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The Built Environment and Childhood Obesity in Durham, NC

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Abstract

The relationship between childhood obesity and aspects of the built environment characterizing neighborhood social context is understudied. We evaluate the association between seven built environment domains and childhood obesity in Durham, NC. Measures of housing damage, property disorder, vacancy, nuisances, and territoriality were constructed using data from a 2008 community assessment. Renter-occupied housing and crime measures were developed from public databases. We linked these measures to 2008–2009 Duke University Medical Center pediatric preventive care visits. Age- and sex-specific body mass index percentiles were used to classify children as normal weight (>5th and ≤ 85th percentile), overweight (>85th and ≤ 95th percentile), or obese (> 95th percentile). Ordinal logistic regression models with cluster-corrected standard errors evaluated the association between weight status and the built environment. Adjusting for child-level socioeconomic characteristics, nuisances and crime were associated with childhood overweight/obesity (P<0.05). Built environment characteristics appear important to childhood weight status in Durham, NC.

Keywords

Built environment; childhood overweight; childhood obesity; North Carolina

Introduction

The childhood obesity epidemic has led to significant increases in morbidity (e.g., diabetes, hypertension).[1–6] Between 1976–1980 and 2007–2008, rates of obesity among US children aged 2–19 years have risen from 5.5% to 16.9%.[7] Contributors to the increase in childhood obesity over the last few decades include environmental factors leading to a propensity to be inactive and eat unhealthy foods.[8]

The built environment includes the physical infrastructure (e.g. buildings, roads, and lighting) and outdoor spaces (parks and urban design) of a place, as well as the policies that shape them. Components of the neighborhood built environment may be important factors contributing to inactivity, either directly through physical barriers to activity or indirectly

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though the impact of the physical environment on the social context of the neighborhood, which may cause individuals to avoid outdoor physical activity due to safety concerns. Although research has demonstrated a relationship between select components of the built environment (e.g., healthful food stores, access to green spaces),[9] little is known about the association between obesity and broader aspects of the built environment that impact both the physical and social context of neighborhoods. Such broader aspects of the built environment characterize communities more generally than conventional measures (e.g. distance to green space, number of fast food establishments) to provide measures of the physical quality, stability, and safety of a community's infrastructure as a whole. Objective measures of the broader built environment that may influence the social context of neighborhoods offer an alternative to subjective self-report by residents and provide clearer data to support community projects and advocacy efforts.

Previous research has also evaluated the relationship between child weight status and both perceived and objective neighborhood safety. A number of studies have shown that parental perception of safety is related to child's weight.[10–15] For example, Singh et al. found that a child's odds of being overweight or obese were 43% and 61% higher, respectively, if their parent/guardian thought the neighborhood was unsafe.[13] On the other hand, objective crime rates, assessed using law enforcement records, have also been evaluated in a few studies, and no association between crime rates and children's weight status has been found.[16–19]

Measures of the built environment, such as litter, damaged housing, and housing tenure, may also inform our understanding of social stability and cohesion within a neighborhood, which may influence childhood weight status, perhaps by influencing the sense of community and perceptions of safety. However, the relationships between these broader measures of the built environment and childhood weight status have been minimally studied. Singh et al. evaluated the relationship between childhood weight status and parent or guardian report of the presence of garbage and litter, poor or dilapidated housing, and vandalism in the neighborhood. After adjustment for age and sex, children in neighborhoods with garbage or litter had 1.44 times the odds of being obese, those in areas with poorly kept or dilapidated/ rundown housing had 1.31 times the odds of obesity, and those in areas with vandalisms had 1.09 times the odds of being obese.[13] Grafova et al. found that children in neighborhoods without physical disorder as assessed by study personnel are less likely to be overweight even after adjustment for individual characteristics including socioeconomic status.[17]

Leveraging detailed survey data on a broad set of built environment variables and georeferenced pediatric patient data, the present study examines whether overweight and obesity among children and adolescents in central Durham, North Carolina, US, is associated with objectively assessed components of the built environment, including violent crime, total crime, housing damage, property disorder, tenure status, vacancy, territoriality, and nuisances. Rather than focusing on physical barriers to inactivity or healthy eating habits, these built environment variable focus on how the built environment may influence inactivity through the social context and character of neighborhoods.

Material and Methods

Patient data

The Duke University Medical Center maintains a patient database with information on all medical visits to service providers in the Duke University Health System (DUHS). This health system encompasses locations in the Raleigh-Durham-Chapel Hill metropolitan area in North Carolina. For this analysis, we identified 45,525 patient visits for preventive ("well-child") visits seen in one of three large clinics in Durham between January 2008 and December 2009. Patient residential addresses were georeferenced to the individual tax parcel level, with a geocoding success rate of 83 percent. Nearly two-thirds (n=29,060) of the preventive-care visits were for children residing in Durham County.

Our study population was restricted to children from the geocoded dataset between the ages of 2 and 18 years who lived within the 29 neighborhoods defining the study area (see below). We excluded children whose health insurance was through Duke University's student health system to protect the privacy of these students. Data on height or weight was missing for 538 records (19%). Patient records with missing data on the key covariates of race, age, and insurance status were also excluded (n=28, 1%). For children with more than one well-child visit during 2008–2009, only data from the earliest well-child visit were used for analysis. The final data set included 1,857 children.

Using 2000 Centers for Disease Control Growth Charts,[20] we calculated age- and sex-specific body mass index percentiles to classify children according to three categories: normal weight (>5th and ≤ 85th percentile), overweight (>85th and ≤ 95th percentile), or obese (> 95th percentile). Since we were interested in the likelihood of being overweight or obese compared to normal weight, we excluded children whose body mass index percentile was ≤ 5th percentile from the analysis (n=72). Thus, our analysis included data on 1,785 children. This study was approved by the Duke University School of Medicine Institutional Review Board.

Study area

This study includes children residing in the 29 neighborhoods making up the urban core of the City of Durham, North Carolina, US. Figure 1 provides a map of the study area. This socially and economically diverse part of Durham includes both established, historical neighborhoods and newer, less loosely established neighborhoods. These 29 neighborhoods represent the extent of the Community Assessment Project (CAP), a survey which collected detailed data on the built environment throughout each neighborhood.

Built environment measures

Community Assessment Project indices—The design, data collection, and index creation for the CAP project has been described in detail elsewhere.[21] The CAP is an objective survey of all tax parcels within the study area (see Figure 1). This survey was built using a Geographic Information Systems (GIS) data architecture; all data are associated with a geographic location. The field team collected data using handheld Global Positioning Systems (GPS) units while walking the streets of each neighborhood during the summer of 2008. Tax parcels were assessed on an individual basis from the public right-of-way, and variables were recorded based on what was visible from the sidewalk or street.

The data collection instrument identified observable variables representing community concerns, based on direct conversations with community leaders, and supplemented with variables represented in the literature.[22–24] Each parcel was assessed for 57 variables that categorized its land use; occupancy status; the physical condition of any buildings, yard, or property; the presence of nuisances such as litter, abandoned cars, and discarded furniture; and evidence of territoriality, such as security bars and “beware of dog” signs. Residential, commercial, and other property types were similarly assessed.[21]

Durham county tax assessor data—We acquired detailed tax parcel data from Durham County. For each residential parcel in the study area, tenure status was determined by comparing the owner's address in the tax record with the physical address of the property. The algorithm used for this process accounted for address discrepancies such as typos and spelling errors. Parcels were marked as owner-occupied when the physical and owner addresses matched, and were marked as renter-occupied when the physical and owner addresses did not match.[21]

Crime data—We acquired crime data from the Crime Analysis Lab of the Durham Police Department. The database included all reported crime incidents for 2006 – 2007, with variables indicating the charge description and physical address at which the incident occurred. These data were georeferenced at the parcel and street level depending on the type of address information provided. For example, some incidents occurred at home or businesses, while others were noted as occurring at specific intersections.[21]

Development of built environment indices

We grouped the CAP-collected built environment variables into five distinct domains: housing damage, property disorder, public-space nuisances, territoriality, and vacancy, each of which consisted of a varying number of variables.[21] Originally collected at the parcel-level, the component variables for each domain were aggregated to the Census block level and divided by the total number of parcels in a given block. These block-level proportions were then standardized to have mean 0 and standard deviation 1.

To represent the local environment for each child, we defined primary adjacency communities (PACs), which include the block in which a child resided and adjacent blocks sharing a line segment or vertex. Block-level proportions of each component variable were summed to the PAC level. The resultant PAC-level proportions in a common domain were summed and standardized by dividing by the total number of underlying blocks. This produced the five indices measuring the extent of housing damage, property disorder, nuisances, territoriality, and vacancy at the PAC-level. Similarly, in order to characterize housing tenure, violent crimes, and total crimes, each metric was aggregated at the block level. Housing tenure for each block was calculated as the proportion of residential tax parcels that were renter-occupied, and these proportions were standardized to have mean 0 and standard deviation 1. The total counts of violent and all crimes in each block were also standardized. Block-level values for tenure (proportion renter-occupied) and crime each were summed to the PAC level and standardized by dividing by the total number of blocks in the PAC. This produced three additional built environment indices: total crime, violent crime, and tenure.[21]

Statistical analysis

We examined the association between weight status and each PAC-level built environment attribute, including the five CAP domains (housing damage, property disorder, territoriality, and vacancy), renter-occupied housing, and violent and total crimes. Unadjusted and adjusted cumulative logistic regression models with the proportional odds assumption were fit for each built environment measure. Standard errors for all parameter estimates were computed using the sandwich estimator method to allow for intra-PAC clustering.[25] We used the Brant test[26] to assess if the proportional odds assumption, which assumes that parameter estimates do not change when comparing alternative weight categories, was violated by any models. When this test indicated that proportional odds did not hold, a partial proportional odds model was fit; thus, allowing non-proportional parameter estimates only for covariates where the proportional odds assumption did not hold.

We constructed tertiles of each PAC-level measure to represent low (better built environment), medium, and high (worse built environment) scores on a given built environment attribute. In adjusted models, we controlled for patient level characteristics including a child's race/ethnicity, health insurance status, age, and sex. Race/ethnicity was entered as non-Hispanic white (reference), non-Hispanic black, Hispanic, or other which grouped Asians and other race. Health insurance status was as Medicaid versus non-Medicaid (reference). Age categories were 2–5 years (reference), 6–11 years, or 12–18 years. All analyses were conducted in Stata 11.0 (StataCorp, College Station, TX).

Results

Description of sample

A summary of the patient population included in this analysis is presented in Table 1. Almost one-third of patients were above the normal weight category, with 18.9% classified as obese. Our study population is primarily non-Hispanic black and over half were enrolled in Medicaid. Figure 2 displays maps of the tertiles of a sample of the built environment indices -- housing damage, tenure, territoriality, and total crime. Higher levels of housing damage and renter-occupied housing (tenure metric) generally follow similar spatial patterns. On the other hand, there are a number of areas where higher territoriality, an index of the level of security measures present in a PAC, are accompanied by lower levels of total crime.

Overall, higher proportions of patients lived in areas with lower levels of housing damage and vacancy, but higher levels of property disorder, nuisances, and crime (see Table 2). Compared to pediatric patients in the normal weight range, overweight and obese patients lived in areas with higher levels of property disorder, territoriality, vacancy, nuisances, and crime.

Modeling results

Of the seven built environment measures, only property disorder, nuisances, violent crime, and total crime were significantly associated with childhood weight category in either unadjusted or adjusted models. Housing damage, territoriality, vacancy, and tenure did not appear to be associated with weight status among children in the CAP study area. Table 3 presents odds ratios and 95% confidence intervals associated with the 4 built environment indices in crude and adjusted models for weight status for which significant associations were found. For those models in which the proportional odds assumption held, a single set of odds ratios are presented. These odds ratios represent the odds ratio associated with the covariate of being in a higher versus any lower weight category, regardless of the cut point between the 3 weight categories -- for example, being obese versus overweight/normal or being obese/overweight versus normal. For those models in which the Brant test indicated that the proportional odds assumption was violated, the odds ratios associated with the logistic model for obese versus overweight/normal and the logistic model for obese/overweight versus normal are both presented.

Compared to children living in PACs with low levels of property disorder, the unadjusted odds of being in a higher weight category were 40% (95% CI 6–86%) and 47% (95% CI: 13–91%) greater among children residing in PACs with medium or high levels of property disorder, respectively. After controlling for patient-level characteristics, property disorder was no longer significantly associated with childhood weight category.

In unadjusted models, children living in PACs with high levels of nuisances had nearly a 70 percent (95% CI: 31–116%) increase in odds of being in a higher weight category compared to children living in low nuisance PACs. Controlling for patient level characteristics, compared to PACs characterized by low nuisance levels, residence in a high nuisance PAC was associated with a 45% increase in odds of being overweight/obese versus normal weight. Since the proportional odds assumption was violated in this adjusted model, the same association does not apply to the comparison of obese vs overweight/normal weight, a logistic model in which no significant association between nuisances and weight category was found.

For the crime indices, the null hypothesis of proportional odds was not rejected by the Brant test (P >.05) in either the unadjusted or adjusted models. Thus, for each model, the odds of being overweight/obese versus normal weight or obese versus overweight/normal weight are the same for each covariate. In unadjusted models, both medium and high levels of violent and total crimes were associated with higher weight (see Table 3). Following adjustment for individual level characteristics, the odds ratio of children being in a higher weight category for children living in PACs with high levels of violent crimes compared to PACs with low levels of violent crime was 1.48 (95% CI= 1.06–2.05). Considering total crime in models controlling for individual level characteristics, residence in medium or high level PACs, compared to low crime PACs, was associated with over a 50 percent increase in odds of being in a higher weight category, with odds ratios of 1.54 (95% CI= 1.08–2.22) ad 1.51 (95% CI= 1.06–2.14) for the comparison of medium and high levels of total crime compared to low levels of total crime, respectively.

Discussion

After adjustment for the patient level characteristics of race, age, sex, and insurance status, higher levels of violent crime, total crime, and nuisances in a child's residential area were associated with higher risk of being above the normal weight range. These aspects of the built environment may reduce childhood activity levels by creating neighborhoods in which parents do not feel comfortable allowing their children to play outside due to a lack of a sense of community or safety. Interestingly, territoriality, an index of the level of security measures present in a PAC, was not associated with childhood weight status. This may be related to the disconnect between territoriality (perceived safety) and actual crime levels as seen in Figure 2. Although we did not, some previous studies have found an association between parental perceptions of safety and child weight.[11–15] Also unlike this study, other studies examining the relationship between crime rates and child weight status found no association.[16–19] Further research should measure physical activity levels among children and examine how activity levels relate to crime and nuisances, as well as the other built environment measures.

This study leveraged georeferenced pediatric patient data on preventive-care visits from the Duke University Health System and detailed data on objectively measured built environment characteristics in the urban core of Durham, NC in order to explore the association between the built environment and childhood weight status. The built environment measures used in this study -- violent crime, total crime, housing damage, property disorder, tenure status, vacancy, territoriality, and nuisances -- focus on how the built environment may influence inactivity through the social context and character of neighborhoods. These factors of the built environment may speak to the social context of a neighborhood by being related to neighborhood stability, community engagement, and sense of community and safety. This perspective extends previous work relating built environment and childhood weight status, in which physical barriers to inactivity or healthy eating habits have tended to be the focus.[9,16,18]

This study is not without limitations. We defined each child's local environment based on the Census block in which they resided and adjacent Census blocks (PACs). The accuracy of the PAC construct in reflecting the boundaries of an individual's living environment may vary by individual. Secondly, while we focus on measures of the built environment that may influence childhood weight and inactivity through the social context and character of neighborhoods, we have not controlled for traditional measures of the built environment that have been previously associated with childhood weight and through physical barriers to activity, such as walkability and green spaces,[9,16,18] and healthy eating habits.[9,16] Thirdly, the study data was cross-sectional in nature, and we do not have a measure of length of residence. In addition, pediatric patients living in the study area but receiving care at clinics unaffiliated with the Duke University Health System were not included in this analysis.

Our research indicates a significant association between domains of the built environment focused on social context and neighborhood characteristics and childhood overweight and obesity. This work holds promise for elucidating key drivers of the burgeoning childhood overweight epidemic, and in so doing, highlights potential for policy interventions. In future research, we hope to examine the joint and independent relationship between all aspects of the built environment (social context, walkability, green spaces, food environment) and childhood weight status.

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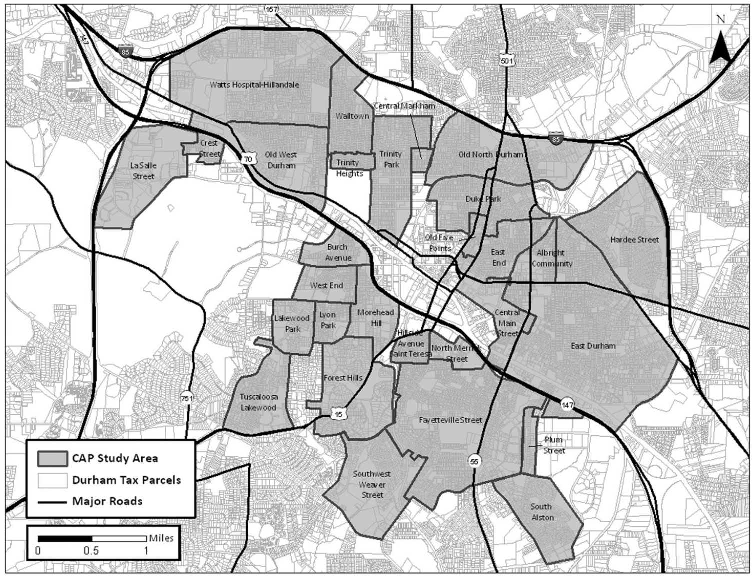

Figure 1.
Map of study area boundaries in central Durham, North Carolina, US.

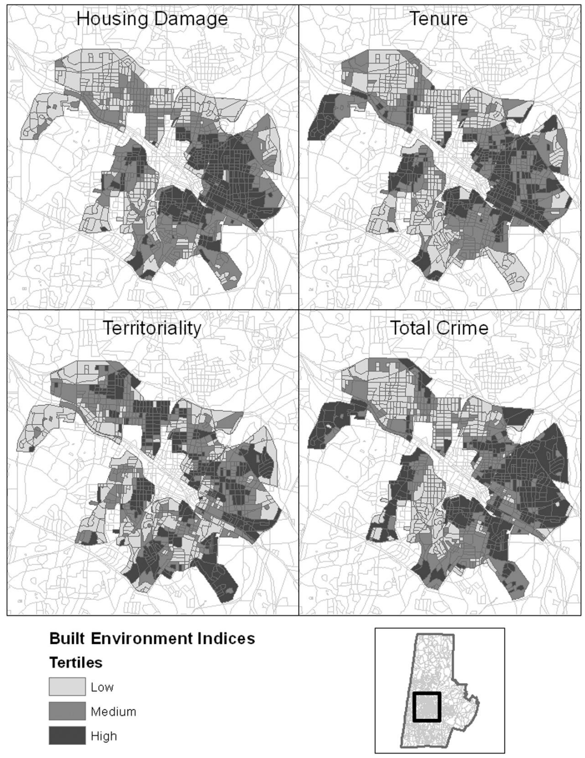

Figure 2.
Tertiles of select built environment indices across the study area.

Table 1

Summary statistics of patient population (N=1,785).

Characteristic	n	%
Weight status		
Normal (>5th and ≤ 85th percentile)	1176	65.9
Overweight (>85th and ≤ 95th percentile)	272	15.2
Obese (> 95th percentile)	337	18.9
Race		
Non-Hispanic white	297	16.6
Non-Hispanic black	1182	66.2
Hispanic	212	11.9
Asian	51	2.9
Other	43	2.4
Age, years		
2–5	794	44.5
6–11	567	31.8
12–18	424	23.8
Male sex	908	50.9
Enrolled in Medicaid	1057	59.2

Table 2

Patient residence in tertiles of PAC-level built environment indices by weight classification.

	All		Weight classification					
			Normal Weight		Overweight		Obese	
	n	%	n	%	n	%	n	%
Total	1785		1176		272		337	
Housing Damage								
Low	631	35.4	428	36.4	89	32.7	114	33.8
Medium	663	37.1	431	36.6	96	35.3	136	40.4
High	491	27.5	317	27	87	32	87	25.8
Property Disorder								
Low	430	24.1	310	26.4	53	19.5	67	19.9
Medium	648	36.3	419	35.6	99	36.4	130	38.6
High	707	39.6	447	38	120	44.1	140	41.5
Territoriality								
Low	627	35.1	414	35.2	81	29.8	132	39.2
Medium	573	32.1	398	33.8	84	30.9	91	27
High	585	32.8	364	31	107	39.3	114	33.8
Tenure								
Low	640	35.9	432	36.7	93	34.2	115	34.1
Medium	505	28.3	319	27.1	86	31.6	100	29.7
High	640	35.9	425	36.1	93	34.2	122	36.2
Vacancy								
Low	656	36.8	442	37.6	89	32.7	125	37.1
Medium	649	36.4	430	36.6	99	36.4	120	35.6
High	480	26.9	304	25.9	84	30.9	92	27.3
Nuisances								
Low	438	24.5	319	27.1	57	21	62	18.4
Medium	546	30.6	369	31.4	68	25	109	32.3
High	801	44.9	488	41.5	147	54	166	49.3
Violent Crime								
Low	399	22.4	295	25.1	52	19.1	52	15.4
Medium	469	26.3	311	26.4	64	23.5	94	27.9
High	917	51.4	570	48.5	156	57.4	191	56.7
Total Crime								
Low	382	21.4	287	24.4	49	18	46	13.6
Medium	452	25.3	285	24.2	73	26.8	94	27.9
High	951	53.3	604	51.4	150	55.1	197	58.5

Abbreviations: PAC, primary adjacency community.

Table 3

Odds ratios and 95% confidence intervals associated with select built environment indices in models for weight status category.[a]

	Unadjusted				Adjusted[b]			
	Overweight/obese vs. normal		Obese vs. overweight/normal		Overweight/obese vs. normal		Obese vs. overweight/normal	
Built environment measure	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Property disorder								
Low	1.00	–	·	·	1.00	–	1.00	–
Medium	1.40	(1.06, 1.86)	·	·	1.19	(0.87, 1.63)	0.88	(0.62, 1.26)
High	1.47	(1.13, 1.91)	·	·	1.28	(0.93, 1.75)	0.87	(0.61, 1.24)
Nuisances								
Low	1.00	–	·	·	1.00	–	1.00	–
Medium	1.33	(0.99, 1.79)	·	·	1.13	(0.84, 1.53)	1.13	(0.84, 1.53)
High	1.68	(1.31, 2.16)	·	·	1.45	(1.09, 1.91)	1.11	(0.81, 1.52)
Violent Crime								
Low	1.00	–	·	·	1.00	–	·	·
Medium	1.49	(1.09, 2.02)	·	·	1.26	(0.89, 1.78)	·	·
High	1.73	(1.32, 2.26)	·	·	1.48	(1.06, 2.05)	·	·
Total Crime								
Low	1.00	–	·	·	1.00	–	·	·
Medium	1.79	(1.32, 2.42)	·	·	1.54	(1.08, 2.22)	·	·
High	1.76	(1.34, 2.31)	·	·	1.51	(1.06, 2.14)	·	·

Abbreviations: CI, confidence interval; OR, odds ratio.

[a]Cumulative logistic models were used when the proportional odds assumption held and partial proportional odds models were used when the assumption was violated. Models with proportional odds have the same ORs for the logistic model of obese/overweight vs normal and the logistic model of obese vs overweight/normal, and thus the ORs are only shown for this first model and the cells for the second model are simply marked with a dot to indicate a purposefully blank cell. For partial proportional odds models, the ORs for both the logistic model of obese/overweight vs normal and the logistic model of obese vs overweight/normal are presented.

[b]Adjusted models include the following covariate: race, age, sex, and insurance status.