



Original article

Changes in the Neighborhood Food Store Environment and Children's Body Mass Index at Peripuberty in the United States

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A B S T R A C T

Purpose: Little is known about the relationship between changes in food store environment and children's obesity risk in the United States. This study examines children's weight status associated with the changes in the quantity of food stores in their neighborhoods.

Methods: A nationally representative cohort of schoolchildren in the United States was followed from fifth grade in 2004 to eighth grade in 2007 ($n = 7,090$). In 2004 and 2007, children's body mass index (BMI) was directly measured in schools. ZIP Code Business Patterns data from the Census Bureau in 2004 and 2007 characterized the numbers of food stores in every ZIP code area by type of store: supermarkets, limited-service restaurants, small-size grocery, and convenience stores. Baseline and change in the numbers of stores were the major exposures of interest.

Results: Girls living in neighborhoods with three or more supermarkets had a lower BMI 3 years later (by -0.62 kg/m^2 ; 95% confidence interval = -1.05 to -0.18) than did those living in neighborhoods without any supermarkets. Girls living in neighborhoods with many limited-service restaurants had a greater BMI 3 years later (by 1.02 kg/m^2 ; 95% confidence interval = $.36$ – 1.68) than did those living in neighborhoods with less than or equal to one limited-service restaurant. Exposure to a decreased quantity of small-size grocery stores in neighborhoods was associated with girls' lower BMI by eighth grade.

Conclusions: The longitudinal association between neighborhood food environment and children's BMI differed by gender. For girls, supermarkets in neighborhoods seemed protective against obesity, whereas small-size grocery stores and limited-service restaurants in neighborhoods increased obesity risk. There was no significant longitudinal finding for boys.

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IMPLICATIONS AND CONTRIBUTION

This study finds a longitudinal association between neighborhood food stores and girls' weight status change in the United States. The number of supermarkets was associated with girls' lower body mass index 3 years later. The neighborhood food environment should be thus targeted as an important venue for childhood obesity prevention.

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There is growing attention to the impact of food environments on health outcomes such as obesity [1–4]. In particular, the retail food environment in neighborhoods is being recognized as an important determinant of what people eat. Cross-sectional studies show that neighborhood access to supermarkets is associated with lower body weight and a healthier dietary pattern in youth [5–9]. In neighborhoods with more food outlets that provide wholesome food choices, children may have a better dietary quality and lower body weight. Children living in neighborhoods dominated by convenience stores and fast-food restaurants tend to have higher body mass indices (BMIs) and consume less healthful foods [6,10–14].

Longitudinal studies on this issue often come from smaller scale study settings and show some conflicting results. For instance, in one study, the presence of convenience stores in neighborhoods was associated with 7-year-old girls' excessive BMI-for-age growth over 3 years, but produce vendors and farmer's markets were inversely associated with obesity risk [13]. However, a study based in Los Angeles County observed that children's greater weight-for-height was associated with having healthy food outlets in the neighborhood [15]. An unmeasured factor is that the food outlet environment in neighborhoods may change over time, and children's growth status could change with the dynamics of local food environment. To our knowledge, nevertheless, there is no larger scale epidemiologic study examining this question longitudinally.

From childhood to adolescence, children experience drastic physical growth [16]. In addition, during this period, children acquire more agency to explore the world outside the home, and they have more opportunity to visit food stores in their neighborhoods [17]. The neighborhood environmental influences on children's growth and their BMI status thus could be critical during this life stage.

This study examined the association between the exposure to four types of food stores in home neighborhoods and children's changes in BMI and weight status using nationally representative data collected in the United States. It provides evidence for the influence of the food store environment on children's obesity development. We used the nationally representative data from the fifth to eighth grade years of the Early Childhood Longitudinal Study–Kindergarten Cohort (ECLS-K).

Methods

Study design and study sample

The ECLS-K is a cohort study of a nationally representative sample of kindergarteners in 1998–1999. The survey aimed to investigate U.S. schoolchildren's experiences in school and collected abundant information on home and school environments from kindergarten to the fifth grade (in Year 2004) and eighth grade (in Year 2007) [18]. In this study, we examined children's BMI and body weight status from the fifth to eighth grades. The study included only those children who had a measured BMI at fifth grade and at eighth grade and who had information on their home ZIP code in 2004 and 2007 ($N = 7,090$). The secondary data analysis study was approved by the institutional review board of Johns Hopkins School of Public Health.

The children's resident ZIP code linked the individual data with data about the neighborhood environment. Data about food stores in neighborhoods came from the ZIP Code Business Pattern (ZBP) database for 2004 and 2007. The ZBP system uses a nationwide business registry and releases the aggregate numbers of establishments with the same North American Industry Classification System (NAICS) code in each ZIP code [19]. The 2000 U.S. Census provided neighborhood demographic and socioeconomic characteristics [20]. We used the five-digit ZIP Code Tabulation Areas (ZCTA5) to define neighborhood units, as the Census Bureau designed the ZCTA5s to coincide with the five-digit postal ZIP code areas. We linked the individual's data in ECLS-K to the neighborhood environmental characteristics by the ZCTA5 of the children's residence.

Outcome variables

Outcomes of interest included children's BMI (kg/m^2) and obesity status at the fifth and eighth grades. Obesity status was defined as a sex-specific BMI-for-age percentile ≥ 95 th on the 2000 CDC growth reference [21]. Children's body weight and height were measured twice during interviews using a digital scale (Seca model 840, Seca North America West, Chino, CA) and the Shorr stadiometer (Shorr Productions LLC, Olney, MD). The two height measurements were averaged if they differed < 2 inches; the two weight measurements were averaged if they differed < 5 pounds. Otherwise, the measurement nearer to the median weight for age or height for age was retained. The changes in the anthropometric measurements from 2004 to 2007 were the outcome of interest.

Exposure variables

According to the ZBP data for the corresponding years of the study (i.e., 2004 and 2007), the built food environment in a given ZIP code was described by the quantities of supermarkets, small-size grocery stores, limited-service restaurants, and convenience stores in 2004 [3,22]. For supermarkets (NAICS = 445,110 and ≥ 50 employees) and small-size grocery stores (NAICS = 445,110 and < 10 employees), the categories were 0, 1, 2, and ≥ 3 in the ZIP code area. For convenience stores (NAICS = 445,120 or 447,110 [convenience stores associated with gasoline stations]), the categories were 0–1, 2–5, 6–10, and ≥ 11 stores in the ZIP code area. For limited-service restaurants (NAICS = 722,211 [limited-service restaurants], 722,212 [cafeterias], 722,330 [mobile food services]), the categories were 0–1, 2–10, 11–25, and ≥ 26 restaurants in the ZIP code area. "Limited-service restaurant" refers to a restaurant where customers order and pay before they are provided with food; we included cafeterias and mobile food services as limited-service restaurants. Convenience stores and limited-service restaurants have a category of 0–1 store because a very small proportion of children lived in a neighborhood lacking convenience stores or limited-service restaurants.

Based on the ZBP data, children were categorized into exposures to different levels of food store environments in 2004. A change in status of the food store environment in the ZIP code areas was described as "increase," "decrease," and "no change" in the quantities of stores between 2004 and 2007. Furthermore, neighborhood food store dynamics were classified as (1) the type of store was absent in 2004 and in 2007 ("absent"); (2) the store was absent in 2004 but present in 2007 ("absent \rightarrow present"); (3) the type of store was present in 2004, and the quantity increased in 2007 ("present, increased"); (4) the type of store was present in 2004, and the quantity decreased in 2007 ("present, decreased"); (5) the type of store was present in 2004, and the quantity remained the same ("present, remained").

Covariates

Child-level covariates included age, sex, and race (Hispanic, black, white, and others). Information on socioeconomic status was based on parents' reports. If the child had two parents, the parents' education level was determined based on the parent who had the higher education level. If the child had one parent, the parent's education level was determined by the only parent's education level. The household's poverty status was defined based on parent-reported income of $< 100\%$ of the federal

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