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# A cross-sectional study of the influence of neighborhood environment on childhood overweight and obesity: Variation by age, gender, and environment characteristics

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ABSTRACT

To examine the influence of neighborhood environment on childhood overweight and obesity in Shelby County Schools, Tennessee, and whether and to what extent that influence varies by age, gender, and the specific environment characteristics. 41,283 students were surveyed covering both individual-level covariates and several objective measures of neighborhood environment. Multilevel logistic regressions were used to examine the influence of neighborhood-level variables on overweight + obesity and obesity with adjustment of individual-level covariates. Further, a stratified analysis for each of the six groups by school level and gender. For both overweight + obesity and obesity, younger children were less sensitive to neighborhood characteristics than older children, and boys are less sensitive than girls. For girls in middle and high schools, the risk of overweight + obesity and obesity were positively associated with population density, and negatively associated with percent of poverty and percent of unhealthy food. Boys' risk of overweight + obesity and obesity were positively associated with distance to park. Neighborhood environment plays an important role in childhood overweight and obesity, and the effects vary by age, gender, and the specific neighborhood characteristic. Intervention programs tailored to specific groups may be more effective than ones targeted to children as a whole.

## 1. Introduction

Childhood obesity is a major public health problem both nationally and internationally (Karnik and Kanekar, 2012; White House Task Force on Childhood Obesity, 2010). Recent data show that about 31.8% of children (2–19 years of age) are either overweight or with obesity (Ogden et al., 2014). Childhood obesity has multiple negative effects on health and wellbeing and the current generation may be the first generation in the past two centuries to have a shorter lifespan than their parents (Olshansky et al., 2005). Moreover, childhood obesity imposes substantial economic costs (Hammond and Levine, 2010). Childhood obesity is more prevalent among minority and groups of lower socioeconomic status (Wang and Beydoun, 2007; Chung et al., 2014), with significant disparities among geographic areas at both the neighborhood and the state levels (Wang and Beydoun, 2007).

The neighborhood environment may be conductive or prohibitive to physical activities and healthy diet that are associated with reduced incidence of overweight and obesity (Auchincloss et al., 2013; Black and Macinko, 2008). It has been reported that children living in neighborhoods with higher land use density, higher land use mix, less crime, higher traffic safety, and greater access to recreational facilities are more likely to be physically active and less likely to engage in sedentary indoor activities such as watching TV, surfing the Internet, and playing computer games (Hillier, 2008). Also, children living in neighborhoods abundant with fast food outlets and poor access to healthy foods are more likely to have unhealthy diets (Ohri-Vachaspati et al., 2013). Among the investigated environmental features, those found to be the most consistently associated with body mass index (BMI) are neighborhood socioeconomic status, walkability, access to recreational resources, and access to healthy foods (Carroll-Scott et al., 2013).

Overall the associations between neighborhood environment and childhood obesity have been established (Feng et al., 2010; Dunton et al., 2009; Lipek et al., 2015). However, our understanding is still limited in terms of the extent of a specific environment characteristics affects risk of overweight and obesity status among a specific group. One problem is that children are not a homogenous group, and the influence of neighborhood environment on childhood obesity may vary

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by individual characteristics including age and gender. For example, as children grow older, they are more autonomous, spend more time outside the house, and have more interactions with neighborhood environment (Aber et al., 1997). Consequently, the influence of neighborhood environment on childhood obesity may be more salient for older children (Alvarado, 2016). Likewise, the influence of neighborhood environment on obesity may be gender specific. Generally, boys are more physically active than girls (Telford et al., 2016). Living in neighborhoods with low safety or poor built-environment, girls are more likely to stay indoors, which may lead to decreased physical activity and obesity (Nogueira et al., 2013). Also, girls may be more sensitive to the food environment because emotional eating under stress is more prevalent among females than males (Vicennati et al., 2009). Finally, boys and girls may react differently to a specific environmental characteristic. For example, among the recreational facilities in the neighborhood, parks were found to be more important to boys, and commercial facilities were more important to girls (Sallis, 1993). Another example is that street intersection density (i.e., the ratio of the street intersections in an area) was found to be negatively related to obesity or overweight for Canadian girls, but not for boys (Spence et al., 2008). One study (Singh et al., 2010) using 2007 National Survey of Children' Health data found living in neighborhood with unfavorable conditions was associated with higher risk of with obesity or overweight and the effects were greater for female and children aged 10–11. Another recent study (Alvarado, 2016) using US national level data found that a disadvantaged neighborhood environment influences obesity more for adolescents than for younger children and more for girls than boys.

Another problem is the measurement of neighborhood environment. As Swinburn et al. (Swinburn et al., 1999) pointed out the general concept of neighborhood environment is nebulous, and we need to dissect it into concrete elements to be amenable to both measure and policy intervention. A specific neighborhood environment characteristic's influence on childhood obesity may vary by the specific group (e.g., age and gender) or the specific behaviors (e.g., physical activity and diet). Ideally, neighborhood environment should be measured from physical (or built), economic, socio-cultural, and political dimensions. For the economic dimension, the percent of poverty is one of the most common measures. For built (or physical) environment, the common measures include population density, land-use mix, access to recreational facilities, and street pattern (Brownson et al., 2009). One particular issue related with the built environment characteristics is that they could be measured both subjectively and objectively. Commonly, subjective measures were self-reported perceptions of environment (Nogueira et al., 2013) while objective measures were directly collected in the field or were obtained by computation on existing land use dataset (Sharifi et al., 2016). Discrepancies were reported between subjective and objective measures of the neighborhoods' environmental characteristics (van Lenthe and Kamphuis, 2011; Ball et al., 2008). It may be plausible that objective measures of neighborhood environment influence children's risk of obesity both directly and indirectly (through perception which may be modified by individual's properties) (Ball et al., 2008).

The aim of this study is to examine the influence of neighborhood environment on childhood overweight and obesity in Shelby County Schools, Tennessee using objective measures on both BMI and neighborhood environment. Particularly, we examined whether and to what extent the influence of neighborhood environment varies by age and gender.

## 2. Methods

### 2.1. Study population

The study population was identified from the children enrolled in Shelby County Schools (SCS), Tennessee's largest school district covering the city of Memphis (TN) and unincorporated areas of Shelby County. SCS is an urban school district with a student population of 111,500 that is 75.7% African American, 14.2% Hispanic; 10% Caucasian; and 2.1% Asian. Data were obtained from a state-mandated screening conducted by Coordinated School Health staff of SCS during the 2014–2015 academic year, which covers all students in Pre-K, K, 2, 4, 6, 8, and 9 grades. Out of about 46,000 eligible students, 41,432 had complete height, weight, and neighborhood-level data. In addition, 147 students were excluded because they lived outside the school district, and two excluded because they were > 18 years old, leaving a sample of 41,283 students (90%) in the study. For each student, the information included age, grade, gender, race, economically disadvantaged status (yes/no, determined by a student's eligibility for the free or reduced lunch program), school type, and residence zip code. Schools were categorized as public schools, charter schools, and alternative schools (i.e., those serving students who are experiencing academic as well as behavioral challenges in the traditional school setting). Also, schools were categorized into three levels: elementary, middle, and high schools. The study outcomes were overweight + obesity (defined as the ≥ 85th percentile) and obesity (defined as the ≥ 95th percentile) as computed from CDC's Growth Charts (CDC, 2017).

### 2.2. Neighborhood-level variables

Residence zip codes were used as proxies of neighborhoods. Table 1 shows detailed information for the six neighborhood-level variables used in this study. The population density and the percentage of the population below poverty level for each zip code were obtained from

**Table 1**
Neighborhood-level environmental variables.

| Name | Description and unit | Mean and range among zip codes | Data source |
|---|---|---|---|
| Population density | # of people/area; thousand persons per mile$^2$ | 2.43, [0.01, 4.65] | American Community Survey (2007–2011) |
| Percent of poverty | Percent of people below poverty level, % | 18.9, [2–61] | American Community Survey (2007–2011) |
| Intersection density | # of intersections/area; # per mile$^2$ | 125.5, [32.1–252.8] | ESRI data DVD (2008) |
| Walk score | A walkability index based on the distance to the closest amenity in a number of categories; walk score ranges between 0 and 100, with a higher number indicating higher walkability. | 30.9, [0–91] | Online (2013) |
| Distance to park | With population size as weights, the distance to the nearest park was calculated for each census block, then aggregated to zip code level; mile | 16.4, [0.018–38.1] | ESRI data DVD (2008) |
| Percent of unhealthy food[a] | The percentage of unhealthy food retailers among the total number of all food retailers, % | 85.3, [50,100] | US census zip code business patterns (2013) |

[a] According to CDC (CDC, 2011), healthy food retailers include supermarkets, supercenters, and produce stores, and less healthy food retailers include convenience stores, fast food restaurants, and small grocery stores with 3 or fewer employees.