compared to higher-income neighborhoods, the results could be biased in either direction. However, a previous analysis of the BCHD food outlet data found little evidence for differential measurement error.[21]

Third, the present analyses did not account for the uncertainty of identified paths to school or imputed HFAI values. Children may not necessarily take the shortest path along roads, but instead cross through parks, or deviate from the shortest path to walk with friends or along roads with sidewalks. Future studies in this area should attempt to validate actual paths taken through self-report or GPS monitoring and assess how exposures to the food environment along paths to school affect purchasing behavior. For example, do food outlets serve merely as a visual cue that prompt purchases, or do children deviate from the most direct path to patronize a particular outlet nearby? Sensitivity analyses looking at larger buffers around paths to school (i.e., 400 and 800 m) were used to compensate for the possibility that children may not take the shortest direct path along roads. In these sensitivity analyses, no significant associations were found between features of the food environment and child anthropometry. Using buffers of 400 m or higher could introduce too much "noise" to pick up any significant associations between the food environment and child outcomes, again biasing results toward the null. As many studies use the 400 m buffer as a standard,[32] this finding highlights the need to explore smaller buffers, particularly when examining children's activity spaces in urban settings.

Finally, weight status and gain over time are determined by numerous variables operating across multiple levels of influence. The MORE Project was primarily designed to assess the impact of community violence exposure on academic and emotional/behavioral outcomes, and therefore did not include measures of physical activity or dietary intake, two important mediators between environmental determinants and child anthropometry. Findings would be strengthened if we had been able to link features of the food environment to intermediate variables such as dietary intake or food purchasing behavior along paths to school. Given the promising results of the current study, future studies in this area are warranted to examine purchasing behavior as well as intermediate variables such as dietary intake and physical activity. It will also be critical for future studies to examine the availability of healthy and unhealthy foods in relation to children's purchasing behaviors, dietary intake, and health outcomes.

Despite these limitations, this study makes an important contribution to the nascent body of literature in this area by characterizing the food environment along paths to school across several dimensions and examining associations with child weight outcomes over time. Children's paths to school provide potential exposures to health-promoting opportunities (e.g., healthy food, physical activity) and health risks (e.g., unhealthy food, environmental hazards and incivilities); more research on these exposures is warranted.[37] Future studies can build on these findings and investigate how changes in aspects of the food environment relate to changes in dietary intake and anthropometry, as well as more comprehensively assessing the availability of both healthy and unhealthy food.

CONCLUSIONS

This study makes a novel and significant contribution to the literature by examining the food environment along paths to school in a low-income, urban setting, and quantifying whether exposures to various food sources are associated with child anthropometry over time. Future studies are needed to explore the food environment along paths to school in relation to health outcomes among larger, diverse samples and to examine pathways by which exposures may influence health.

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