The Toxic Food Environment Around Elementary Schools and Childhood Obesity in Mexican Cities

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Introduction: The childhood obesity epidemic is a global concern. There is limited evidence in Mexico linking the local food environment to obesity. The purpose of this study is to describe the links between the local food environment around elementary schools and schoolchildren's BMI in two Mexican cities.

Methods: Cross-sectional surveys were conducted in 60 elementary schools in two Mexican cities (i.e., Cuernavaca and Guadalajara) in 2012–2013. Anthropometric measurements on schoolchildren were collected, as well as environmental direct audits and observations in a 100-m buffer around schools. Children's BMI was evaluated according to WHO-recommended procedures. In BMI models, the explanatory variable was the number of retail food sources. These models were adjusted for child's characteristics, schools' socioeconomic background, compliance with federal guidelines concerning unhealthy foods within schools' facilities, and corresponding city. Analysis was conducted in 2014.

Results: The number of mobile food vendors was higher around public schools than outside private schools ($p < 0.05$). Linear regression procedures showed a significant positive statistical association between children's BMI and the number of mobile food vendors around schools. Schoolchildren from the highest tertile of mobile food vendors showed 6.8% higher BMI units than those from the lowest tertile. Children attending schools within the highest tertile of food stores also had 4.7% higher BMI units than children from schools in the lowest tertile.

Conclusions: Health policy in Mexico should target the obesogenic environment surrounding elementary schools, where children may be more exposed to unhealthy foods.
(Am J Prev Med 2016;51(2):264–270)

Introduction

The obesity epidemic has attracted global attention[1]; yet, only few countries have shown progress in terms of effective policy tools to prevent it.[2] The health and economic consequences of being overweight or obese are significant, as every 15 extra kilograms of body weight increases the risk of early death by approximately 30%.[3,4]

Lifetime healthcare expenditures for people with obesity are at least 25% higher than for someone of normal weight. National costs are likely to increase if prevalence rates of overweight and obesity in children keep rising.[5] Children with obesity are prone to be obese adults and are more at risk of developing chronic diseases such as heart failure, stroke, Type 2 diabetes, several types of cancer, and osteoarthritis.[6,7] The driving factors of obesity are complex and diverse; they operate over a lifetime and at different levels of social, economic, environmental, cultural, and legal systems. Data from developed countries reveal complex links between childhood obesity and the physical and social environment.[8] Today, these links are often framed into the "built environment" model, which refers to the structural

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0749-3797/$36.00
http://dx.doi.org/10.1016/j.amepre.2016.02.021

landscape created or modified by people.[9] The obesogenic environment involves high access to processed foods and sugar-sweetened beverages, financial barriers to healthy food sources, sedentary lifestyles, and growing social inequalities.[10] The influence of the obesogenic environment may be stronger within neighborhoods where local food retailers offer unhealthy products very accessible to children.[11]

Research on the relationships between the toxic food environment and childhood obesity in less developed countries has received very little attention.[12] In most of these countries, including Mexico, evidence-based policy targeting the obesogenic environment is in its infancy. Today, one in three Mexican children aged 5–19 years is of excessive weight, a rate slightly behind U.S. children.[13] In Mexico, direct costs of chronic diseases such as diabetes and hypertension are estimated between 3 and 4 billion U.S. dollars/year.[14,15] The health system in Mexico has not yet directed enough effort or created policies to avert this epidemic.[16]

Given that Mexico's population is experiencing a rapidly growing intake of unhealthy food products,[17,18] health authorities have issued a series of guidelines to reduce availability of such products inside schools.[19] Most of this unhealthy food is easily available outside the school premises and often at a short walking distance from the school gate. The objective of this study is to assess the associations between the food environment surrounding elementary schools and schoolchildren's BMI in two Mexican cities.

Methods

Cross-sectional studies were conducted in two Mexican cities. These two cities were selected both because of their prevalence of overweight and obesity in schoolchildren (31.8% in Cuernavaca, Morelos, and 37.0% in Guadalajara, Jalisco, according to the 2006 National Health and Nutrition Survey)[20] and urbanization characteristics. Multiple sources of data, including databases from the Ministry of Education in Mexico, were used to obtain sampling frames of elementary schools and children.

School Selection

Data were collected in two cities, in October of 2012 in Cuernavaca and from January to March 2013 in Guadalajara. Children's guardians and school authorities provided informed consent to conduct this investigation. The IRB from the Instituto Nacional de Salud Publica approved the study in April 2012.

Stratified probabilistic sampling techniques were used. Random selection was done using Epidata, version 3.1. Strata were represented by the schools' categories (i.e., public or private), and all schools had the same probability of being selected. A total of 34 schools were eligible in each city.

Eligible schools were assigned to private or public categories, and this information was used as a proxy of SES of children; the rationale was that tuition fees charged in private schools are not affordable to low-income households. Originally, 68 elementary schools were selected, but information could be gathered only from 48 (70.6%). Perceived lack of safety in these neighborhoods prevented almost 30% of participation from schools' staff, parents, and children. A total of 12 schools were replaced with the closest unit from the same SES category. Complete information was gathered from 60 schools (29 in Cuernavaca and 31 in Guadalajara) and 725 schoolchildren.

A GIS was built to locate eligible schools using ArcGIS, version 10.0. Eligible schools were geocoded and their precise location point was validated using onsite checking and Google Maps. Satellite photographs were used to define a 100-m buffer around the school gate. This 100-m buffer was set because of the proximity and density of mobile food vendors outside the schools. Walking surveys, ground observation, and direct audits around eligible schools allowed identifying and classifying all retail sources within the buffer. Data were recorded during normal school hours. If the people in charge of the retail food sources granted permission, trained research staff took photographs of the foods and beverages sold in their facilities.[10]

Students from fourth and fifth grades (aged 9–11 years, depending on the grade level) were randomly selected, with an average of four children from each classroom participating in the study. Their parents signed an informed consent form. Some schools had more than one class at each grade level, therefore yielding more eligible children; the number of individuals participating in each school increased directly with the number of students in both the fourth and fifth grade classrooms.

After standardization procedures, research staff collected anthropometric direct measurements on barefoot children.[21] Electronic scales (Tanita, Model 803) were used to measure body weight, while height was measured using a 1-mm precision stadiometer (SECA, Model 206). The authors made duplicate readings and averaged them. BMI was calculated using weight and height. Values were considered as plausible if BMI was within the range of 10–38. All measurements met this criterion.

Measures

BMI z scores for age and sex were used to classify overweight and obesity, as recommended by WHO. Overweight was defined as ≥ 1 and <2 SDs and obesity was defined as ≥ 2 SDs.[22]

Retail food sources were classified into three types: mobile food vendors (e.g., peddlers, pushcarts, or stands that place themselves selling candies, ice cream, beverages, and snacks); these mobile food vendors sell their products right outside the school gate and are observed exclusively at the beginning and the end of the school schedule; therefore, they are different from the temporary street food stands. The former was further classified according to the type of foods sold:

1. unhealthy food (e.g., pork rinds, candies, tamales, ice cream, icicles, sorbets, pizzas, French fries, beverages with whipped cream and chocolate, donuts);
2. healthy food, such as sandwiches, gelatin snacks, fruits, vegetables, freshly made juices, and yogurt; and
3. mixed (vendors that offered products from both categories, i.e., healthy and unhealthy food).

Food stores (convenience and grocery stores and super and minimarkets) and food establishments represented the other two types of retail food sources. Food establishments were further categorized as

1. fast food restaurants, in which foods are prepared and served to be consumed quickly; waiters are not part of this foodscape;
2. cafeterias, places selling coffee and other beverages, snacks and sweets, and sometimes appetizers and entrées;
3. restaurants, where foods and beverages are served by waiters to the customers' table (fast food and cafeterias are not included);
4. temporary street food stands are retailers found from 8:00AM to 5:00PM outside the school gate and always within the 100-m buffer; they mainly offer traditional Mexican foods and beverages; and
5. other establishments (e.g., poultry markets, bakeries, ice cream parlors, places that sell products in bulk, and stationary stores) also retailing packaged foods and bottled beverages, even though their primary business purpose may be different from traditional retail food establishments.

Eligible schools were visited, and structured observations inside their facilities allowed the authors to assess compliance with current guidelines concerning the availability of sugar-sweetened beverages and processed food in schools. The current Mexican guideline prohibits retailing sugar-sweetened beverages and food that does not comply with national carbohydrate, fat, sugar, and sodium per serving criteria.[23] Compliance and non-compliance were considered a variable in the model. However, some schools did not permit information gathering about food sold inside, and for that reason a third category of "no information" was created.

Statistical Analysis

The dependent variable was children's BMI and the explanatory variables were the numbers of mobile food vendors and food stores surrounding elementary schools. Control or confounding variables included child's sex and age, public or private school affiliation, compliance with food regulations within schools' facilities, and corresponding city. Frequency distributions were first created for each of the explanatory variables, and the prevalence of type of retail food sources available around each school was measured. A multiple linear regression analysis including students grouped into school clusters was used to determine the relationship between the children's BMI and the number of retail food sources within the school's buffer. The primary statistical unit of analysis was the school, as the number of schools determined the total df available in the model. Because the distribution of BMI was skewed toward higher numbers, the variable was natural log transformed. The models were adjusted according to children's age; sex; and type of school (i.e., public or private), as a proxy of SES, and grouped all children within clusters. Preliminary modeling with hierarchical models was tested with schools nested within cities, and children nested in schools. Only the model with children nested within schools showed significant variance (data not shown); the coefficients for the independent variables in this hierarchical model were virtually the same as in the simpler regression model with schools used to cluster children. The clustered regression model data were used for a better interpretation. All combinations of retail food sources in the BMI model were tried, but only the number of mobile food vendors and food stores had significant explanatory power (other retail sources had a small range of counts), so food establishments were dropped from the model. Stata, version 13.1, was used for the statistical analysis, which was concluded in 2014.

Results

A total of 60 schools participated in this investigation (29 in Cuernavaca and 31 in Guadalajara). Of the 725 studied schoolchildren, 24.8% were overweight and 20.7% were obese (Table 1).

The authors detected 246 mobile food vendors, 103 food stores, and 177 food establishments. Most of these (85.4%, 73.8%, and 67.2%, respectively) were observed in the proximity of public schools.

As Table 2 shows, a median of four mobile food vendors were found outside each school (minimum, zero; maximum, 18); there were significantly more food vendors outside public schools than outside private schools. Most of the mobile food vendors were classified as unhealthy (85%) (data not shown). A median of two food stores were observed around public schools; the median was one food store in private schools. The most commonly observed establishments surrounding private schools were fast food restaurants; public schools'

Table 1. General Characteristics of the Sample Population in Two Cities, Mexico, 2013

	n (%)
Number of schools by city	
Cuernavaca (*n*=29)	332 (45.8)
Guadalajara (*n*=31)	393 (54.2)
Type of school	
Public (*n*=34)	465 (64.1)
Private (*n*=26)	260 (35.9)
Sex	
Female	412 (56.8)
Male	313 (43.2)
Age (years)	
9	269 (37.1)
10	311 (42.9)
11	145 (20.0)
Nutritional status	
Normal	391 (54.5)
Overweight	180 (24.8)
Obese	150 (20.7)

Table 2. Median Number of Retail Food Sources Around Elementary Schools by School Type in Guadalajara and Cuernavaca, Mexico, 2013

Type of retail food source	Public schools, Median (P25, P75)	Private schools, Median (P25, P75)	Total, Median (P25, P75)
Mobile food vendors	6 (3, 9)	1 (0, 3)[a]	4 (1, 7)
Food stores: convenience and grocery stores, supermarkets, and mini markets	2 (1, 3)	1 (0, 2)	2 (1, 3)
Food establishments	3 (1, 5)	2 (1, 4)	2 (1, 4)
Fast food restaurants	0 (0, 1)	0 (0, 1)	0 (0, 1)
Cafeterias	0	0	0
Restaurants	0	0	0
Temporary street food stands	1 (0, 2)	0 (0, 1)	1 (0, 1)
Other establishments selling food	1 (0, 2)	0 (0, 1)	1 (0, 2)

[a]Differences between public and private schools. Median test, $p<0.05$.
P25, 25th percentile; P75, 75th percentile.

proximity showed more temporary street food stands and other establishments.

Table 3 illustrates the linear regression model between BMI (expressed in natural logarithmic units) and the number of mobile food vendors and food stores around schools. A significant positive statistical association was found between the tertiles of mobile food vendors outside the school and children's BMI, even after adjusting for other potentially confounding variables. This model suggests that the larger the number of vendors outside the school, the higher the children's BMI. Children from schools with a larger number of vendors outside the school's facilities (two to six, Tertile 2) had 4.7% more BMI units than those in schools in Tertile 1 (95% CI=0.4, 8.4); children attending schools from Tertile 3 (seven to 18 vendors) had 6.8% more BMI units (95% CI=2.1, 10.9); and children from Tertile 3 had 4.7% more BMI units than those from Tertile 1 (95% CI=1.0, 8.4).

Table 3. Association Between Natural Log-Transformed BMI and Retail Food Sources Around Schools.

Independent variable[a]	β coefficient (95% CI)	*p*-value	% change in BMI from omitted category
Sex (male)	0.060 (0.034, 0.087)	<**0.001**	6.2
Type of school (private)	0.063 (0.026, 0.103)	**0.003**	6.5
City (Guadalajara)	0.019 (−0.014, 0.052)	0.252	1.9
Complies with the regulations=No	0.016 (−0.020, 0.051)	0.380	1.6
Complies with the regulations=No data	0.011 (−0.032, 0.055)	0.605	1.1
Age=10 years	0.003 (−0.033, 0.039)	0.867	0.3
Age=11 years	0.044 (0.011, 0.078)	**0.011**	4.5
Tertiles of number of mobile vendors			
Tertile 2	0.047 (0.006, 0.0087)	**0.024**	4.7
Tertile 3	0.066 (0.022, 0.110)	**0.004**	6.8
Tertiles of number of stores			
Tertile 2	0.033 (−0.006, 0.073)	0.092	3.4
Tertile 3	0.046 (0.009, 0.083)	**0.015**	4.7
Constant	2.811		

Note: Boldface indicates statistical significance ($p<0.05$). N=725; R^2=0.060; SE adjusted for 60 clusters (schools).
[a]Omitted categories: sex=female; type of school (SES) = public; city=Cuernavaca; complies with federal food-in-school regulations=yes; age=9 years; tertiles=1.

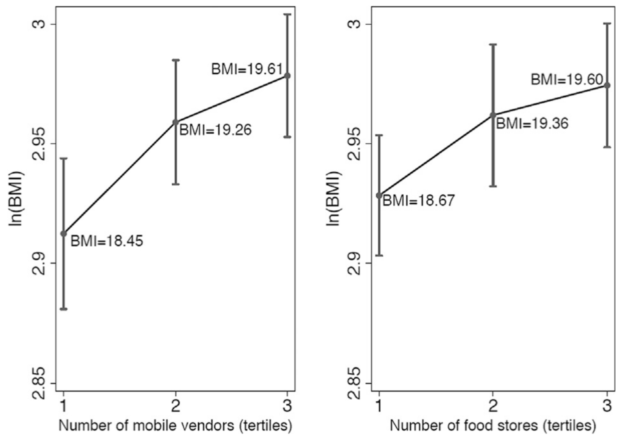

Figure 1. Partial regression of natural log BMI in 9–11-year-old children on tertiles of mobile food vendors (left) and food stores (right) within a 100-m buffer of 60 private and public schools in Cuernavaca, Morelos, and Guadalajara, Jalisco, Mexico, from model in Table 3.

Note: Number of mobile food vendors by tertile: 1st=0–1; 2nd=2–6; 3rd=7–18. Number of food stores by tertile: 1st=0–1; 2nd=2–2; 3rd=3–6. Linear trends of BMI for both tertile food vendors and stores were significant (p=0.007 and p=0.009, respectively).

Estimates were adjusted in the model of natural log BMI shown in Table 3 with type of school (public/private); sex; if the school complies with the Ministry of Education's regulation to not make available junk food in the school; integer age in years; and tertiles of number of food vendors and food stores. Vertical bars are the 95% confidence intervals of the estimated natural log BMI.

Figure 1 indicates the geometric mean of children's BMI by tertile of the number of vendors and the tertile of the number of food stores as fit by the adjusted regression model.

Discussion

The results showed high counts of retail food sources and easily available processed and unhealthy food (i.e., products high in sugar, salt, and fat content) within the 100-m buffer of elementary schools; this processed and unhealthy food is easily available only a few steps away from the school gate. The number of mobile food vendors was significantly higher in the proximity of public schools. Even more important perhaps, the number and location of retail food sources varied between public and private school surroundings. Nevertheless, proximity of food retailers may not be the only concern. Statistically positive associations were detected between the number of mobile food vendors around schools and children's BMI. Although there were more retail food sources located around public than around private schools, children's BMI showed no statistical difference. Similarly, the interactions between the local food environment–related variables and the school's category on BMI were not statistically significant, suggesting that the general effect of the food environment on children's BMI may not be linear, and that explanatory links may not depend only on the school's category (proxy of SES, as used in this investigation).

The data showed that children attending private schools had higher rates of overweight and obesity than children from public schools. This is consistent with recent observations in the Mexican adult population,[24] but different from other studies suggesting that obesity in Mexico is becoming concentrated among lower-SES groups.[25] The present data reinforce the growing need to identify the links among childhood obesity, the local food environment, and SES. It is necessary to push the boundaries of the "built environment" theory, using stronger SES indicators and blended or mixed methods to capture the complexities of the obesogenic environment.

Similar observations have been reported in industrialized countries.[26] For instance, recent studies in California analyzed the local food environment around public schools and found that a higher density of convenience stores in an 800-m buffer was associated with a higher prevalence of overweight in school children, which contrasted with the weight of those attending schools with no convenience stores in their surroundings.[27] One research study[28] in the area of East Harlem, NY, reported that children aged 6–8 years in schools with a higher convenience store density had a higher BMI (OR=1.90, 95% CI=1.15, 3.15) than those living in neighborhoods with a lower concentration of this type of stores. Others have indicated a higher risk of overweight and obesity associated with more fast food restaurants (OR=1.01, 95% CI=1.0, 1.01).[11] Similar to the findings in the present investigation, two research studies[29,30] have described a significant positive association between low-income communities and the availability of convenience stores. Nonetheless, most of these studies used indirect or intermediate methods to evaluate neighborhood characteristics and the obesogenic environment.

Moreover, the authors noted that research and health policy addressing the social determinants of childhood obesity in developing countries are in very early stages. Available evidence from Mexico's obesogenic environment, in particular, is limited. Only two studies have applied similar approaches to this study; one[31] of them described food intake during the regular commute from school to home and associations with obesity, and the other[32] evaluated the obesity enablers in the school surroundings and found that the prevalence of overweight in children from high-income families increased with consumption of out-of-home junk food (OR=1.67, 95% CI=1.11, 2.51). Both studies reported a great availability of food, drinks, and obesogenic products in these surroundings.

Limitations

The present investigation has methodologic strengths and limitations deserving some remarks. First, the study used direct data measurements (e.g., anthropometric measurements, in-person audits of the local food environment). Even though direct methods may be more time consuming and relatively expensive, they provide the most accurate description of children's BMI and the food environment in their neighborhood during a normal school day.

The cross-sectional design of this study and its results only reflect associations, not a cause-and-effect link. Furthermore, data on individual diet or physical activity from schoolchildren are incomplete and therefore not included in the models. In addition, the characteristics of retail food sources and the products offered outside the school were only identified, but it is uncertain if the students consumed these products or not. Other limitations include information bias and potentially confounding variables affecting the neighborhood, households, schools, and children. For instance, although a telephone survey was used to collect data on SES and transportation patterns (home–school), parents expressed safety concerns and did not provide answers about income and their children's whereabouts. Schools that refused observation inside their facilities to assess compliance with current guidelines might be offering unhealthy food to schoolchildren. Children-related variables, such as pocket money to purchase available foods, may play a role in this set of findings. Financial constraints and time dictated the buffer size. Some authors argue, however, that a small buffer can provide more-detailed information reflecting the local food environment.[30]

Finally, because child weight would be more highly correlated within each school than between schools, children were clustered in each school. Whereas this procedure reduced the possibility of violating the general linear model assumption of independent observations, it also reduced the power to detect statistically significant differences between schools.

Conclusions

Health protection measures should target the toxic food environment surrounding elementary schools, where children may be more exposed to unhealthy products and marketing practices. The policy agenda is far from complete, and society, as a whole, increasingly demands concerted efforts to build stronger governance, accountability research, and education programs to reduce the obesity epidemic. Policy instruments and prevention measures should shift their focus away from individual behavior and should, instead, be directed to shape the social and environmental determinants of health within a holistic framework.

This study was possible thanks to funding from the National Council of Science, No. SALUD-2011-1-160496. We thank Ana Isabella Ley for her assistance.

No financial disclosures were reported by the authors of this paper.

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