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ORIGINAL ARTICLE

Improved parental dietary quality is associated with children's dietary intake through the home environment

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Summary

Background

Improving access to supermarkets has been shown to improve some dietary outcomes, yet there is little evidence for such effects on children. Relatedly, there is a dearth of research assessing the impact of a structural change (i.e. supermarket in a former food desert) on the home environment and its relationship with children's diet.

Objective

Assess the relative impact of the home environment on children's diet after the introduction of a new supermarket in a food desert.

Methods

Among a randomly selected cohort of households living in a food desert, parental diet was assessed before and after the opening of a full-service supermarket. The home environment and children's intake of fruits and vegetables was measured at one point – after the store's opening. Structural equation models were used to estimate the pathways between changes in parental dietary quality at follow-up and children's dietary intake through the home environment.

Results

Parental dietary improvement after the supermarket opened was associated with having a better home environment ($\beta = 0.45$, $p = 0.001$) and with healthier children's dietary intake ($\beta = 0.46$, $p < 0.001$) through higher family nutrition and physical activity scores ($\beta = 0.25$, $p = 0.02$).

Conclusions

Policy solutions designed to improve diet among low-resource communities should take into account the importance of the home environment.

Keywords: African–American children, dietary quality, food deserts, home environment.

Introduction

Obesity in childhood is associated with a slew of chronic health conditions, as well as premature illness and death in adulthood (1). Low-income African–American children suffer dramatic disparities in obesity relative to white children; for example, from 2011 to 2012, the prevalence of obesity was 20.2% among

African–American children compared with 14.1% among whites (2). Increasingly, researchers have focused on how racial residential segregation has created unequal food environments that promote obesity. For example, evidence suggests greater access to food sources that promote unhealthy eating in neighbourhoods with a higher proportion of low-income African Americans (3).

Recent policy efforts to curb childhood obesity and address differences in food environments, including the first lady's Let's Move! Campaign and the Healthy Food Financing Initiative, have focused, in part, on eliminating 'food deserts' (i.e. areas with limited access to fresh and/or healthy foods) by encouraging full-service supermarkets to locate in such low-income, low-resource neighbourhoods in the USA (4). Researchers and advocates have posited that food deserts are 'obesogenic' because they limit residents' local options for obtaining fresh, nutrient-dense foods (3,5). Policymakers have, in turn, shown enthusiasm for encouraging such retail venues to locate into these areas to provide access to fresh and affordable produce. Recent studies to assess diet-related improvements by using pre-post quasi-experimental designs in the USA have found mixed results. Most have not shown significant differences in weight or dietary outcomes (e.g. daily fruit and vegetable intake) between residents of the intervention and comparison groups (6–8), although the largest of the studies found improvements following the opening of the supermarket in added sugars, kilocalories and empty calorie intake (7). That study, in addition to Cummins *et al.*, found improved perceptions and awareness of access following the opening (6,7). Only one study specifically focused on parent/caregivers of children ages 3–10 and found no statistically significant impact of the new supermarket on mean total energy intake or intake of healthful foods among children (8). This is consistent with other cross-sectional research that did not find an association between greater access to supermarkets and healthful dietary behaviours (e.g. consumption of fruits and vegetables) and body mass index in children and adolescents of diverse racial/ethnic background (9,10).

Studies exploring the environmental correlates of children's obesity have postulated that some relationships are distally related to the individual (e.g. poor neighbourhood conditions), whereas others are more proximally related (e.g. home environment) (11). Indeed, research has shown a positive association among several factors in the home environment, such as availability of fruits and vegetables in the home (12,13), norms around meals such as breakfast and parental child-feeding practices (14–16) and children's intake. Emerging evidence has put forward that the home environment is particularly important for children of lower socioeconomic background (17), including African-American families (18). So far, however, the evidence is almost exclusively based on cross-sectional studies that focus on a single part of the pathway, either direct associations of neighbourhood conditions or of the home environment on child diet.

To date, very little is known about the pathways that may operate among the obesogenic neighbourhood environment, the home environment and child dietary behaviours, especially for low-income African-American families living in a neighbourhood experiencing dramatic changes in the neighbourhood food environment. Use of simultaneous regression modelling via systems of equations may help clarify hypothesized pathways.

Data that were collected as part of the parent study were also used in this research study. The parent study collected extensive data prior to and after the opening of the supermarket from a randomly selected cohort of low-income African-American families living in two sociodemographically similar neighbourhoods with no supermarket access at baseline. In 2013, one of these neighbourhoods received a new full-service supermarket funded, in part, by the Healthy Food Financing Initiative. All households that became part of the cohort were administered questionnaires that included 24-h dietary recall data and extensive sociodemographic information. These data were collected in 2011 (prior to the opening of the supermarket) and 2014 (after the opening of the supermarket). An additional data collection effort was added in 2014, where all households with children were surveyed on the home environment, including measures of family norms around meals and physical activity, screen time, sleep routine and parental use of foods and beverages as reward using. Children's diet was via food frequency questionnaire as reported by parent/caretaker.

Materials and methods

Study population

This study builds upon a landmark natural experiment set to longitudinally examine the food-purchasing behaviours and diet among a randomly selected population of households in two major Pittsburgh food desert neighbourhoods, one of which underwent a transformation by obtaining a full-service supermarket. Additional details about the study are available elsewhere (19). The study focuses on residents of Pittsburgh Hill District and Homewood neighbourhoods, which are approximately 6 mi apart, but both in the City of Pittsburgh: both neighbourhoods are similarly low-income and predominantly African American.

Baseline data were used to focus on households who indicate at least one child aged 5–13 years living in either neighbourhood. During the in-person follow-up interview in 2014, a total of $n=214$ households were invited to participate; $n=162$ households enrolled in the current study. The study excluded households with teenagers, infants and toddlers because they might represent a

threat to validity ($n = 157$): research shows that teenagers have greater independent access to food relative to younger children, whereas infants and toddlers might be problematic because of their unique dietary needs and child-feeding practices (20,21). In households where there was more than one child between the ages of 5 and 13, the data collector chose the child with the closest birthday to the date of the interview as a method of random selection and asked the parent/guardian to answer the questions with that child in mind. The participants received a \$15 gift card for participating in the interview for this supplemental study on children. The RAND Corporation Institutional Review Board approved the study (HSPC: 2013-0748-AM01).

Parental dietary quality and intake assessment

Data collectors guided parent/guardians through two 24-h recalls by using the online Automated Self-Administered 24-h recall, which uses a modified version of the US Department of Agriculture's Automated Multiple-Pass Method (22). Although the tool is designed to be self-administered, trained data collectors guided the participants through the recall in case of any literacy issues, and it was carried out on study computers in case there was a lack of internet access. To indicate parent/caregiver dietary quality, Healthy Eating Index (HEI) 2010 scores were derived (23,24) which include 12 components, five of which represent the major food groups found in the US Department of Agriculture's MyPyramid (i.e. total fruit, total vegetables, total grains, milk and meat and beans). A maximum score in the HEI is 100; higher scores reflect better adherence to federal dietary guidelines (i.e. 2010 Dietary Guidelines for Americans) (25).

Child's home environment assessment

The data collectors used the Family Nutrition and Physical Activity (FNPA) screening tool to assess aspects of the food and physical activity environment inside the child's home (26). This tool included questions about families' breakfast and general eating patterns, food and beverage choices available in the home, parental child-feeding styles, screen time, family and child's physical activity, as well as the extent to which the family has a daily routine or schedule. The home environment has been shown to predict weight-related outcomes across diverse samples of children (27,28). All 10 items were rated on a four-point Likert scale, with higher values indicating healthier environments. In our sample, the scale exhibited acceptable reliability (Cronbach's $\alpha = 0.60$).

In addition, home food availability was assessed via the Nutrition Environment Measures Survey (29), which asks the respondents to indicate which if any items from an 18-item list (e.g. fruits, candy or cookies) were available in the home in the past week. The binary variables with values [0, 1] indicate presence (yes or no).

Child's dietary intake assessment

The parents were asked how many servings of fruits and how many servings of vegetables the child ate in a typical day only once after the supermarket opened. Examples of a serving were given for different types of fruit/vegetable. The responses for the fruit and vegetable items were as follows: 1 = does not eat any fruit/vegetable, 2 = less than one serving, 3 = one serving, 4 = two servings, 5 = three servings, 6 = four servings, 7 = five servings and 8 = six or more servings.

Statistical analysis

Covariates

The following are the criteria for choosing confounders: (i) exposure–mediator; (ii) mediator–outcome; or (iii) exposure–outcome after excluding any mediator–outcome confounders that are likely affected by the exposure (30). Parental-level covariates included income, education, age, sex, concern about child's weight, receipt of benefits from the Supplemental Nutrition Assistance Program (SNAP), neighbourhood (i.e. Hill District or Homewood) and levels of food insecurity for the household. Child-level covariates included age, sex and receipt of free school breakfast and/or lunch by the child.

Structural equation modelling (SEM) is a pathway-based approach that can handle multi-equation models and allows estimation among latent (unobserved) and observed variables of multiple effects transmitted over combinations of paths (31,32). SEMs allow us to model latent variables such as the home environment by using observed variables such as availability and foods and family nutrition and physical activity norms as indicators of latent variables; thereby, the models simultaneously estimate direct and indirect relationships. (33) Thus, SEM can be used to construct a model by using variables for the home environment and then estimate relationships among parental diet, the home environment and child diet. MPLUS version 7.11 (34) was used with maximum likelihood estimation, and statistical significance was set at $p < 0.05$ (two-sided). Maximum likelihood estimation accounts for missing data at random and allows our model to use available data without needing to use imputation methods (35,36).

Latent variables used in structural equation modelling

Latent variables are underlying complex concepts that are not directly observed but can be inferred mathematically from multiple observed variables. Thus, latent variables are useful to summarize a number of variables into one meaningful factor. The data that were collected that capture certain features of latent home environment (e.g. fruits available in the home) and child diet (e.g. number of servings of fruit child eats) were used as indicators of latent home environment and child diet. First, two separate latent variables were created – ‘home food availability’ and ‘FNPA patterns’ – to capture the home environment because the study's hypothesis was that they were separate constructs. Foods in the home are indicators of the physical environment in the home, while FNPA patterns indicate food-related behaviours within the home. To reflect ‘home food availability’, responses to the 18 food availability questions were used as indicators. Among the 18 variables included, the variables with sufficient variability with <85% of the population had the same response with those that loaded significantly onto the latent variable ‘home food availability’. The 10 responses to the FNPA screening tool indicated the latent variable ‘FNPA patterns’. Second, a latent variable for child diet by using the parent assessments of their child's diet was created. The indicators retained in the model were those that loaded statistically significantly ($p < 0.05$) onto the latent variable or improved fit.

Structural equation modelling

To test our hypothesis that the change in parental diet after the supermarket opened influenced children's dietary outcomes through their home environment, a

SEM was constructed as shown in our conceptual model (Fig. 1). Change in parental diet was defined by the parent's HEI score after the supermarket opened auto-regressed on the parent's HEI score before the supermarket opened. Our model was weighted to account for sample attrition between baseline and follow-up to ensure that the results generalize to the baseline sample. Attrition weights were the inverse probability of response at follow-up estimated that included all of the sociodemographic and additional baseline characteristics as predictors. The following statistics were used to define model fit. A statistically non-significant Chi-Square test statistic (37), a root mean square error of approximation <0.06 (38) and comparative fit index (39) values approaching 1.0 imply that the model fits the data well.

Results

As shown in Table 1, the parents were on average, female, in their mid-thirties, with a high school education or some college, with a per capita household income of \$7709 and slightly concerned over their child's weight. Over two-fifths (44%) of the parents reported that their household experienced some level of food insecurity (e.g. skipping meals), and 70% reported receiving benefits from SNAP. Most participants lived in the Hill District (68.5%) relative to Homewood (31.5%).

Table 1 also shows that the mean age of the children was 9.3 ranging from 5 to 13, on average, were female, and received free or reduced school breakfast and/or lunch. Intake was slightly lower for vegetables relative to fruits. The majority of the children had fruits and vegetables available in the home in the last week; however, they were also exposed to a variety of unhealthy foods such as sugary breakfast cereals, candy, cookies, hot dogs and snack chips (data not shown).

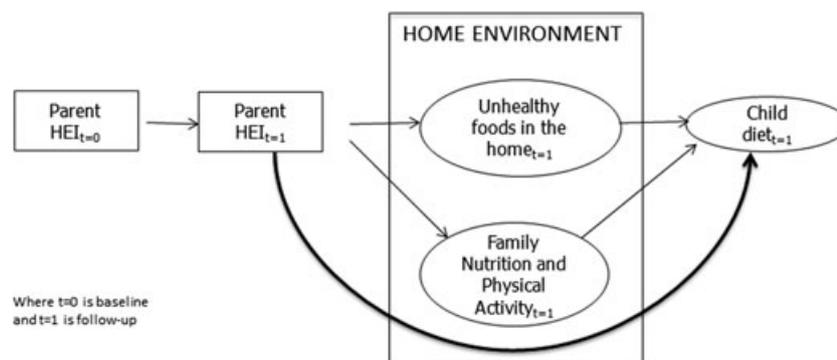


Figure 1 Conceptual model.

Table 1 Sociodemographic characteristics of the study sample ($n = 132$)

Parent-level	Percentage or mean (range; STD)
Gender	
Female	93.3
Male	6.7
Education	
Less than high school	12.1
High school	38.7
Some college	40.0
College degree	9.2
Per capita household income	7709 (714–67,500; 8511)
Age	36.7 (18–86; 12.7)
Household food insecure	44.3
Neighbourhood	
Hill District	68.5
Homewood	31.5
SNAP participation	69.9
Mean level of concern about child weight	
Child eating too much when parent not around	1.9 (1–5; 1.4)
Unconcerned	63.4
Concerned a little	12.4
Concerned	7.6
Fairly concerned	3.7
Very concerned	12.9
Child having to diet to maintain a desirable weight	1.7 (1–5; 1.3)
Unconcerned	70.1
Concerned a little	10.8
Concerned	5.2
Fairly concerned	6.2
Very concerned	7.7
Child becoming overweight	1.9 (1–5; 1.5)
Unconcerned	85.4
Concerned a little	12.2
Concerned	9.6
Fairly concerned	6.3
Very concerned	18.4
Child-level	
Child's age	9.3 (5–13; 2.7)
Child's gender	
Female	56.7
Male	43.3
Free/reduced school breakfast	66.7
Free/reduced school lunch	70.2
Dietary intake—typical servings per day	
Fruit intake	
≤1 serving	24.9
2 servings	32.1
3 servings	29.3
4+ servings	13.6
Vegetable intake	
≤1 serving	37.4
2 servings	37.7
3 servings	14.8
4+ servings	10.1

For the children's diet, fruit and vegetable intakes were the only two indicators that loaded significantly onto the latent 'child diet' variable (Table 2). The observed indicators that related to latent 'home food availability' were as follows: candy or cookies, regular milk, white bread, low-fat milk, whole grain bread, regular soda and white rice. Lastly, the 10 FNPA screener items as indicators of 'FNPA patterns' were retained.

Figure 2 presents the estimated effects of a model that links changes in parental diet to the home environment and children's diet. For clarity, only statistically significant associations at $p < 0.05$ are presented. The results suggest that the relationship between change in parental dietary quality and children's diet after the supermarket opened operated indirectly through family nutrition and physical activity patterns. Specifically, healthier parental dietary intake was indirectly and positively associated with children's healthy dietary behaviours ($\beta = 0.46$, $p < 0.001$) through family nutrition and physical activity that promote healthy eating and active living ($\beta = 0.25$, $p = 0.02$). In contrast, although healthier parental dietary intake was associated with having a less unhealthy home environment as measured by availability of unhealthy foods ($\beta = -0.38$, $p = 0.001$), it was not associated with children's dietary behaviours. The model fit the data well according to the root mean square error of approximation of 0.03, comparative fit index of 0.84 and Tucker–Lewis index of 0.81. The chi-Square statistic of 394 with 346 degrees of freedom and borderline statistically significant $p = 0.05$ suggests that the model may not fit the data well. However, the Chi-Square statistic is sensitive to sample size and is often inflated in large studies (40).

Discussion

This study demonstrates that the home environment is a critical pathway in the relationship between parental dietary quality and children's diet, following the opening of a supermarket in a former food desert. Specifically, parental dietary improvement after the supermarket opened was associated with having a better home environment ($\beta = 0.45$, $p = 0.001$) and with healthier children's dietary intake ($\beta = 0.46$, $p < 0.001$) through higher family nutrition and physical activity scores ($\beta = 0.25$, $p = 0.02$). Our data support other research that suggests that the home environment is critical to understanding dietary quality, especially among vulnerable children of colour (41,42). This analysis also adds to the important policy debate of how and to what extent changes in the neighbourhood environment may improve children's diet and diet-related outcomes, including obesity.

Family nutrition and physical activity played a comparatively larger role on children's diet than home

Table 2 Standardized model estimates of latent variables and indicator factor loadings

Latent variable and indicators	Factor loading	SE	Est./SE	p-value
Latent lack of healthy foods in the home indicated by	0.377	0.117	3.219	0.001
Candy or cookies	0.433	0.119	3.647	0.000
Regular whole milk	0.681	0.108	6.290	0.000
White bread	-0.445	0.115	-3.878	0.000
Low fat milk	-0.382	0.126	-3.037	0.002
Whole grain bread	0.912	0.074	12.405	0.000
Regular soda	0.700	0.097	7.235	0.000
White rice				
Latent family nutrition and physical activity patterns indicated by				
Family eating	0.245	0.106	2.300	0.021
Food choices	0.483	0.109	4.432	0.000
Beverage choices	0.219	0.096	2.283	0.022
Restriction and reward	0.254	0.095	2.661	0.008
Screen time	0.405	0.098	4.113	0.000
Television usage	0.390	0.094	4.142	0.000
Family activity	0.483	0.092	5.249	0.000
Child activity	0.317	0.114	2.781	0.005
Family routine	0.439	0.086	5.111	0.000
Latent child diet indicated by				
Daily serving of fruits	0.690	0.088	7.853	0.000
Daily serving of vegetables	0.884	0.088	10.058	0.000

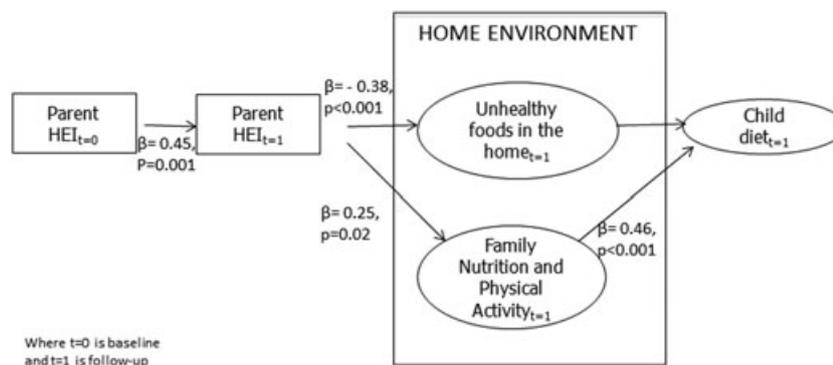
SE, standard error.

food availability of a variety of 18 items, and thus the role of family nutrition and physical activity ought to be considered when implementing policies or programmes at the neighbourhood level. These findings are in line with other studies that find social aspects of the home food environment (e.g. mealtime structure) to also be strongly associated with consumption of healthy

and unhealthy foods (43). This also points to the importance of norms and highlights the need to understand the risk factors for obesity as learned lifestyle behaviours that are taught from infancy. Interventions that cast improvement in diet as a family issue and seek to do so by encouraging positive social norms in the home are likely an important avenue for future research, especially as results from interventions focused solely on environmental factors (e.g. supermarkets) continue to yield mixed findings (6–8).

This study has some limitations that should be noted. First, children's diet is based on parental report rather than direct observation, as in the case of parents whose estimates of dietary quality derived from a 24-h dietary recalls. Second, because the child's data were collected only at follow-up, it was not possible to assess change over time similar to the parents. Thus, our SEM results are limited to associations and directionality cannot be proven.

However, using both sets of data, this research makes several important advances. First, this study was able to quantify indirect pathways from change in parental diet after the supermarket opened to children's dietary outcomes through their home food environment by using SEMs. Second, this study examined direct pathways between changes in parent diet to children's dietary behaviours to capture parental effects that might occur through unmeasured factors that are independent of the home food environment. Third, two different measures of the home environment that captured availability of foods in the home as well as norms and behaviours around healthy eating and physical activity were used. Taken together, this study is the first to elucidate the role of home environment among African-American families experiencing changes in their neighbourhood food environment.

**Figure 2** Standardized estimates from the structural equation model of the association of parental change in diet and child's diet through the home environment.

Taken together, the findings from this study highlight the crucial role of the home environment on children's diet for other neighbourhoods undergoing a transformation of the food environment. Future research should not discount the importance of factors such as norms and behaviours inside the home that may mitigate – or exacerbate – children's exposure to toxic food environments. Policies that seek to confront poor diet among our most vulnerable children need to simultaneously address the role of the home environment within the larger context of the neighbourhood and community setting. For example, allocating resources in order for the new supermarket to be the site for nutrition education programming that empowers families with the technical skills, nutrition knowledge and self-confidence to prepare healthy and affordable meals may be a powerful way in which ongoing policy efforts can be harnessed to concurrently focus on the home environment. Similarly, promoting participation in federal food and nutrition assistance programmes is another way in which families in these communities can have access to family-friendly educational materials through the SNAP Education, as well as programming throughout the community (e.g. faith organizations) (44). This multi-prong approach is also more receptive to the lived-experience that shapes food access and consumption among these families and would ensure that the preferences related to nutrition and physical activity that children develop at home will help them achieve and maintain a healthy weight and healthful diet well into adulthood.

Conflict of Interest Statement

None of the authors have anything to disclose.

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intellectual content: Flórez, Richardson, Ghosh-Dastidar, Huang, Wagner and Dubowitz.

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