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Green Neighborhoods, Food Retail and Childhood Overweight: Differences by Population Density

Gilbert C. Liu, MD, MS; Jeffrey S. Wilson, PhD; Rong Qi, MS; Jun Ying, PhD

Abstract

Purpose. *This study examines relationships between overweight in children and two environmental factors—amount of vegetation surrounding a child's place of residence and proximity of the child's residence to various types of food retail locations. We hypothesize that living in greener neighborhoods, farther from fast food restaurants, and closer to supermarkets would be associated with lower risk of overweight.*

Design. *Cross-sectional study.*

Setting. *Network of primary care pediatric clinics in Marion County, Indiana.*

Subjects. *We acquired data for 7334 subjects, ages 3 to 18 years, presenting for routine well-child care.*

Measures. *Neighborhood vegetation and proximity to food retail were calculated using geographic information systems for each subject using circular and network buffers. Child weight status was defined using body mass index percentiles.*

Analysis. *We used cumulative logit models to examine associations between an index of overweight, neighborhood vegetation, and food retail environment.*

Results. *After controlling for individual socio-demographics and neighborhood socioeconomic status, measures of vegetation and food retail significantly predicted overweight in children. Increased neighborhood vegetation was associated with decreased risk for overweight, but only for subjects residing in higher population density regions. Increased distance between a subject's residence and the nearest large brand name supermarkets was associated with increased risk of overweight, but only for subjects residing in lower population density regions.*

Conclusions. *This research suggests that aspects of the built environment are determinants of child weight status, ostensibly by influencing physical activity and dietary behaviors. (Am J Health Promot 2006;21[4 Supplement]:317–325.)*

Key Words: Obesity, Environment Design, Ecosystem, Food Industry, Prevention Research. Manuscript format: research; Research purpose: modeling/relationship testing; Study design: cross-sectional; Outcome measure: biometric: body mass index percentile; Setting: Marion County, Indiana; Health focus: social health; Strategy: built environment; Target population age: youth; Target population circumstances: Midwestern urban and suburban youth, mostly with public health insurance, predominantly African American

INTRODUCTION

Obesity and its complications constitute an important, growing, and well-documented public health problem in the United States.[1] The dramatic increase in childhood overweight coupled with the expression of primary risk factors for obesity-related disease at young ages clearly indicate the need for prevention of obesity in childhood.[2] Inadequate physical activity and nutrition are major contributing factors to this epidemic.[3–5] Environmental conditions, such as the built environment, have been identified as intervening factors in the obesity epidemic through their constraining effect on physical activity and perhaps diet.[6–10]

Research has shown a significant relationship between urban form and health.[11] Using methods drawn mostly from transportation studies, researchers have correlated features of the built environment with both self-reported (diaries) and objective data on people's physical activity.[12] Certain types of urban patterns, such as sprawl, correlate negatively with physical activity.[13] At the neighborhood level, research has identified correlation between physical activity and street pattern, land use, and pedestrian infrastructure.[14,15] An increased presence of supermarkets has been associated with increased fruit and vegetable intake in both Black and White adults.[10]

Studies focusing on the built environment's roles as a correlate of childhood overweight remain inconclusive. For example, a recent study of childhood obesity and ''neighborhoods'' that used straight line distances between children's residences and ''op-

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Gilbert C. Liu is in the Children's Health Services Research Program, Indiana University School of Medicine, Indianapolis, Indiana. Jeffrey S. Wilson is in the Department of Geography, Indiana University-Purdue University Indianapolis, Indianapolis, Indiana. Rong Qi is in the Division of Biostatistics, Indiana University School of Medicine, Indianapolis, Indiana. Jun Ying is at the Institute for the Study of Health, University of Cincinnati, Cincinnati, Ohio.

Send reprint requests to Dr. Gilbert C. Liu, Indiana University School of Medicine, Pediatrics, Riley Research Bldg 330, 699 West Dr., Indianapolis, IN 46202; gcliu@iupui.edu.

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portunities for exercise'' concluded that there was no difference between obese and nonobese children.[16] In a study that used a more sophisticated approach of modeling street network distances, researchers found no relationship between proximity to playgrounds, fast-food restaurants, and childhood overweight; however, this study was cross-sectional, only included children ages 3 to 5 years, and was limited to Black and White racial groups.[17] It remains to be seen whether the associations between the built environment, physical activity, and diet observed in adults have similar significance when assessed in pediatric populations. Survey research has established that there are clear differences in the types and correlates of these health behaviors in children versus adults;[8] thus, studies of environmental factors predicting diet, physical activity, and ultimately obesity risk remain at an exploratory phase.

In the current research, we explore associations between risk for childhood overweight and two environmental factors: the amount of vegetation surrounding a child's residence and the proximity of the child's residence to various types of food retail locations. The overall framework for the research is the Health Field Model.[18] This model postulates that health status is a function of social, environmental, economic, and genetic factors, each of which presents an opportunity to intervene. Health care researchers have developed models of obesity-related behavior that fit within and elaborate on the Health Field Model.[19] The model and its variants are particularly relevant to the research described because of their explicit recognition of the importance of policy-making systems that can influence physical or social environment factors that have been shown to influence obesity-related behaviors.

Specifically, we focus on the relationship between body mass index (BMI) and satellite-based measures of landscape greenness extracted at multiple radii around children's residences. The premise of the research is that exposure to green landscapes plays a role in promoting psychological and physiological well-being that can explain, at least in part, spatial patterns of overweight and obesity in children. Time spent outdoors is a clearly established correlate of physical activity in children; access to parks or other outdoor play spaces has also been associated with increased physical activity in youth.[20–22] We also examine network distance to fast-food restaurants and supermarkets, hypothesizing that closer proximity to fast-food restaurants is associated with excess caloric intake and higher risk of overweight, whereas closer proximity to supermarkets is associated with dietary behaviors protective against overweight. A secular trend of increased proportion of children's meals being comprised of fast food parallels rising rates of childhood overweight, and consumption of fast food has been frequently implicated as an important cause of obesity.[23,24] The present study adds to findings of previous research by expanding the demographic representation of study subjects, incorporating neighborhood vegetation linked to individual-level BMI data, and adjusting analyses for neighborhood socioeconomic status, population density, and individual socio-demographics. The study also illustrates the potential for integrating biophysical remote sensing from space-borne sensors with pediatric medical data to investigate relationships between physical characteristics of residential landscapes and prevalence of overweight and obesity in children.

METHODS

Design

We conducted a cross-sectional study that analyzed pediatric clinical data that were linked with environmental data through geocoding of subjects' residential addresses.

Sample

We queried an electronic medical record system (Regenstrief Medical Record System, Indianapolis, Indiana)[25] to identify all children between the ages of 3 and 18 years seen for routine well-child care in a network of seven urban primary care clinics (Indiana University Medical Group) in Marion County, Indiana in the calendar year 2000. We established that well-child care/routine health maintenance was the purpose for the clinic visit through either ICD-9 codes or terms in a keyword field such as the diagnosis list. We identified a subset of these children who had same-day height and weight measurements. Anthropometric measurements as part of IUMG routine health maintenance visits are conducted by nurses or medical technicians using calibrated scales and stadiometers.[26] For children having more than one record during this period, we used only the first observation. We excluded those with medical documentation suggestive of pregnancy, congenital heart disease, chromosomal abnormalities, anomalies of the adrenal gland, multiple congenital anomalies, cystic fibrosis, and cerebral palsy. We also excluded those subjects whose addresses were not located in Marion County, Indiana.

Measures

We extracted demographic information including age, race/ethnicity, and gender for all children meeting these study criteria. Race/ethnicity was categorized as Hispanic, non-Hispanic White, non-Hispanic Black, or other race. For simplicity, we refer to these groups as Hispanic, White, Black, and Other.

We calculated each subject's body mass index (BMI). Children are overweight when their BMI exceeds the 95th percentile adjusted by age and sex, and ''at risk for overweight'' when their BMI exceeds the 85th percentile. Thus, childhood overweight is a statistical definition based on the 2000 Centers for Disease Control and Prevention growth charts for the United States (www.cdc.gov/growthcharts/). Such statistical definitions among children are in contrast to standard clinical outcomes-based definitions defining obesity ($\text{BMI} \geq 30\ \text{kg/m}^2$) and overweight ($\text{BMI} > 25\ \text{kg/m}^2$) in adults. There are not enough data establishing causal links between childhood overweight and adult outcomes to define obesity in children, particularly for young children and racial/ethnic minority groups. BMI values for each study subject were categorized using an overweight index as follows: 4 if BMI > 98th percentile, 3 if BMI > 95th percentile, 2 if BMI > 85th percentile, and 1 otherwise.

Patient data were geocoded using street centerline files from the Indianapolis Mapping and Geographic Infrastructure System. Supplementing automated geocoding routines in ArcGIS 9.0 (ESRI, Redlands, California) with manual address matching yielded a 91.8% geocoding success rate. Those subjects who were not successfully geocoded did not differ significantly in terms of age, race, gender, or insurance distribution. Marion County, Indiana, is divided into nine townships that served as the geographic unit for classifying each study subject as living in higher population density regions versus lower population density regions. We chose to incorporate a factor for population density based on the premise that systematic differences exist in the built environment, landscape, and zoning policies across regions of differing population densities. Furthermore, differences have been identified in physical activity behaviors and their correlates for persons living in rural versus urban areas.[27] Township population density data came from the Year 2000 U.S. Census. Three strata of population density (sparsely populated = 0–149 persons/sq km, moderately populated = 150–499 persons/sq km, and densely populated = >500 persons/sq km) have been recommended for European Union epidemiologic studies.[28] Two townships, Decatur and Franklin, each with a population density of 295 persons per square kilometer, met the criteria for ''moderately populated regions,'' based on this classification; the other seven townships fell into the densely populated category. We modified the above criteria, expanding the cutoff point for the moderately populated category to 695 persons/sq km, thus dividing the townships in this analysis into three having lower population density and six having higher population density. This classification roughly corresponds to three regions with higher proportion of rural areas versus six regions that include an urban core, the City of Indianapolis, and rapidly developing surrounding suburban and commercial areas.

Vegetation, Food Retail, and Census Data

Measures of neighborhood vegetation were obtained from Landsat Enhanced Thematic Mapper Plus (ETM+) satellite imagery for the month of July 2000. Pixel values in the satellite images were converted to physical measurements of Normalized Difference Vegetation Index. These calculations are based on the principle that growing plants strongly absorb radiation in the visible region of the spectrum while strongly reflecting radiation in the near-infrared region. Normalized Difference Vegetation Index values range from −1 (usually water) to +1 (dense, healthy, green vegetation). Moderate values represent shrub and grassland (0.2 to 0.3), while high values indicate temperate and tropical rainforests (0.6 to 0.8). Food retail locations and categorization were derived from hygiene grading conducted by the Marion County Health Department. We used a modification of the 1997 North American Industry Classification System codes and definitions described by Morland et al.[10] to identify large brand-name supermarkets, smaller non-brand-name grocery stores, fast-food restaurants, and convenience stores.

Area-level measures of socioeconomic characteristics have been shown to provide complimentary and additive information to individual-level indicators.[29,30] Moreover, studies have demonstrated that area-level measures of socioeconomic position are related to health status independent of individual-level variables.[29] We included Median Family Income from Census 2000 block group data as a covariate representing neighborhood-level socioeconomic status. This Census indicator only reports income for related people; therefore, it is more likely to include a larger subset of the population of interest (i.e., families with children) and less likely to be diluted with single-person households. Rather than simply assigning to each child the Median Family Income of the block group where their residence was located, we calculated a value for each study subject's particular analytic buffer using an average of data for all block groups falling within the buffer. Each value contributing to the buffer estimate was weighted by the proportion of the block group contained within the buffer.

Normalized Difference Vegetation Index values were calculated individually for each study subject using a 2-km circular buffer. Proximity to each type of food retail location was calculated using network distance along street centerlines. All analytic buffers centered on the subject's home address. We excluded those study subjects whose residences were positioned such that the buffer radius extended beyond the edge of the county, as these would have had incomplete environmental data. Transportation studies commonly use a convention of a quarter mile as an estimate of how far adults will walk in settings that provide alternatives between motorized and nonmotorized travel.[31] However, whether this convention is linked to other forms of physical activity, such as biking, is unclear, and to our knowledge, the typical range of child travel behavior remains undefined. In a recently published study assessing built environment correlates of directly measured physical activity, researchers arbitrarily designated 1-km network buffers to conduct analysis of neighborhood factors.[32] The designation of a relevant spatial analytic area is challenging from a number of viewpoints; for example, an analytic unit for representing neighborhoods may be defined based on spatial processes such as patterns of use or social phenomena such as networks of relationships. Institutional definitions of neighborhood often are different from an individual's interpretation of space and delineation of boundaries.[33] Our choice of a 2-km analytic buffer was based on univariate logistic regressions that examined associations between Normalized Difference Vegetation Index summarized at various buffer sizes and occurrence of overweight in the study sample. The 2-km buffer displayed the strongest level of significance in these regressions.

Analysis

Continuous variables are summarized by mean and standard deviation. The means are compared between high and low population density regions using two sample *t*-tests. Categorical and ordinal variables are summarized by frequency (in percent). Pearson χ^2 tests are used to compare the frequencies between high and low population density regions.

The primary endpoint, overweight index, is considered an ordinal variable. Its association to the region factor (the high population density region vs. the low population density region) and other environmental predictors are assessed using cumulative logit models. We use both simple and full models in our analyses. The simple model uses environmental indices as only predictors, and the full model uses both environmental and demographic predictors and factors.

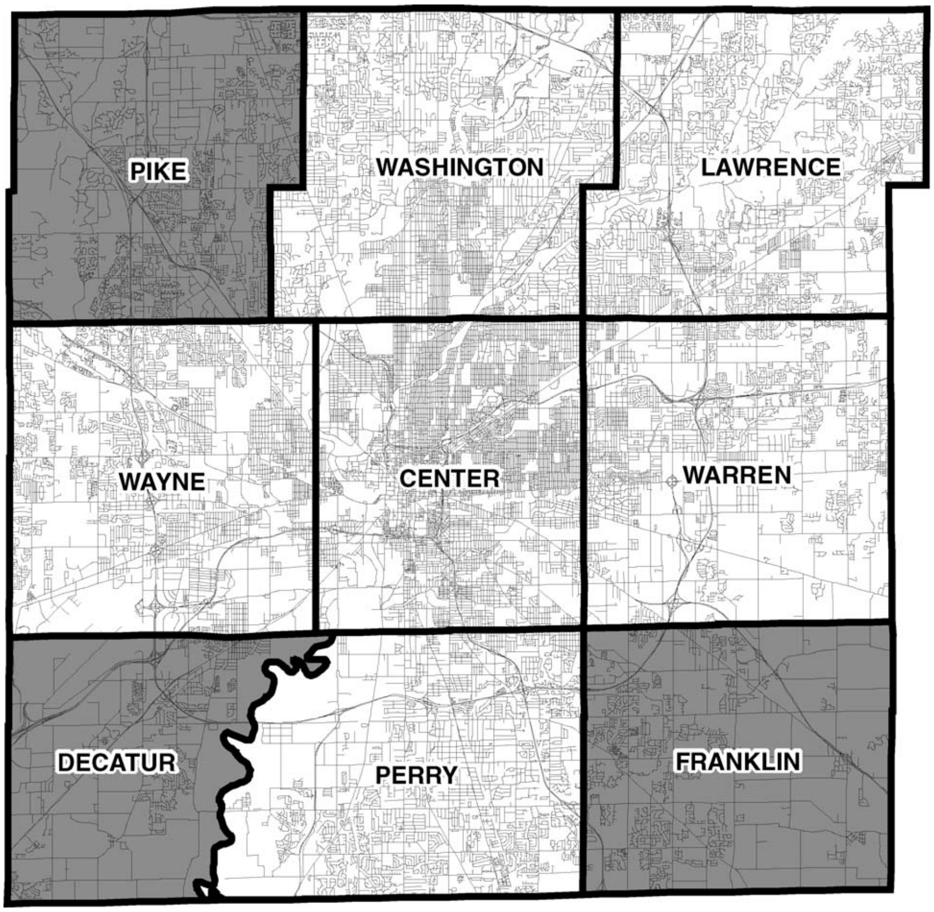
A p value $< .05$ is considered statistically significant in the test. All statistical analyses were performed using SAS version 9.1 (SAS, Cary, North Carolina) software.

RESULTS

The Higher Population Density Townships consist of Center, Wayne, Perry, Lawrence, Washington, and Warren townships with a mean (standard deviation) of population density 2637 persons/km^2 (745). The Lower Population Density Townships consist of Franklin, Decatur and Pike townships with a mean (SD) of population density 1083 persons/km^2 (553). The mean values of township population density differed significantly: $p = .02$. This classification of townships is based on a natural break in the distribution of population density values and is further supported by visual inspection of street density, which revealed that the Higher Population Density Townships have greater road development (Figure 1).

Figure 1

Marion County, Indiana Townships and Street Centerlines



A total of 7334 subjects are included, with mean age of 8 years (Table 1). There was no significant difference between mean age in Higher and Lower Population Density Townships. The families living in the Lower Population Density Townships had higher neighborhood median family incomes. The mean distance to grocery stores, convenience stores, and fast-food chains is larger in the Lower Population Density Townships, while mean distance to supermarkets is larger in the Higher Population Density Townships (Table 1). There were no significant gender differences between the two township types (Table 2). The proportion of White subjects is similar in the two township types. More Black subjects and fewer Hispanic subjects are found living in the Higher Population Density Townships in our study sample.

In an initial model incorporating only individual demographic factors and categories of population-density, age and race were associated with the risk of overweight (Table 3). However, interaction terms combining individual demographics with regional population density were not significant. Neighborhood median family income had no effect on the risk of overweight in a model adjusted by demographic factors and population density (Table 3), but showed significance when it was the only predictor in the model (Table 4). A higher neighborhood median family income lowered the risk of obesity for subjects residing in the Higher Population Density Townships, but had no effect in the Lower Population Density Townships. Table 4 also shows that older subjects had higher risk of overweight.

Vegetation, distance to the nearest grocery store, and distance to the nearest supermarket were negatively associated with the risk of overweight in the Higher Population Density Townships, when they were the only predictors in the cumulative logit models (Simple model results, Table 5). Other environmental indices, including distance to the nearest convenience store, distance to the nearest fast-food restaurant, and distance to the nearest grocery store, showed marginal effects on the risk of overweight in the Higher Population Density Townships. When

Table 1

Summary of Age, Neighborhood Income and Environmental Indices by Township Population Density

Variable	Higher Population Density Townships (n = 6897) Mean (SD)	Lower Population Density Townships (n = 437) Mean (SD)	*p**
Age (y)	8.06 (3.78)	8.12 (4.02)	.76
Neighborhood median family income ($1000s)	40.20 (10.29)	52.70 (8.55)	<.01
Normalized Vegetation Difference Index	0.11 (0.08)	0.13 (0.08)	<.01
Distance to nearest food retail (km)	2.36 (1.60)	3.56 (2.54)	<.01
Distance to nearest grocery store (km)	4.58 (3.54)	6.72 (5.14)	<.01
Distance to nearest convenience store (km)	3.00 (1.79)	4.19 (3.12)	<.01
Distance to nearest fast food restaurant (km)	3.25 (1.85)	4.56 (3.08)	<.01
Distance to nearest supermarket (km)	7.12 (3.93)	6.77 (5.31)	.07

* *p* values are from two sample *t*-tests.

full models were considered after adjusting for age, race, gender, and family income, only vegetation showed significance in the Higher Population Density Townships. With regard to findings for the Lower Population Density Townships, distance to the nearest supermarket was positively associated with risk of overweight.

DISCUSSION

This paper presents the results of an exploratory analysis of the relationship of childhood overweight to objective measures of vegetation and food retail environments. In Higher Population Density Townships, increased amounts of vegetation surrounding a child's residence were associated with less risk of overweight. In Lower Population Density Townships, closer proximity between a child's residence and a large, brand-name supermarket was a risk factor for overweight. These associations remained significant even after controlling for individual-level sociodemographics and median family income of the surrounding area. Moreover, the statistical strength of the environmental associations was comparable to individual-level factors such as race and age in predicting childhood overweight.

Table 2

Race/Ethnicity, Gender, and Weight Status Distributions by Township Population Density*

Variable		Higher Population Density Townships (n = 6897)	Lower Population Density Townships (n = 437)
Race/ethnicity	Non-Hispanic White	22.8%	21.1%
	Non-Hispanic Black	60.7%	45.1%
	Hispanic	14.9%	28.2%
	Other race/ethnicity	1.7%	5.7%
	*p**	<.01	
Gender	Female	49.1%	45.6%
	Male	50.9%	54.4%
	*p**	.15	
Overweight index	BMI $\leq$ 85%	60.2%	61.3%
	85% $<$ BMI $\leq$ 95%	17.3%	16.7%
	95% $<$ BMI $\leq$ 98%	9.2%	8.7%
	BMI $>$ 98%	13.3%	13.3%
	*p**	.96	

* *p* values are from Pearson χ^2 tests.

The interaction between human health and the physical environment constitutes an active area of interdisciplinary research, crosscutting fields such as planning, architecture, psychology, geography, and public health. This study expands on previous research regarding environmental correlates of overweight in children by examining a study population that is notable for a wide age range and relatively large numbers of Hispanic subjects, a previously understudied minority ethnic group. Additional strengths of this study include the use of directly measured height and weight data and the use of novel biophysical remote sensing data to describe characteristics of individual level ecosystems.

Previous research on the interaction between human health and the physical environment suggests that exposure to green landscapes has a positive influence on variety of psychological and physiological processes. An often cited example is the work of Ulrich, who found that postsurgical hospital patients with window views of green landscapes had significantly shorter recovery periods and reduced need for pain medication compared to patients with views of urban settings.[34] Other researchers have found positive effects of green landscapes on children. Wells concluded that greener residential environments were associated with

Table 3

Summary of Factors and Predictors in the Cumulative Logit Model†

Variable	*p*
Township population density	.24
Gender	.86
Race/ethnicity	<.01
Age	<.01
Median family income of neighborhood	.82
Interaction terms	
Gender × Township population density	.68
Race/ethnicity × Township population density	.36
Age × Township population density	.77
Median family income of neighborhood × Township population density	.31

†The cumulative logit model uses the overweight index as the dependent variable.

improved cognitive functioning in children after controlling for several possible covariates.[35] In a national-level study, Kuo and Taylor concluded that activities conducted in green outdoor settings reduced children's Attention Deficit Hyperactivity Disorder symptoms more than activities conducted in other environments.[36]

Studies of inner-city neighborhoods have shown that outdoor spaces with trees are used with higher frequency by youth and adults than treeless outdoor spaces; moreover, the greater the number of trees, the more simultaneous users.[37,38] Research has also observed that children were twice as likely to be supervised by adults in green inner-city spaces compared to barren but otherwise similar spaces.[39] Survey research posits several reasons for the positive effect of vegetation on use of outdoor spaces. Shade from tree canopy and scenery in the form of flowers and shrubs are associated with report of increased walking.[7] Vegetation may also promote activity in less direct modes. For example, presence and maintenance of landscaping has been shown to be a strong indicator of territorial personalization, with implications that inhabitants actively care about their homes.[40] Such neighborhoods may display increased community surveillance that deters crime and ultimately increases outdoor physical activity. This study extends the findings that green spaces are associated with positive health outcomes, and is the first study to our knowledge that demonstrates that increased neighborhood vegetation is associated with reduced risk of childhood overweight.

Findings from recent research regarding adult subjects suggests that closer proximity to fast-food restaurants and convenience stores raises risk of overweight, while closer proximity to supermarkets may be expected to protect against overweight.[41,42] Morland used a large multi-city sample of adults to identify a positive association between fruit and vegetable consumption and number of supermarkets in the study subjects' neighborhoods.[10] Results of this study's multivariate modeling indicated an increased risk of overweight only for subjects who lived in low population density regions and were farther from supermarkets. In the context of the few other studies of associations between food environments and diet or body mass index in children, published results remain mixed and relationships poorly understood.[16,17] What is certain is that American adults and children are consuming greater quantities of food,[43] food retail portion sizes have increased substantially,[44] and palatable, inexpensive energy-dense foods are readily accessible. Economists have suggested that in our current environment, energy-dense diets high in sugar and fat represent the lowest-cost and highest-palatability option to consumers.[45] Interestingly, urban dwellers pay 3% to 37% more for groceries in their local community than suburban

Table 4

Age, Neighborhood Income, and Race/Ethnicity Covariates for Cumulative Logit Model*

		Overall		Higher Population Density Townships		Lower Population Density Townships	
Variable		Mean (SE)	*p*	Mean (SE)	*p*	Mean (SE)	*p*
Age†		0.06 (0.01)	<.01	0.07 (0.01)	<.01	0.05 (0.02)	.03
Median family income of neighborhood ($1000)†		−0.06 (0.02)	<.01	−0.07 (0.02)	<.01	−0.002 (0.12)	.99
Race/ethnicity‡	Non-Hispanic Black	−0.23 (0.06)	<.01	−0.24 (0.06)	<.01	−0.07 (0.25)	.79
	Hispanic	0.21 (0.07)	<.01	0.20 (0.08)	<.01	0.30 (0.27)	.25
	Other race/ethnicity	−0.14 (0.17)	.41	−0.03 (0.18)	.88	−0.66 (0.51)	.18

* Values are mean (standard error) of log (OR) of overweight estimated from a cumulative logit model.

† A positive (negative) log (OR) indicates the increased (decreased) risk of overweight in response to one year increase of age or $1,000 increase of the median family income of the neighborhood.

‡ A positive (negative) log (OR) indicates the higher (lower) risk of overweight of the other race/ethnic group as compared to the non-Hispanic White group.

Table 5

Adjusted Odds for Environmental Predictors of Child Overweight*

		Higher Population Density Townships			Low Population Density Townships		
Variable	**Model†**	**Odds**	**SE**	***p***	**Odds**	**SE**	***p***
Normalized Difference Vegetation Index‡	Simple	0.851	1.030	<.01	1.123	1.129	.34
	Full	0.899	1.038	<.01	1.134	1.132	.31
Distance to nearest food retail location of any type (km)	Simple	0.973	0.015	.06	1.000	0.039	.98
	Full	0.998	0.017	.91	1.005	0.039	.91
Distance to nearest grocery store (km)	Simple	0.983	0.007	.01	1.024	0.018	.19
	Full	0.997	0.008	.69	1.026	0.018	.15
Distance to nearest convenience store (km)	Simple	0.977	0.013	.08	1.006	0.031	.84
	Full	0.998	0.014	.91	1.008	0.031	.80
Distance to nearest fast-food restaurant (km)	Simple	0.977	0.013	.08	1.009	0.031	.77
	Full	0.996	0.014	.77	1.011	0.031	.71
Distance to nearest supermarket (km)	Simple	0.980	0.006	<.01	1.035	0.019	.05
	Full	0.990	0.006	.13	1.038	0.019	.03

* The cumulative logit models use the obesity index as the dependent variable.

† The simple model uses each environmental predictor as the only predictor in the cumulative logit model; the full model adds age, race, gender, and median family income of the neighborhood as additional factors and predictors in the model.

‡ The changes in odds are based on 0.1 increments of Normalized Difference Vegetation Index.

residents who purchase similar groceries at large supermarkets.[46] Moreover, supermarkets have sharply declined in low-income inner-city areas, and thus residents of such areas may be constrained to food shopping at small stores with limited, high-priced selections.[47] Further research is needed that examines issues of access (e.g., family transportation patterns), types and costs of different foods actually served at establishments, and valid measures of dietary intake in young children.

The influence of population density on this study's environmental variables points may have implications for research into built environment factors as targets for obesity prevention. Research on the impact of population density on health has followed numerous lines of inquiry, including differential access to services and amenities,[48] varying degrees of social support,[49] and the relationship between social capital and health.[50] Differential access to services and amenities is a plausible explanation for how population density functioned as a significant covariate in this analysis. Even though lower population density townships were greener, the lack of a significant association between landscape greenness and risk of overweight may be more related to the form and variability of neighborhood vegetation than its intensity in urban versus suburban or rural settings. Regarding relationships between proximity to food retail locations and risk of overweight, it is conceivable that similar issues of access/exposure, or perhaps social support/norms, may also systematically differ between regions of lower versus higher population density.

The racial distribution of this population, as well as its regional basis, limits generalization of findings. However, our study group consisted of large numbers of Blacks and Hispanics, who have been shown to be at higher risk for obesity-related morbidity and mortality in studies of adults.[51] Also, we again emphasize that Hispanics as a group have been underrepresented in previous studies of obesity risk factors, even though they are the fastest-growing ethnic group in the U.S. The form of the associations between environmental variables and risk of overweight merits additional investigation; a linear association between neighborhood vegetation and risk of overweight is unlikely. Studies of urban parks have found that densely wooded areas are perceived as unsafe because they provide hiding places for criminals and conceal criminal acts.[52] Researchers have long recognized that obesity is a health outcome that arises from a wide array of causal factors, including social, economic, genetic, and environmental factors.[53] As mentioned previously, the general hypothesis for this study is that environmental factors such as vegetation and food retail affect health-related behaviors (such as providing opportunities for or barriers against physical activity and healthy diet) and that these behaviors in turn affect the accumulation of body mass. It is important to keep in mind, however, that these behaviors are only a few of the factors determining a person's weight status. Finally, cross-sectional studies cannot determine causality and are challenged by issues of endogeneity. Longitudinal data that capture clinical data for subjects residing in the same place before and after changes such as the development of a park or construction of a supermarket are needed to assess unknowns stemming from individual preferences.

Our study adds to an accumulating body of literature suggesting that the built environment significantly affects health behaviors and health outcomes. Understanding interactions between environment and obesity will inform the design of future environmental approaches to the prevention and management of obesity. The urgent

SO WHAT? Implications for Practitioners and Researchers

This study seems to indicate that greener neighborhoods and closer proximity to supermarkets are associated with reduced risk of overweight in children. Combined with other research, there seems to be preliminary support for the assertion that aspects of the built environment are determinants of child weight status, ostensibly by influencing physical activity and dietary behaviors. With increased knowledge of environmental correlates, health care practitioners may develop more sensitive and specific clinical screening tools for obesity prevention. In addition, researchers may assist in identifying high-risk individuals in either high- or low-risk geographic areas, designing targeted community interventions, and informing neighborhood development policies for obesity prevention.

need for environmental approaches to the prevention of childhood overweight is underscored by the overwhelming evidence that rates of childhood overweight are dramatically increasing, overweight adolescents are likely to become obese adults, and that sustainable weight loss is not achieved by most overweight adults. Multidisciplinary teams including planning and public health expertise should work in collaboration with public and private agencies to develop and disseminate successful strategies for modifying our current obesogenic environment into one that promotes health through such effects as increasing physical activity and proper nutrition.

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