THE IMPACT OF NEIGHBORHOOD CHARACTERISTICS ON PHYSICAL ACTIVITY AND OBESITY IN LOW-INCOME CHILDREN

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ABSTRACT

The prevalence of childhood overweight/obesity has received much attention in recent years as a serious public health issue. There is a growing body of research concerning the role of the built environment in the obesity epidemic. For low income children, who are more likely to be obese, it is also likely that neighborhood safety plays an important factor in physical activity. In this study we examine how neighborhood safety and the built environment, influence the physical activity and obesity levels among low-income children. The study was based on two primary research questions:

- To what degree do neighborhood safety and the built environment impact low-income children's physical activity levels?
- Do these factors influence whether or not low income children are obese?

Methods. Data was collected from a cross-sectional survey of 800 parents of children receiving Medicaid in four Florida counties. The survey included questions about perceived neighborhood safety, physical activity, and demographics. The child's body mass index (BMI) was calculated based on parent-reported of height and weight.

Our measures of the built environment were developed at the zip code level using Geographic Information System (GIS). We calculated four measures that have been shown in prior studies to contribute to "walkability" in neighborhoods: street connectivity, intersection density, density of major and local road miles, and the ratio of major road miles to local road miles.

Findings. Results indicate that low income children's physical activity is influenced by both neighborhood safety and walkability factors. In bivariate analysis, children more frequently walked for 10 or more minutes, and were more likely to walk or bike to school in areas where there was higher street intersection density. Children whose parents reported keeping their children inside due to safety concerns were less likely to take walks. Measures of neighborhood safety exhibited a positive relationship on parents' satisfaction with the amount of exercise their children got. However, neither neighborhood safety nor walkability appears to influence obesity.

INTRODUCTION

The prevalence of childhood obesity has received much attention in recent years as a serious public health issue. According to data from the National Health and Nutrition Examination Study, the percentage of children who are overweight has more than doubled, and among adolescents the rates have more than tripled since 1980.[1] The increase in obesity rates in children has coincided with an increase in the diagnosis of medical problems that were previously only seen in adults, including type II diabetes, asthma, and hypertension.[2,3] In addition, childhood obesity is a key predictor for obesity in adulthood, where it is one of the leading preventable causes of death.[4]

Research suggests that certain populations possess a higher risk of becoming overweight than others. One group that has a particularly high rate of being overweight is low-income children.[5,6] Strauss et al. found that children with low socio-economic status were almost twice as likely to develop obesity than children from the highest 15% of socio-economic status.[5] According to a study by the CDC, the prevalence of overweight among low-income children under the age of five increased from 18.6% in 1983 to 21.6% in 1995.,

In general, the factors that contribute to obesity on an individual level can be divided into factors relating to either input or output. Input of calories includes the amount and type of food consumed. Output is the amount of calories burned. On the most basic level, if an individual's input is greater than the output, he/she will gain weight overtime. This study focuses on physical activity, which falls into the output portion of the obesity equation.

There is a growing body of research concerning the environmental factors that impact rates of obesity and physical activity among all populations. Several studies have demonstrated the impact of neighborhood characteristics, such as "walkability" and safety, on activity levels and obesity rates in adults.[9,11-17] The term "walkability" refers to the neighborhood's overall conduciveness to walking and/or biking both for fitness and transportation. Land use patterns that have been found to contribute to "walkability," include street connectivity, low dead end density, high population density and land use mix.[8,16,17] Studies have shown that, in adults, these elements are related to a higher incidence of active transportation choices, such as walking or biking,[8,9] and, in some instances, lower rates of overweight and obesity.[17] In children, these elements have been found to effect the likelihood of walking or biking to school.[8]

Neighborhood safety has also been studied for its effects on physical activity and obesity rates in adults and children. In a few studies, lower levels of perceived neighborhood safety have been associated with lower rates of physical activity and higher rates of obesity in children.[9,10,15] Lumeng, et al. found that neighborhood safety ratings in the lowest quartile were associated with higher risk of overweight compared to safety ratings in the highest quartile.[15]

While both walkability and safety have each been shown to have an impact on physical activity and obesity, few studies have examined their independent influence while controlling for the other. In addition, little is known about the physical activity patterns of low-income children, and more specifically, how both of these neighborhood factors may influence physical activity and overweight status among this population. It is important to understand if the emerging trends in research on neighborhood characteristics are applicable to low-income children, because they have a higher risk of obesity and are more likely to be concentrated in areas that possess specific characteristics, such as higher crime rate.[1,5,6]

The present study was designed to fill these gaps in the literature. The study compared the levels of physical activity and overweight status among low-income children with perceived neighborhood safety and elements that have been found to contribute to overall "walkability," including, residential density, street connectivity and land use mix,[8,16,17] as well as other neighborhood factors such as proximity to school and parks. The study also examines the effect of both safety and walkability on physical activity and overweight status.

The primary research questions were as follows:

- Do neighborhood safety and the built environment have an impact on low-income children's physical activity levels?
- Do these factors have an impact on the overweight status of low-income children?

In sum, this study seeks to build on the growing research concerning the relationship between neighborhood characteristics and increasing rate of obesity among low-income children. Gaining a stronger understanding of these potential obstacles and how they affect physical activity for low-income children could help to inform the design of policies and programs targeted at encouraging physical activity and overall health among this population.

METHODS

Recruitment and Data Collection

Data was collected from a cross-sectional survey of 800 parents/guardians of children receiving Medicaid, who lived in one of four Florida Counties: Broward, Duval, Palm Beach, or Escambia. Medicaid is the state-administered program that provides health coverage for low-income children and families. The telephone survey was administered in September and August, 2006 and there was a response rate of 44%. Figure 1 illustrates the distribution of respondents by zip code between the four counties.

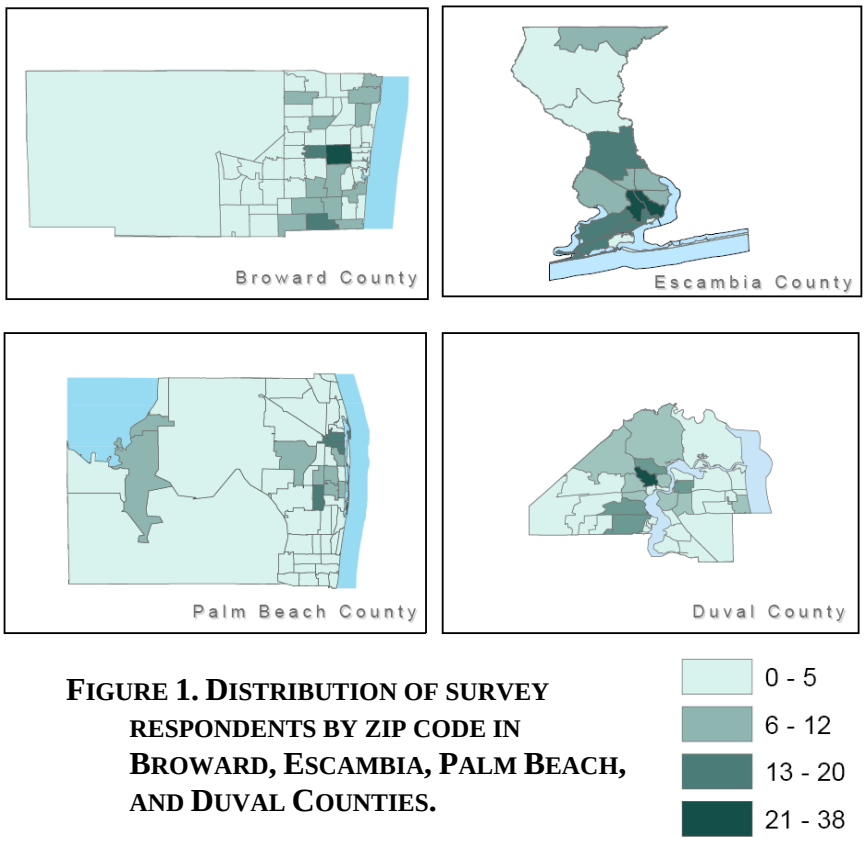

FIGURE 1. DISTRIBUTION OF SURVEY RESPONDENTS BY ZIP CODE IN BROWARD, ESCAMBIA, PALM BEACH, AND DUVAL COUNTIES.

The survey included questions about perceived neighborhood safety, certain neighborhood characteristics, health status of the child, and physical activity. The survey also provided data on the gender, age, and ethnicity of the child and parent, as

well as information on the parent's educational attainment and the zip code in which the child lived.

Dependent Variables

Physical Activity and Overweight

The dependent variables are self-reported measures of physical activity and overweight status. Questions measuring physical activity included the number of days per week that the child exercises and walks ten or more minutes, both of which were adapted from a study by Brownson and colleagues[18], as well as whether the child regularly walks or bikes to school. Parents were also asked to rate their overall satisfaction with the amount of exercise their child gets.

Parents provided information on their child's overall health status, and the height and weight of the child, which allowed us to calculate the child's Body Mass Index (BMI). Using growth charts from the Centers for Disease Control, we computed the percentile that the child's weight fell in compared with children of the same age and gender. Children with BMI's over the 85th percentile for their age group are considered overweight and children with BMI's over the 95th percentile are considered to be obese.

Independent Variables

Neighborhood Safety

Neighborhood safety was measured by the parent's perceptions of the level of safety in the neighborhood. Parents were asked to rate the overall safety of nearby playgrounds and parks[18] , as well as to answer such questions as, "In the last seven days, was there ever a time that you kept your child inside because you were concerned about the safety of playing outside?" Perceptions of safety have been used in several studies as a measure of neighborhood safety.[9-11,15]

Walkability

Walkability was measured using three variables that have been shown in previous research to contribute to increased walking - intersection density, residential density and land use mix.[8,13,16,17] These measures were developed using Geographic Information Systems (GIS). The three measures along with data sources are described in Table 1. Each of the measures was calculated at the zip code level; there were respondents in 134 different zip codes throughout the four counties. Originally, intersection density was calculated in two different ways – using 3-,4-,and 5-way intersections and then taking into account only 4-way intersections. However, there was no substantive difference between the two different calculations in terms of overall findings. The street connectivity and land use mix variables were recoded into three categories – high, medium, and low – which each contained approximately a third of

TABLE 1. MEASURES OF WALKBILITY

Measure	Definition	Scale of Measure-ment	Equation	Data Source(s)	Mean	Std Dev.
Residential Density	Number of housing units per square mile	Zip Code	# of households/ Sq miles of zip code	2000 U.S. Census Data	771.8	703.9
Street Connectivity	Number of 3-, 4- and 5- way intersections per square mile	Zip Code	# of intersections/ sq mile of zip code	Street and zip code Tiger Data from ESRI (2000)	80.9	42.8

the respondents. The residential density variable was recoded into four categories each with a roughly equal number of respondents. \

Land Use Mix*	Evenness of distribution of square footage of residential, commercial, and office development	Zip Code	Equation below*	Florida D.O.T. Parcel Land Use data(2000)	.65	.21

**Land use mix = (-1) x [(square footage of commercial/ total square footage of commercial and residential) ln (square footage of commercial/total square footage of commercial and residential) + (square footage of residential/ total square footage of commercial and residential) ln (square footage of residential/total square footage of commercial and residential)]/ ln (n2); where n2 = 0 through 2 depending on the number of different land uses present.*

Control Variables

Control variables used in multivariate models included the age, gender, and race/ethnicity of the child, These variables helped to control for differences in physical activity and health that were attributable to individual differences. For example, four-year-old children may be less likely to walk to school overall than older children. In addition, we controlled for the parent's education, because there is evidence that a higher level of education is correlated with better health and more physical activity, and this trend may hold true for children, as well.

ANALYTIC APPROACH

We used univariate analysis to describe the socio-demographics of the sample, as well as the general trends in rates of overweight/obesity and physical activity, and the number of respondents for each zip code. We computed bivariate relationships between the independent variables, neighborhood safety and characteristics of the built environment, and the dependent variables of physical activity and weight status. This analysis shows the raw percentages of children from each neighborhood category that engage in different levels of activity and that are overweight or obese. For example, the bivariate analysis helped to answer the questions, " What percentage of children from neighborhoods with a low-level of perceived safety are overweight?" or "What percentage of children from neighborhoods with a high-level of street connectivity frequently walk or bike to school?"

Finally, we used a multivariate logistic regression model to examine the effect neighborhood safety and the built environment on the dependent variables. We controlled for the effects of the independent variables as well as for gender, age, race/ethnicity, overall health of the child, and parent's education. We examined whether the walkability measures were highly correlated and suitable for making a scale, and found that they were not. Thus, they are entered as separate items.

RESULTS

Univariate Analysis

Descriptive statistics of the sample population are presented in Table 2. Over half of the children in the sample were African American, and there were slightly more females than males (52.1%). The ages of children were fairly evenly distributed between 4 and 15, though a much smaller percentage was between 16 and 18 years old.

The overwhelming majority of parents/guardians responding to the survey were female (92%). Most had attained an education level of high school or more, while nearly 25% had not graduated from high school.

Most parents reported that their child's overall health was either excellent or very good (71%); however, the BMI obtained from self-reported height and weight revealed that nearly half of the children were either overweight or obese. It should be noted that the sample for which we were able to calculate BMI was greatly reduced, because many respondents felt they could not accurately provide either their child's height or weight.

TABLE 2. CHARACTERISTICS OF SAMPLE POPULATION	
Gender	Percent (n=800)
Male	47.9
Female	52.1
Age of Child	
4 – 7	31.6
8 – 11	28.6
12 – 15	27.6
16 – 18	12.2
Race/Ethnicity	
African American	57.8
Latino/a	12.1
White	23.3
Other	6.8
Gender of Parent/Guardian	
Male	8.4
Female	91.6
Education Level of Parent/Guardian	
Less than High School	24.6
High School or GED	39.2
College or greater	36.2
County of Residence	
Palm Beach	21.8
Escambia	22.0
Broward	28.1
Duval	28.1
Overall health of child	
Excellent or very good	71.2
Good, fair or poor	28.8
Parent Reported Weight	
About Right	75.4
Underweight	7.8
Overweight	16.8
Body Mass Index (n=616)	
Average	51.5
Overweight	17.4

Obese	31.2

TABLE 3. NEIGHBORHOOD SAFETY AND WALKABILITY	
Safety	Percent (n= 800)
Kept child inside due to safety concerns	
Yes	26.3
No	73.7
There is a safe, outdoor place to play outside of home	
Very True	41.4
Somewhat True	34.4
Not True	24.2
It is not safe to go on walks during the day in neighborhood	
Very True	14.5
Somewhat True	21.9
Not True	63.6
Walkability	
Intersection Density	
High	39.6
Medium	32.9
Low	27.5
Residential Density	
High	36.4
Medium	28.1
Moderate	29.3
Low	6.2
Land Use Mix	
High	31.3
Medium	44.3
Low	24.4

Over 25% of parents reported having kept their child inside due to safety concerns in the past week and nearly 25% agreed that there was no safe outdoor place to play in the neighborhood. Though the majority of parents felt that their neighborhoods were generally safe, there was still a higher rate of safety concerns among this low-income population than among the general population.

Bivariate Analysis

TABLE 4. BIVARIATE RELATIONSHIPS: NEIGHBORHOOD SAFETY					
	Kept child inside due to safety concerns		There is a safe, outdoor place to play outside of the home		
	Yes (%)	No (%)	Very True (%)	Somewhat True (%)	Not True (%)
Health					
In general, child's health is…					
Excellent or very good	65.6*	73.0	77.1**	66.2	68.6
Good, fair, or poor	34.4	27.0	22.9	33.8	31.4
Weight					
Normal	57.4	49.8	48.5	51.1	55.1
Overweight	14.8	17.9	19.7	16.7	15.2
Obese	27.7	32.3	31.8	32.1	29.7
Physical Activity					
Parental Satisfaction with amount of exercise child gets					
Satisfied	77.0***	88.8	91.0***	84.5	78.5
Dissatisfied	23.0	11.2	9.0	15.5	21.5
Days/Week child plays or exercises					
3 or less	24.4	19.6	17.9*	19.6	28.0
4-5	32.7	32.2	31.0	36.7	28.6
6-7	42.9	48.2	51.1	43.7	43.4
Days/week child walks 10+ minutes					
3 or less	24.2*	20.8	19.6**	24.3	20.7
4-5	41.4	34.9	31.3	36.7	44.6
6-7	34.4	44.3	49.1	39.0	34.7
Child regularly walks or bikes to school					
Yes	30.9	30.6	30.2	32.1	28.9
No	69.1	69.4	69.8	67.9	71.1

*<.05, **<>01, ***<.001

Table 4 illustrates the bivariate relationships between the individual level measures of neighborhood safety and health/physical activity. Safety concerns were significantly related to the overall health rating of the child. Parents who reported having kept their child indoors due to safety concerns were 7% more likely to report their child's health as good, fair, or poor. Children who had access to a safe place to play outside of the home were most likely to have excellent or very good health. However, there were no significant relationships between neighborhood safety concerns and the overweight status of the child.

TABLE 5. BIVARIATE ANALYSIS: WALKABILITY (AGAIN PUT PERCENTAGE SIGNS IN)

	Intersection Density			Residential Density				Land use Mix		
	Low %	Med %	High %	Low %	Med %	Mod %	High %	Low %	Med %	High %
Health										
Overall health of child										
Excellent or very good	74.4	73.2	69.1	71.8	73.4	71.7	59.6	69.3*	69.3	79.0
Good, fair, or poor	25.6	26.8	30.9	28.2	26.6	28.3	40.4	30.7	30.7	21.0
Weight										
Normal	49.4	53.3	56.2	48.2	56.3	50.9	55.2	52.8	55.1	47.1
Overweight	19.4	16.3	13.9	17.4	16.7	18.4	20.7	16.5	14.4	21.7
Obese	31.1	30.5	29.9	34.4	27.0	30.7	24.1	30.7	30.5	31.2
Physical Activity										
Parental Satisfaction with amount of exercise										
Satisfied	81.4	82.2	87.2	84.5	86.7	87.4	78.3	83.0	86.5	86.8
Dissatisfied	18.6	17.8	12.8	15.5	13.3	12.6	21.7	17.0	13.5	13.2
Days/Week child plays or exercises										
3 or less	23.5	22.0	17.8	18.6	20.1	20.4	33.3	23.5	19.2	19.4
4-5	34.3	36.6	34.4	33.2	31.1	29.4	37.8	31.2	30.9	33.5
6-7	42.2	41.4	47.8	48.2	48.8	50.2	28.9	45.2	49.8	47.1
Days/week child walks 10+ minutes										
3 or less	18.7*	28.0	16.7	26.8	22.0	16.4	17.8	20.7	25.0	18.6
4-5	34.3	36.6	34.4	35.7	32.5	38.0	40.0	35.5	35.1	36.6
6-7	47.0	35.4	48.9	37.5	45.5	45.5	42.2	43.8	39.9	44.8
Child regularly walks or bikes to school										
Yes	21.2*	29.9	32.7	29.4	27.0	36.3	23.9	23.1*	30.2	36.0

No	78.8	70.1	67.3	70.6	73.0	63.7	76.1	76.9	69.8	64.0

*p<.05, **p<.01, ***p<.001

Intersection density was significantly related to walking and biking behavior in children. Children living in areas with high intersection density most frequently walked 10 or more minutes per day (48.9%),though this relationship is not monotonic and children living in low intersection density areas also walked frequently (47%). Children living in high intersection density areas were more likely to walk or bike to school regularly (32.7%) than children living in medium and low intersection density areas (29.9% and 21.2%, respectively). Land use mix was similarly related to the frequency of walking and biking to school. Residential density showed no significant relationship with any of the dependent variables.

Multivariate Analysis

In multivariate logistic regression, many of the relationships that were significant in bivariate analyses were no longer significant. Additionally, a few other significant relationships emerged. Intersection density and land use mix were significantly related to children regularly walking or biking to school. Children who lived in areas with low intersection density or a low amount of land use mix were less likely to walk or bike to school regularly. Intersection density was negatively related with weight status; children in areas of low intersection density were less likely to be overweight. However, parents of children living in these areas of low intersection density were also much more likely to be dissatisfied with the amount of exercise their children get.

Parental satisfaction with the amount of exercise their child got was also significantly related with both measures of neighborhood safety. Parents who reported having kept their child inside due to safety concerns were much more likely to be dissatisfied with the amount of exercise their child got. Parents who stated that there was a safe place for children to play outside of the home were less likely to be dissatisfied with the amount of exercise their children got.

TABLE 6. ADJUSTED ODDS RATIOS FROM LOGISTIC REGRESSION MODELS

	Health is Excellent or very good	Child is overweight/ obese	Dissatisfied with amount of exercise child gets	Walks 10+ minutes everyday	Plays or exercises everyday	Regularly walks or bikes to school
Land Use Mix						
Low	.58	1.16	.77	.90	1.03	.54*
Medium	.66	.91	.79	.78	1.18	.82
High	--	--	--	--	--	--
Residential Density						
Low	1.84	2.09	.47	.42	2.43	1.91
Medium	1.85	1.47	.47	.50	2.49	2.05
Moderate	1.67	1.66	.38	.59	2.53	1.86
High	--	--	--	--	--	--
Intersection Density						
Low	1.01	.58*	2.59*	1.09	1.10	.51*
Medium	.85	.62*	1.41	.77	1.16	.72
High	--	--	--	--	--	--
Kept child due to safety concerns						
Yes	.78	.69	2.22**	.74	1.07	1.19
No	--	--	--	--	--	--
There is a safe place to play outside the home						
Very True	1.35	1.36	.45*	1.48	1.19	1.10
Somewhat True	.93	1.00	.76	1.42	.84	1.14
Not True	--	--	--	--	--	--
R-Square	.16	.31	.11	.21	.29	.09

These models also control for child's age, child's gender, ethnicity, parental education level. *p<.05, **p<.01, ***p<.001

DISCUSSION

Overall, there were only a few statistically significant relationships between our measures of safety and walkability and the measures of physical activity and weight status in our sample. After controlling for socio-demographics and other independent variables, land use mix and intersection density were significantly related to walking and biking to school. Our safety measures of having kept the child inside because of safety concerns and having access to a safe place to play outside of the home were both significantly associated with the parents' overall satisfaction with the amount of exercise the child got. However, none of the factors were significantly related to weight status in the children.

Walkability

As in other studies, the walkability variables, land use mix and intersection density, had an impact on whether or not the child regularly walked or biked to school. This finding is not particularly surprising given past research. A high degree of land use mix and 3- and 4-way intersection density is indicative of more dense urban development and a gridded street network. More dense development increases the likelihood that the child's school is within reasonable walking or biking distance from home. A gridded street network makes it easier for the pedestrian or biker to choose a direct route to school.

The walkability variables had no influence on the other physical activity variables of playing and exercising and walking 10+ minutes everyday. It seems that the more generalized physical activities such as playing/exercising and general walking are not influenced by walkability factors, possibly because they are not necessarily destination-oriented activities. It is not clear why intersection density exhibited a significant relationship with parental satisfaction with the amount of exercise children got, but not with whether or not the child walks 10+ minutes or plays/exercises everyday.

Past research has shown residential density to have an impact on physical activity and active transportation choices. In theory, residential density should be closely related to the other walkability characteristics, land use mix and dead end density. However, in this study, residential density exhibited no significant relationship with any of the dependent variables.

Given the limited influence of walkability variables on physical activity levels, it is not particularly surprising that walkabilty was not related to the weight status of the children. As in past studies, this research reveals a link (though weak) between

walkability and active transportation choices, but does not go beyond that link to find a relationship between walkability and childhood obesity.

Safety

The safety measures – whether or not the parent had kept the child inside due to safety concerns and whether the child had access to a safe outdoor place to play – were significantly related to whether or not the parent was satisfied with the amount of exercise her child got. Parents who reported safety concerns were less likely to be satisfied with their child's level of physical activity. However, perceived safety was not related to any of the other dependent variables. (PARENTS who are more concerned about safety are more likely to be concerned about other things such as physical activity).

It is quite possible that this study raises more questions than it answers. Very few, if any, prior studies on the impact of neighborhood characteristics on physical activity and health have focused on low-income children. The fact that this study found few relationships between neighborhood characteristics and physical activity and health could be due to the focus on this population. We know that low-income children are at a greater risk for being overweight and it appears that there are many contributing factors to this problem. While walkability and safety may have some impact on physical activity, this research shows no link between these variables and weight status. Clearly, more focused research is needed to discover the factors that impact physical activity and weight status in low-income children, as this group may be subject to unique influences not found in the broader population.

LIMITATIONS AND FUTURE RESEARCH

The findings of this study should be interpreted in light of several limitations. . The walkability variables were measured at the zip code level, which cannot capture differences in walkability factors among neighborhoods within zip codes. Therefore, all children living in the same zip code were considered to live in an area with the same land use mix, intersection density, and residential density.

The safety variables were measured using parental perception and reaction to safety issues in their neighborhoods. While several studies have utilized perceived safety to measure overall neighborhood safety, perception of safety may not capture real safety issues in the area as well as objective measures. In addition, the measures of safety in this study did not specify a difference between safety from crime and safety from traffic.

Nearly all of our dependent variables were based on parental-report, including weight, height, overall health, and physical activity levels. This could lead to problems with accuracy and conflicting data. Many parents declined to report either their child's height or weight because they felt they could not give an accurate estimate. This led to a reduced sample for which we could calculate BMI.

Future research on the built environment and health should focus on low-income children. It would be helpful to measure built environment variables at a smaller level and to include objective measures of health and physical activity. In addition, future research should address the different environments between urban and rural low-income populations.

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