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Research Article

Lifestyle and Environmental Factors Associated with Predictors of Childhood Obesity

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Abstract This cross-sectional study examined the relationship between behaviors (physical activity and eating patterns) and socioeconomic and built factors that affect childhood obesity. A sample of 171 participants were selected from three elementary schools in Montclair, California. Family SES and health information about the students were gathered. The number of parks, fast food restaurants, and grocery stores within school district border lines were tallied, and data was analyzed using logistic regression. Lower income was associated with 2.11 times higher odds of consuming fast food, and 3.06 times higher odds of consuming soda. Feeling unsafe in the neighborhood was associated with 2.57 times higher odds of consuming fast food. Children whose parents had some college education were 3.23 times more likely to consume milk, 2.97 times more likely to consume vegetables, and 2.29 times more likely to engage in physical activity than parents with no more than high school education. Children engaging in physical activity were 69% less likely to be obese. Parent income, parent education, and concern for neighborhood safety affected the eating habits and physical activity level of children in Montclair. Increased fast food consumption and decreased physical activity were associated with higher BMI percentiles among this population.
Keywords *BMI; Built environment; Childhood obesity; Food-environment; Physical activity; SES*

1. Introduction

Obesity in childhood is a worldwide public health problem (Chung et al., 2014) and a major risk factor for health complications previously only diagnosed in adults (De Onis et al., 2010; Rao et al., 2016). Childhood obesity is often tracked into adulthood resulting in increased risk for premature mortality and non-communicable diseases, such as type II diabetes, some cancers and cardiovascular disease (Ho et al., 2017). From the 1980s, the prevalence of childhood obesity increased alarmingly (Misqueleiz et al., 2017). However, recent evidence suggests that in the 21st-century obesity in children may have plateaued in developed countries (Chung et al., 2014; Rao et al., 2016; Misqueleiz et al., 2017; Foster et al., 2017). Nevertheless, the increasing prevalence in developing nations and the sustained high rates in the developed world (Katz, 2014) highlights the need to understand the correlates associated with childhood obesity.

Fundamentally, obesity is the result of high caloric intake relative to expenditure (McCarthy et al., 2017). For effective interventions, it is essential to consider the multiple factors influencing physical activity and eating behaviors (Carroll-Scott et al., 2013). A socioecological model views the determinants of childhood obesity at multiple levels - individual, social and environmental, affecting activity and food consumption (Carroll-Scott et al., 2013; Papas et al., 2007). The social and built environments, as well as the socioeconomic status (SES) of a community, have all been documented as potentially important domains influencing obesogenic behavior (Carroll-Scott et al., 2013).

The design of the built environment determines how a community interacts with the physical space around them (Carroll-Scott et al., 2013; Papas et al., 2007). Some research suggests that proximity to supermarkets and reduced access to convenience stores promotes healthier eating behaviors and lower rates of obesity (Larson et al., 2009). Nevertheless, the influence of the built environment on increased obesity levels is mixed (McCarthy et al., 2017; Sallis et al., 2012; van Loon et al., 2014; Kurka et al., 2015). Access to recreational facilities has been correlated with increased physical activity levels (Sallis et al., 2012), while children living in communities with lower walkability scores and access to recreational facilities engaged in less exercise (Kurka et al., 2015).

The role of SES and the influence on childhood obesity has also been observed by Shrewsbury and Wardle (2008). There appears to be a predominantly inverse relationship between SES and obesity (Chung et al., 2014; Lissner et al., 2016; Newton et al., 2017), and parental education was the most common factor consistently inversely associated (Shrewsbury and Wardle, 2008).

The overall aim of this study was to identify the relationship between behaviors (physical activity and eating patterns) and socioeconomic and built factors that affect childhood obesity. We hypothesize that social and environmental factors affect eating patterns and physical activity in children resulting in childhood obesity.

2. Methods

Study Design and Sample

This is a cross-sectional, observational to determine if the built environment and socioeconomic status of children were related to children's eating behaviors and physical activity level. Parental income and parental education level (which reflected socioeconomic status) as well as the parental perception of neighborhood safety, the number of fast food restaurants, grocery stores, and parks (which represented the built environment) were examined for their relationship to children's eating behaviors and physical activity level. The association between these factors and childhood obesity rate were also examined.

A power analysis for multiple regression with six predictors was conducted using SAS to determine appropriate sample size using an alpha of 0.05, a power of 0.80, and a medium effect size ($f2 = 0.15$). Based on these assumptions, the desired sample size is 98. Three schools were randomly selected from eight elementary schools located within the Montclair, California school district. All students from the three elementary schools in grades 1-5 (approximately 500 students in each school) received take-home consent forms to request participation in this study.

Study Variable, Instrumentation, and Measurement

In this study, there were six independent variables used: (1) parental income and (2) parental education level (both representing socioeconomic status) as well as (3) number of fast food restaurants within the school catchment areas, (4) number of grocery stores, (5) number of parks, and (6) parents'/guardians' perception of neighborhood safety (all representing the built environment).

Likewise, there were six dependent variables: (1) physical activity, and the (2) consumption of fast food, (3) milk, (4) soda, (5) vegetables, and (5) fruit. The effect of six factors including physical activity, and the consumption of fast food, milk, soda, vegetables, and fruit on childhood obesity (represented by body mass index BMI) was also undertaken.

The operational definition for obesity in the study was based on BMI that was calculated using a child's weight and height. This was then used to find the matching BMI for age percentile using the Child BMI Calculator from the Centers for Disease Control and Prevention website (Child and Adolescent Health Measurement Initiative, 2007). A BMI between the 1st and 84th percentiles was categorized as having a healthy weight whereas children with a BMI between the 85th and 94th percentiles were categorized as overweight. If the child's BMI was above the 95th percentile, then they were considered obese. Children with a healthy weight or who were underweight were grouped since there were only four participants considered underweight. There were three resulting BMI categories: (1) healthy (2) overweight, and (3) obese. Child weight and height measurements were recorded using the Adam MDW-250L digital medical scale.

The built environment was measured observationally by counting the number of parks, grocery stores, and fast food restaurants within the school district and confirmed by comparing the counts to the Geographic Information System (GIS) data. GIS data were derived from the California Department of Public Health database to obtain the number of parks, grocery stores (including corner stores and markets), and fast food restaurants within each school's catchment area. Built environment was also measured by the parents'/guardians' perception of their neighborhood's safety, using the 2007 National Survey of Children's Health (Centers for Disease Control and Prevention, 2010).

Sections of the 2007 National Survey of Children's Health were also used to measure socioeconomic status. In using the questions in this survey, socioeconomic status was measured in terms of (a) parent/guardian education, and (b) parent/guardian income (Centers for Disease Control and Prevention, 2010).

The 2005 Dietary Guidelines for Americans were used to determine the standards for what is considered a healthy diet (consumption of fruit, vegetables, and milk) and being physically active among children (U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2005). We used the 2007 National Survey of Children's Health. Physical activity to measure physical activity based on two questions. Firstly, the parents/guardians were asked, whether on most days during the past week, the child exercised, played a sport, or participated in physical activity for at least 20 minutes that made him/her sweat and breathe hard (Yes or No). Secondly, the child was asked how many days during the previous week did they engage in vigorous physical activity (as identified above) (1) 0 days (2) 1-3 days (3) 4-6 days (4) Everyday (5) Don't know (6) Refuse to answer (Centers for Disease Control and Prevention, 2010).

To measure healthy diet, questions from the 2003 University of California, San Francisco Family Health Outcomes Project (FHOP) survey were used, as well as the 2010 National Youth Physical Activity and Nutrition Survey (Family Health Outcomes Project, 2003). Questions about food and beverage consumption were open-ended, and responses were collected as continuous variables representing the servings of milk, soda, fruits, and vegetables consumed daily.

Data Collection

Take-home surveys for parents and guardians, written in both English and Spanish, were given to teachers to distribute to their students. The students were directed to deliver the survey, consent, and assent forms to their parents or guardians until the sampling goal was reached. Parents/guardians assisted their children by completing a survey questionnaire on behalf of their child but with the child's

input. For the purposes of the study, a child and their parent/guardian were counted as a single unit. Surveys consisted of twenty-two questions and took less than 10 minutes to complete, which was determined after pilot testing the survey. Child weight and height measurements for BMI were collected during school hours. The nurse's office at each of the three selected elementary schools was used to provide privacy, and each measurement took no longer than five minutes per child.

Data Analysis

The association between SES, built environment, food environment, physical activity, and eating habits was assessed using two models. Logistic regression analysis for dichotomous variable outcomes and ordinal logistic regression analysis for multiple variable outcomes were conducted. We also developed another model using logistic regression for addressing the association between child participation in physical activity, eating habits, and child obesity (represented by BMI).

Frequency tables were used to identify predictor variable levels with insufficient counts for any category of physical activity and food consumption. For instance, the initial seven levels of parent/guardian education were collapsed into three levels (high school graduate or less, vocational/business trade school, and some college or more). Furthermore, neighborhood safety was reduced from four to two levels (sometimes/never safe and usually/always safe). After collapsing the variables, univariate ordinal logistic regression was used to assess the association between each predictor variable with physical activity and food consumption. The objective was to look at one single predictor variable at a time and its correlation with physical activity, each of the food consumption variables, and child BMI percentile. After using univariate ordinal logistic regression, a multivariate model was developed in order to look at multiple variables and the correlation between physical activity, food consumption, and child BMI percentiles. All tables show the adjusted cumulative odds ratios, along with 95% confidence intervals that were computed using ordinal logistic regression. All analysis was done by using SPSS 20 software and confirmed with SAS 9.3 (SAS Institute).

3. Results

Descriptive Statistics

A total of 194 students responded to the consent and survey forms that were distributed to grades 1-5 in the 3 schools randomly selected in Montclair. Only 171 students presented for the anthropometric measurements (BMI) and assented to be a part of the study. However, this was higher than the sample size of 92 required for medium effect size. The sample was composed of 39.2% obese participants, 35.7% overweight, and 25.1% healthy weight (Table 1).

Table 1: *Distribution of socioeconomic, environmental, and obesity-related variables*

Variable	Count	Variable	Count
BMI Category		**Fast Food Outlets**	
95th Percentile and above	67	Region 1	53
85th – 94th Percentile	61	Region 2	28
1st – 84th Percentile	43	Region 3	90
Parent's Education		Grocery Stores	
9th – 12th Grade/No Diploma	9	1	53
Graduate/GED Completed	71	4	118
Vocational/Trade	32	Age	
Some College Credits (No Degree)	30	6	17

Associate's Degree	16	7	45
Bachelor's Degree	9	8	37
Master's Degree	1	9	36
Parent's Income		10	25
Less than $15,000	0	11	11
$16,000 to $20,000	5	Gender	
$21,000 to $25,000	42	Male	63
$26,000 to $30,000	72	Female	108
$31,000 to $35,000	40	Race/Ethnicity	
$36,000 to $50,000	12	Asian/Other	14
$51,000 to $75,000	0	Hispanic	101
More than $75,000	0	Non-Hispanic Black	33
Neighborhood Safety		Non-Hispanic White	22
Never	7		
Sometimes	91		
Usually	60		
Always	13		
Parks			
Region 1	53		
Region 2	29		
Region 3	89		

Socioeconomic Status (SES)

Children whose parent/guardian reported being from a low-income family were 2.11 times more likely to consume fast foods and 3.06 more likely to consume soda than those who reported being from a higher income family (Table 2). In contrast, children with a parent/guardian who reported some college-level education or higher as well as those who reported having a vocational business trade education were 3.23 and 3.87 times more likely to drink milk, respectively than those children from families where the parent or guardian has no more than a high school education (Table 2).

Table 2: *Multivariate analysis of physical activity outcome*

Variable	OR (95% CI)	P Trend	Variable	OR (95% CI)	P Trend
Parent's Education		0.0660	Age		0.6015
High school graduate or less	1		6-7	1	
Vocational/Business trade school	2.81 (1.05 – 7.54) *		8-9	0.80 (0.33 – 1.99)	
Some college or more	2.29 (0.94 – 5.56)		10-11	0.83 (0.39 – 1.77)	
Parent's Income			Gender		
Low Income	1		Male	0.89 (0.43 – 1.81)	
High Income	1.52 (0.63 – 3.72)		Female	1	
Neighborhood Safety			Race/Ethnicity		0.1134
Sometimes/Never	0.95 (0.47 – 1.93)		Asian/Other	3.91 (0.73 – 20.98)	
Usually/Always	1		Hispanic	2.05 (0.73 – 5.79)	
Parks		0.4827	Non-Hispanic Black	1.93 (0.58 – 6.36)	
Region 1	1.30 (0.60 – 2.80)		Non-Hispanic White	1	

Region 2	0.90 (0.36 – 2.25)
Region 3	1

Children whose parent/guardian reported having a vocational/business trade education were 2.81 times more likely to engage in physical activity compared to those who reported no more than a high school education (Table 3). Furthermore, children whose parent/guardian reported some college-level education or higher as well as those that reported having a vocational/business trade education were 2.97 and 2.63 times more likely to eat vegetables, respectively, compared to those who reported no more than a high school education (Table 2). However, the latter was not statistically significant (Table 2).

Table 3: *Multivariable analysis of milk, vegetable, and soda consumption*

Variable	OR (95% CI) Milk Consumption	P Trend	OR (95% CI) Vegetable Consumption	P Trend	OR (95% CI) Soda Consumption	P Trend
Parent education		0.1256		0.0243		0.9562
High school graduate or less	1		1		1	
Vocational/ Business trade school	3.87 (1.34 – 11.15) *		2.63 (0.97 – 7.15)		1.8 (0.59 – 5.49)	
Some college	3.23 (1.11 – 9.47) *		2.97 (1.18 – 7.51) *		1.01 (0.35 – 2.95)	
College Graduate or more	1.95 (0.66 – 5.82)		Not Calculated**		1.14 (0.36 – 3.58)	
Parent's Income						
Low Income	1.98 (0.78 – 5.05)		1		3.06 (1.01 – 9.21)*	
High Income	1		2.14 (0.73 – 6.28)		1	
Neighborhood safety						
Sometimes/Never	1.14 (1.67 – 2.38) *		1.08 (0.52 – 2.24)		1.2 (0.54 – 2.63)	
Usually/Always	1		1		1	
Grocery stores						
1	2.45 (1.10 – 5.47) *		0.67 (0.30 – 1.49)		1.55 (0.66 – 3.67)	
4	1		1		1	
Age		0.1676		0.6548		0.9758
6-7	1		1		1	
8-9	1.03 (0.48 – 2.19)		0.56 (0.25 – 1.25)		1.59 (0.68 – 3.74)	
10-11	2.15 (0.81 – 5.71)		0.92 (0.36 – 2.36)		0.91 (0.35 – 2.37)	
Gender						
Male	1.20 (0.57 – 2.50)		1.03 (0.50 – 2.14)		1.91 (0.85 – 4.31)	
Female	1		1		1	
Race/Ethnicity		0.3771		0.8712		0.2925
Asian/Other	1.56 (0.32 – 7.68)		0.83 (0.16 – 4.25)		1.91 (0.36 – 10.17)	
Hispanic	1.67 (0.58 – 4.79)		1.09 (0.36 – 3.33)		2.09 (0.69 – 6.33)	
Non-Hispanic Black	1.36 (0.40 – 4.68)		0.84 (0.24 – 2.99)		1.83 (0.50 – 6.64)	

Non-Hispanic White	1	1	1

Built Environment

Children whose parents/guardians reported sometimes or never feeling safe in the neighborhood were 2.57 times more likely to eat fast food than children whose parents/guardians reported usually or always feeling safe in their neighborhood (Table 4).

Gender was found to be an important confounder in the fast food consumption model, in which males were 2.22 times as likely to consume fast food compared to females (Table 4).

Table 4: *Multivariable analysis of fast food outcome*

Variable	OR (95% CI)	P Trend
Parent's Education		0.3806
High school graduate or less	1	
Vocational/Business trade school	1.37 (0.54 – 3.45)	
Some College	2.10 (0.75 – 5.87)	
College graduate or more	1.34 (0.47 – 3.79)	
Parent's Income		
Low Income	2.11 (0.89 – 5.03)	
High Income	1	
Neighborhood Safety		
Sometimes/Never	2.57 (1.29 – 5.14) *	
Usually/Always	1	
Fast Food Outlets		0.1485
Region 1	1.82 (0.87 – 3.81)	
Region 2	1.52 (0.62 – 3.76)	
Region 3	1	
Age		0.3565
6 – 8	1	
9 – 10	0.81 (0.39 – 1.67)	
10 – 11	0.67 (0.28 – 1.60)	
Gender		
Male	2.23 (1.12 – 4.45) *	
Female	1	
Race/Ethnicity		0.1355
Asian/Other	0.50 (0.11 – 2.27)	
Hispanic	0.51 (0.20 – 1.34)	
Non-Hispanic Black	0.77 (0.26 – 2.32)	
Non-Hispanic White	1	

Food Consumption, Physical Activity, and BMI

There appears to be an association between physical activity, fast-food consumption and child body mass index percentile. Children who ate fast food 2-3 times a week and 4-6 times a week were 11.39 and 24.97 times more likely to be obese, respectively than those who ate fast food 1 or fewer times per week (Table 5). Furthermore, children who engaged in 1-3 days and 4-6 days of physical activity per week had 69% and 78% lower odds of obesity, respectively, then those who did not engage in physical activity throughout the week (Table 5). These odds ratios from the variables in the multivariate model remained significant after adjusting for factors such as age, gender, and race/ethnicity.

Table 5: *Multivariable analysis of BMI percentile*

Variable	OR (95% CI)	P Trend
Vegetable Consumption (servings/day)		0.9500
0	1	
1	0.84 (0.30 – 2.34)	
2	0.90 (0.28 – 2.90)	
Milk Consumption (servings/day)		0.1729
0	1	
1	1.71 (0.79 – 3.68)	
2	1.86 (0.73 – 4.74)	
Soda Consumption (servings/day)		
0 – 1	1	
2 – 4	0.74 (0.37 – 4.74)	
Fruit Consumption (servings/day)		0.5951
0	1	
1	1.36 (0.49 – 3.78)	
2 – 3	1.40 (0.48 – 4.06)	
Fast Food Consumption (times/week)		<0.0001
0 – 1	1	
2 – 3	11.39 (4.67 – 27.79) *	
4 – 6	24.97 (7.78 – 80.20) *	
Physical Activity (days/week)		0.0052
0	1	
1 – 3 days	0.31 (0.14 – 0.72) *	
4 – 6 days	0.22 (0.06 – 0.74) *	

4. Discussion

The results of this study support prior evidence suggesting that social and environmental factors affect food consumption and activity levels in children (Carroll-Scott et al., 2013). Likewise, there appears to be an inverse relationship between socioeconomic status (SES) and being overweight or obese as has been documented for developed countries (Shrewsbury and Wardle, 2008). Children residing in lower SES families and with access to poorer food environments tend to acquire poorer eating behaviors and engage in lower physical activity levels (Li et al., 2015). Access to poorer food environments in this study appeared to be reflected in parental perceptions of the safety of their built environment.

The higher odds of consuming fast food and soda by children of low-income parents in this study is supported by other research (Robinson et al., 2012; Ohri-Vachaspati et al., 2014). Both proximity and density of fast food restaurants and convenience stores appear to be associated with increased consumption of fast food (Mellor et al., 2011; He et al., 2012). Fast food restaurants may tend to establish themselves in lower income areas (Mellor et al., 2011), and a much greater percentage of advertising pertains to these food items than for healthier food items such as fruits and vegetables (Robinson et al., 2012).

The consumption of fruits and vegetables has also been negatively associated with lower incomes. However, it appears that parental influence may have a more consistent impact on healthier food behaviors (van der Horst et al., 2007). Siblings and parents who eat more fruit and vegetables act as role models for younger children resulting in a greater consumption for them also (van der Horst et al., 2007; Pabayo et al., 2012). Similarly, accessibility to fruit and vegetables is a strong determinant in their consumption by children (de Jong et al., 2014). Children from lower SES are less likely to have

access to fruit and vegetables and therefore have an inadequate intake of fruit and vegetables (Glen et al., 2013). This is disconcerting since dietary behaviors are often tracked into adulthood, and low fruit and vegetable intake are connected to future unfavorable outcomes (Glen et al., 2013).

Previous research also suggests that increased consumption of sugar-sweetened beverages usually displaces milk consumption (Pabayo et al., 2012). Similarly, in this study, parental income was related to soda and milk consumption. Children of parents with a lower income drank more soda while children of parents who had a higher parental education drank more milk. Ballew et al. (2000) found that children who drink milk are more likely than soda drinkers to meet their nutritional requirements, such as calcium. Moreover, even though the authors found an inverse relationship between milk and soda consumption, the effect was small, accounting for lower than 10% of the variance between milk and soda consumption.

Likewise, the increased level of physical activity corresponding to increased parental education has also been confirmed by other studies (Robinson et al., 2012). Children from lower SES (parental income) were found to have greater opportunities for sedentary behavior such as screen time and less access to portable play equipment such as bikes and jump ropes than children who were more physically active. Furthermore, parents of lower SES were more likely to engage in sedentary behavior, such as TV watching, with their children (Pabayo et al., 2012; Tandon et al., 2012). Likewise, the SES of the community in which the child lives influence the type of facilities that they have access to (Ohri-Vachaspati et al., 2014). Although the parental perception of safety is related to physical activity (Papas et al., 2007), we found no significant relationship. However, it is suggested that a parent's fear of danger (e.g., excessive road traffic or crime) can be an important predictor of physical activity in younger children, with parents preferring to keep them indoors (Robinson et al., 2012).

Parental perception of neighborhood safety in this study, however, was related to fast food consumption. Lumeng et al. (2006) found that parental perception was significantly associated with obesity even after controlling for SES, suggesting that it was an independent predictor. Parents who perceive their neighborhood as unsafe often reside in lower-income communities. Research suggests that fast food consumption is higher in these neighborhoods (Carroll-Scott et al., 2013), along with an increased risk of obesity (Lumeng et al., 2006). Moreover, there is a difference between gender responses to safety, with females more likely to modify their behaviors if they feel the neighborhood is unsafe (Suglia et al., 2016). This may explain the relationship between parental perception of safety and higher fast food consumption established for males in this study.

Overall, this study looked at the disparity in childhood obesity (BMI percentile) centered on the built and social environment and the interconnectivity with a child's individual behaviors. Childhood obesity is a public health concern resulting in unfavorable outcomes later in life (Chung et al., 2014). Healthy eating behaviors and increased physical activity are strong mediators of childhood obesity. In corroboration with other literature, affluence seems to have a protective effect toward individual behaviors such as healthy eating and the level of physical activity among children (Carroll-Scott et al., 2013; Newton et al., 2017) and their subsequent levels of obesity. Low SES in developed countries has consistently been found to be related to increased obesity levels (Robonson et al., 2012). It appears that parental characteristics (such as income and education) and parental perceptions of their environment are strong predictors of a child's obesity (Ohri-Vachaspati et al., 2014).

Some limitations of this study should be noted. The small sample size limits the generalizability of this study. Secondly, self-reported data were used in measuring socioeconomic status and parental perceptions of neighborhood safety. It is likely there may be some social desirability bias about some responses given by the parents since they knew the purpose of the research project in examining how SES and built environment factors influence childhood obesity.

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