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Factors influencing whether children walk to school

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ABSTRACT

Few studies have simultaneously evaluated multiple levels of influence on whether children walk to school. A large cohort of 4338 subjects from 10 communities was used to identify the determinants of walking through (1) a one-level logistic regression model for individual-level variables and (2) a two-level mixed regression model for individual and school-level variables. Walking rates were positively associated with home-to-school proximity, greater age, and living in neighborhoods characterized by lower traffic density. Greater land use mix around the home was, however, associated with lower rates of walking. Rates of walking to school were also higher amongst recipients of the Free and Reduced Price Meals Program and attendees of schools with higher percentage of English language learners. Designing schools in the same neighborhood as residential districts should be an essential urban planning strategy to reduce walking distance to school. Policy interventions are needed to encourage children from higher socioeconomic status families to participate in active travel to school and to develop walking infrastructures and other measures that protect disadvantaged children.

1. Introduction

Overweight and obesity during childhood increase the risk for a number of adverse health conditions including type 2 diabetes (Al Mamun et al., 2009), high cholesterol levels, cardiovascular complications (Thompson et al., 2007; Siervo et al., 2012), cancer (Bracci, 2012) and unfavorable musculoskeletal conditions (Haukka et al., 2012). In 2009–2010, 17% (or 12.5 million) of US children and adolescents aged 2–19 years were obese (CDC, 2010; Ogden et al., 2012). Childhood obesity is largely thought to result from an imbalance between energy intake (i.e., dietary patterns) and expenditure (i.e., physical activity) (Goran et al., 1998). Energy expenditure has received much attention in recent years, as evidence is accumulating for the role of physical inactivity and sedentary behavior in the onset and progression of overweight and obesity among children and adolescents (Ogden et al., 2012; Sothern, 2004). Physical inactivity is itself a leading cause of disease and disability (WHO, 2004; Jarrett et al., 2012; Lee et al., 2012).

Active transportation to school, including walking, incorporates physical activity into daily routines, reduces risk of childhood obesity (Giles-Corti et al., 2003), and alleviates automobile congestion and traffic-related air and noise pollution (Cavill and Davis, 2007). Walking and biking provide a reliable and affordable form of transport for most segments of the population (Lumsdon and Tolley, 2001). Kjartan (2004) estimated that the benefits (e.g., improved health, reduced noise and air pollution) of investments in infrastructure for walking and biking are 4–5 times larger than the associated costs and concluded that such investments are more beneficial to society than automobile-related transport investments.

Panter et al. (2008) provided a framework for the decision making process around travel choices for school for children and adolescents. The framework contains four main domains of influence on active travel behavior: individual factors, those associated with the physical environment, external factors such as planning and government policies, and main moderators including age, gender and distance.

Whether children engage in active transportation to school is consistently associated with child and parent perceptions of the neighborhoods through which children walk to school or other destinations (Carver et al., 2005). Concerns about traffic volume and risks (Carlin et al., 1997), air pollution (Binns et al., 2009), harassment (Larkin, 1994), street crossings and lack of traffic lights (Timperio et al., 2004) are frequently identified as factors that negatively affect perceptions about walking to school.

Walking to school and other forms of active transportation are also associated with urban form and land-use planning (Pucher et al., 2010; Frank et al., 2007; Voorhees et al., 2010). Because of

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the prevalence of low density suburban development (Schlossberg et al., 2005) and associated auto-dependency, the percent of children using active transportation to school (including walking and bicycling) dropped from 42% in 1969 to about 16% in 2001 (US CDC, 2008). Policy makers and scientists suggest a variety of land use planning strategies to encourage walking, including building new sidewalks; adding more road intersections (a measure of street network connectivity) and increasing traffic signals (Boarnet et al., 2005a, 2005b); promoting more land use mix; and placing schools in areas of high population density. Braza et al. (2004), for example, found positive correlations between higher population density, greater school size, higher number of intersections, and increased rates of walking or biking to school.

Additionally, demographic factors have been identified as having an influence on walking. Cooper et al. (2003) suggested that gender played an important role in the likelihood that youth would walk to school, with boys being more likely to walk to school and also engage in physical activity after school. Evenson et al. (2003) also explored the prevalence and correlates of walking to school and found rates of walking were generally higher for older boys (in high school) who were non-white, had a lower body mass index, and had parents that were infrequently home after school. Previous studies also found that children of parents having inadequate income or who were in lower paid occupational categories were more likely to walk to school (Pabayo et al., 2011).

Neighborhood landscape measures used in past studies manifest basic land use mix (such as percentage residential or commercial land use) (Frank et al., 2005) but they do not employ detailed metrics that characterize various dimensions of land use configuration such as shape and diversity. We conjecture these land use configurations such as convoluted roadways might indicate disorganized built environment and could thus impact whether a child walks to school.

While these and other studies have identified several factors impacting rates at which children walk to school, little analysis has integrated such individual-level factors, land use metrics, school-level variables, and other neighborhood characteristics simultaneously. The advantage of integrating all these factors into a single study is that when investigating the effect of one factor, other variables can control for confounding.

Our study incorporated an extensive list of factors, including novel land use configuration metrics, to develop multi-level models to identify factors that promote or inhibit walking to school in a large cohort of children.

2. Materials and methods

2.1. Study population

Study participants were children recruited from 13 Southern California Children's Health Study (CHS) communities during the 2002–03 school year. The present study was limited to 10 of these communities that had standardized land use data available in the Los Angeles metropolitan area. Students in participating schools were enrolled in kindergarten or first grade (5–7 years of age). Informed consent was obtained from a parent or guardian who completed a questionnaire. The study was approved by the University of Southern California Institutional Review Board. Questionnaires were completed and returned from 65% eligible children, leaving 4338 participants in the 10 communities for analysis. More information on the study design and the spatial distribution of the communities is available from McConnell et al. (2006). The questionnaires and derived variables used for this analysis included individual, school and town-level data. Measures included baseline CHS respondent data, child physical activity, socioeconomic status, land use and built environment characteristics.

2.2. Food access around schools

We assumed access to food around the school environments might change children's or accompanying parents' behavior for walking to school (e.g., encouraging walking for buying groceries after school). We included the number of grocery and fast food stores and no food stores within a 500m network buffer around schools and the number of schools with no food stores within a 500m network buffer in the analysis. The food data were acquired from the InfoUSA (Omaha, NE) dataset and the detailed description of these variables can be obtained from Jerrett et al. (2010).

2.3. Traffic density and air pollution exposure estimates

Traffic density variables were based on the California Department of Transportation Functional Class (FC) data for year 2000. Because the FC data are linked to a road network with lower positional accuracy, the annual average daily traffic (AADT) volumes were conflated to the Teleatlas road network. The link-based traffic volume data are available for freeways, highways, arterials, and some major collectors. We explored point estimates of traffic density (i.e., AADT) around each child's home using the 150 and 300 m distance buffers, details of which can be found from McConnell et al. (2006) and Jerrett et al. (2010).

Exposure to air pollution was assigned using the California LINE source dispersion model (CALINE4). This model used Gaussian plume dispersion parameters with traffic data, emissions factors, and local meteorology to estimate exposure to the mixture of near-roadway pollutants at the homes of the children. It is based on a model for the incremental increase in nitrogen oxides (NO_x) above regional background levels, as previously described (Shankardass et al., 2011). We assigned exposures for freeway and non-freeway sources to the baseline addresses of the children.

2.4. Urban form of land use represented by landscape metrics

We adapted ecological analysis tools, used to characterize natural landscapes, for use in characterizing land use patterns. Specifically, we utilized Fragstats (McGarigal et al., 2002), a widely-used set of habitat fragmentation metrics, to characterize buffer areas surrounding children's homes and schools. In landscape ecology, these metrics delineate the spatial organization of habitat (or vegetation) patches of various types, revealing the complexities of the landscape. Individual Fragstats metrics can be calculated at different spatial scales and provide many ways for describing both land use composition and configuration. For our purposes, we looked at "habitat patches," which are areas of uniform urban land use of a particular type (e.g., residential, commercial, institutional, industrial, etc.).

The Fragstats program computes a large number of metrics. We considered the following Fragstats landscape metrics in our characterization of land use configurations around children's homes and schools: land shape index (LSI); percentage of landscape in a particular use (PLAND); fractal dimension (FRAC); contiguity (CONTIG); Simpson's diversity index (SIDI), and contagion and interspersion (CONTAG).

A brief explanation of each metric is described as follows: LSI (≥1) measures perimeter to area ratio, or "clumpiness," of a land use. As values approach 1, the shape of land use becomes more compact (like a square). Thus, higher values indicate more convoluted boundaries and appear less as a symmetric shape, and imply potentially less opportunity for physical activity. PLAND (≥0 and ≤100) measures landscape composition by computing the