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Patterns of food and physical activity environments related to children's food and activity behaviors: A latent class analysis

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ABSTRACT

Relationships between food and physical activity (PA) environments and children's related behaviors are complex.

Latent class analyses derived patterns from proximity to healthy and unhealthy food outlets, PA facilities and parks, and counts of residential dwellings and intersections. Regression analyses examined whether derived classes were related to food consumption, PA, and overweight among 404 low-income children.

Compared to children living in Low PA-Low Food environments, children in High Intersection & Parks-Moderate Density & Food, and High Density-Low Parks-High Food environments, had significantly greater sugar-sweetened beverage consumption (ps < 0.01) and overweight/obesity (ps < 0.001). Children in the High Density-Low Parks-High Food environments were more likely to walk to destinations (p = 0.01)

Recognizing and leveraging beneficial aspects of neighborhood patterns may be more effective at positively influencing children's eating and PA behaviors compared to isolating individual aspects of the built environment.

1. Introduction

The majority of US children neither consume diets considered healthy according to the standards set forth in the 2015–2020 Dietary Guidelines for Americans (US Department of Agriculture and US Department of Health and Human Services, 2015), nor participate in the recommended amount of physical activity (PA) per the 2008 Physical Activity Guidelines for Americans (US Department of Health and Human Services, 2008). Fewer than 30% of children meet or exceed the recommended intake of fruit, about 7% consume enough vegetables, and less than 1% meet whole grain intake recommendations (Kirkpatrick et al., 2012). Only 8% of adolescents and fewer than half of 6- to 11-year-old children engage in the recommended 60 or more minutes of daily moderate or vigorous activity (Troiano et al., 2008; US Department of Health and Human Services, 2008).

The social ecological model of health behavior posits that dietary and PA behaviors do not occur in a vacuum, and that attempting to explain or predict behavior at the individual level only is insufficient (Glanz and Mullis, 1988). Rather, it is important to recognize that an individual can simultaneously act on the environment and be influenced by multiple elements of the environment (Bandura, 1977); relationships among individual characteristics and those of the physical and sociocultural environments must be taken into account.

Food and PA environments have been examined for their roles in nutrition and activity behaviors, respectively. While availability (i.e., proximity, density, and presence) of various types of food outlets have been associated with children's food intake, these relationships appear inconsistent due in part to differences in how availability has been conceptualized and measured (Lytle, 2009). For example, in a study of 9–10-year-old children, *proximity* to a supermarket was not associated with increased fruit and vegetable intake, but a higher *density* of supermarkets (i.e., number per km^2) near children's homes was associated with higher vegetable intake (Skidmore et al., 2010). Similarly, low- and middle-income children participating in the 2006 Health Behavior in School Aged Children Study had lower odds of consuming fruits and vegetables when they attended schools in areas with a high density of fast food outlets and low density of supermarkets (Svastisalee et al., 2012). Sugar-sweetened beverage (SSB) intake has

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been associated with the presence of any convenience stores or grocery stores within 1600 m, and restaurants within 800 and 1600 m, of adolescents' homes (Laska et al., 2010). Others, however, have observed no associations between food outlet availability and food intake (An and Sturm, 2012).

The PA environment includes not only public and private recreation environments such as parks or gyms for leisure activity, but also urban form aspects, such as higher street connectivity and residential densities, that facilitate active transportation. As observed with relationships between food environments and dietary behaviors, associations between PA environments and PA behaviors have been mixed for children across different age groups (Ding et al., 2011). For example, among 3–12 year-olds, street connectivity (e.g., higher intersection density, fewer cul-de-sacs) has been found to be positively (Roemmich et al., 2007; Frank et al., 2007), negatively (Carver et al., 2008), and not (Larsen et al., 2009; Kerr et al., 2007; Braza et al., 2004) related to PA outcomes. However, residential density has been consistently associated with increased walking for transportation (Sallis et al., 2016; Larsen et al., 2009; Frank et al., 2007) among adults and children (Ding et al., 2011). Associations between park proximity and density and children's measured activity have been mixed as well (Bancroft et al., 2015).

Inconsistent findings observed for environmental measures may be attributed to methodological differences among studies, as well as differences in settings and subjects (Lytle, 2009; Brownson et al., 2009). Most studies have been designed to identify, via multivariable regression analyses, the unique effect of each environmental feature after adjusting for those of others. These analyses, however, have not accounted for the potential impact of the *combined* presence or absence of a variety of environmental features, as patterns of features in fact occur like mosaics in communities. Because environmental factors are complex and interact in multiple ways, it is critical to consider multiple factors when attempting to predict individual-level behaviors (Sallis et al., 2008) rather than attempting to isolate the potential contribution of each environmental characteristic (Kurka et al., 2015; Adams et al., 2013; Wall et al., 2012; Norman et al., 2010).

Several data driven approaches are possible for examining combinations of factors. Clustering methods, in contrast to a multiple regression modeling approach, can reduce model complexity while still retaining information from several environmental indicators, but some methods have important limitations. Though traditional cluster analysis methods (e.g., k-means clustering) can identify groups of similar observations, they place constraints on indicator scaling and do not afford straightforward statistical comparisons among models. Supervised machine learning methods (e.g., support vector machines) can identify groups of similar observations while allowing for statistical comparisons, but these methods rely on first "training" a clustering model using sets of observations that have *a priori* known class memberships. Latent class analysis (LCA) is an empirical approach for identifying distinct *patterns* of separate categorically-scaled environmental features within unknown class memberships, in which each identified class represents a distinctive pattern of indicator categories (e.g., presence vs. absence of each environmental feature). Further, LCA allows for statistical comparisons of solutions that differ in the numbers of classes extracted. Once these patterns of environmental features have been identified, they can then be related to the individual-level behaviors of interest (Meyer et al., 2015).

The purpose of this study was to examine the presence of patterns (latent classes) of objectively-measured built environment features, such as PA facilities, public parks, intersections, residential dwellings, and healthy and unhealthy food outlets across low-income New Jersey communities. Associations between derived latent classes and reported dietary and PA behaviors and weight outcomes among children were then analyzed. We hypothesized (a) that LCA would identify at least one pattern characterized by both high access to unhealthy food options and low access to PA opportunities, and (b) that this pattern would be associated with poorer dietary and PA outcomes relative to other patterns.

2. Methods

2.1. Study population

The data for this study were collected from June 2009 through March 2010 from a random-digit-dial sample of 1408 households with at least one child in the age range of 3–18 years, and with landline telephones. Households were located in Camden, Newark, New Brunswick, and Trenton, New Jersey. Using standard calculations (The American Association for Public Opinion Research, 2009) the sample of 1408 represented a 49% response rate, similar to the Center for Disease Control and Prevention's (CDC) New Jersey Behavioral Risk Factor Surveillance System (BRFSS) 2010 response rate of 50.2%. One child from each household was randomly selected as the index child, and survey questions focused on him/her. The sample was representative of 3–18-year-old children in each of the four cities included in the study, as compared to the 2000 Census, with similar racial/ethnic, age, and gender group proportions represented (US Census Bureau, 2016). The respondent was the adult who made most of the food-shopping decisions for the household (referred to as parent). A multi-call design was used to conduct telephone interviews, which were conducted in either Spanish or English and took 36 min to complete. Participants were offered a $10 incentive upon completion. At the conclusion of the survey parents were asked to participate in a follow-up study in which they weighed and measured themselves and their children using instructions based on CDC guidelines (Centers for Disease Control and Prevention, 2014) and a tape measure mailed to their homes along with a reporting worksheet. Parent-measured heights and weights of children have been reported to highly correlate with professionally measured values (Carnell and Wardle, 2008) and are more accurate than are parent-reported estimates (Huybrechts et al., 2011). An additional $10 incentive was offered for completion of this task. Approximately 40% (n = 485) of the surveyed households who provided their mailing addresses returned completed worksheets with measured heights and weights for the index child.

The Institutional Review Boards of Rutgers University and Arizona State University approved study protocols. Participants provided informed consent before the start of the study.

2.2. Parent- and child-level characteristics

Demographic variables measuring parent and index child characteristics were assessed by asking parents, "Is the child a male or female?"; "What is the child's age?"; "Is the child of Spanish, Hispanic, or Latino origin or descent?"; "What is the child's race?" (race/ethnicity categorized into non-Hispanic white, non-Hispanic black, Hispanic); "Was the child born outside of the United States, Puerto Rico, or other US territories?"; "What is the highest grade or level of school the child's mother has completed?" (categorized into high school or less, some college, bachelors or higher); "During 2008, what was your family's total income from all sources, before taxes and other deductions? (including job wages, public assistance, social security, child support, and any other sources of income)?" (converted to a ratio of the US federal poverty level [FPL]).

2.3. Outcome variables

Survey questions also assessed the index child's food consumption and PA behaviors. Questions were derived from validated surveys, as cited below.

2.3.1. Food behavior

Parents were asked, "How often over the past month (i.e., times per month, week, or day) did the child eat 1) a green leafy or lettuce salad,