Overweight Children: Assessing the Contribution of the Built Environment

Irina B. Grafova

Department of Health Systems and Policy
School of Public Health
University of Medicine and Dentistry of New Jersey
335 George Street, Suite 2200, New Brunswick, NJ 08903
Phone: (732)-235-5619
Fax: (732)-235-9780
grafovib@umdnj.edu

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Abstract

Objective. To examine the relationship between the built environment and overweight status in children.

Methods. Analyses were based on 2,482 children aged 5-18 and their primary care givers who participated in the second wave of the Child Development Supplement (CDS-II) of the Panel Study of Income Dynamics (PSID). A number of built environment characteristics were examined: population density, alpha index of connectivity, urban design, pedestrian fatality from motor vehicle crashes, neighborhood physical disorder, restaurant density, and grocery store and convenience store densities.

Results. Living in a neighborhood with higher convenience store density (OR=1.31, p<0.05) and living in a neighborhood built after 1969 (OR=1.87, p<0.01) is associated with a higher probability of being overweight for children and adolescents. Living in the neighborhood where no physical disorder (OR=0.53, p<0.01) is observed is associated with a decreased likelihood of being overweight.

Conclusions. The results of this study emphasize a particular importance of the built environment of the neighborhood for weight status of children and adolescents. Additional studies are needed to clarify the underlying mechanism behind this association.

Key words: built environment; children; obesity

Introduction

The prevalence of overweight status in children in the United States has become an increasing public health concern (Must and Strauss, 1999). Recent evidence suggests that the built environment may influence children's weight. For example, children living in sprawling counties are more likely to be overweight (Ewing et al., 2006) than children living in areas with more compact development. Adolescents living in older suburbs that tend to have more pedestrian friendly urban design are more likely to be physically active than residents of newer suburbs (Nelson et al., 2006) that tend to be less pedestrian friendly.

Examining the influence of the built environment on children's weight is challenging for several reasons. First, overweight status results from an energy imbalance in which caloric intake exceeds energy expenditures. The built environment may influence both energy intake (through its influence on food availability) and energy expenditure (by facilitating or impeding physical activity) (Booth et al., 2005).

Second, both energy expenditure and energy intake are influenced by a number of factors. For instance, a higher level of physical activity in children is associated with better sidewalks (Jago et al., 2006, Jago et al., 2005, Lee et al., 2007), higher quality recreational facilities (Romero, 2005), easier access to recreational facilities (Gomez et al., 2004, Gordon-Larsen et al., 2006, Mota et al., 2005, Norman et al., 2006, Powell et al., 2007a, Timperio et al., 2004), greater housing density (Roemmich et al., 2006), and higher neighborhood walkability (Kerr et al., 2006). It could be challenging to assess correctly the effect of a certain built factor without taking into account other built, social, and economic environment factors because they may occur (Powell et al., 2007b) and influence children's weight jointly.

Third, the impact of some of these factors could be complex. For example, the effect of food store density may depend on the type of food store (e.g. convenience stores versus chain supermarkets) in question (Powell et al., 2007c).

Finally, the observed correlation between neighborhood environment and weight status of children may be due to parents of overweight and non-overweight children selecting to reside in particular areas rather than due to a causal relationship.

Using a nationally representative survey, this study examines the relationship between overweight status of children ages 5-18 and eight built environment factors reflecting: population density, street connectivity, urban design, neighborhood physical disorder, and food environment. We model overweight status of children using a multinomial logistic regression model in which we control for individual, family and neighborhood level confounders.

Methods

Survey Design and Sample

This paper draws on the 2002-2003 waves of the Child Development Supplement (CDSII) of the Panel Study of Income Dynamics (PSID) as the primary data set. The PSID is a longitudinal survey based on a nationally representative sample of U.S. individuals and their families. Since 1968, the PSID has collected data that includes employment, income, wealth, education, housing, etc. In October 2002 – May 2003, the PSID supplemented its main data collection with additional data on 5-18 year old children and their parents. The CDS-II is a nationally representative sample of 2,907 children.

Outcome Measure

Both weights and heights of children were measured by the interviewer using strain gauge lithium bath scales and measurement tape, respectively (Mainieri, 2006). The Body Mass Index (BMI) of children was calculated as weight in kilograms, divided by square of height, measured in meters. Children were classified as being overweight if their BMI was above the 95th percentile of the gender-age specific BMI distribution from Center for Disease Control Growth Charts.

Data Sources for Environment Measures

With the exception of parental reports of informal social control and interviewer-observed neighborhood disrepair, all built environmental measures considered in this study are objective. These measures were created from linkage to several secondary data bases: the (a) 2000 Census, (b) 2002 Economic Census, (c) 2002 Uniform Crime Reporting (UCR) Program Data maintained by Federal Bureau of Investigation (FBI), (d) 2002 Fatality Analysis Reporting System (FARS) of National Highway Traffic Safety Administration, (e) 2000 Topologically Integrated Geographic Encoding and Referencing system (TIGER). Table 1 reflects the source of environmental measures, the geographic level at which they were linked (census tract or county of residence[1]), and the summary statistics.

Built Environment Measures

We used five characteristics reflecting neighborhood ***urban sprawl and walkability***.

<u>Population density</u> equals total population of the census tract in thousands per square mile of land.

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[1] Census tracts are nested within counties. Unfortunately, we could not find census tract level data with national coverage for neighborhood pedestrian danger, neighborhood crime and neighborhood food environment. So, instead, we utilized county level data. This approach was applied by previous researchers (Ewing et al., 2006, Gordon-Larsen et al., 2000). Using both county and census tract data means that some environmental features could, potentially, be measured with error. This measurement error would result in attenuation bias (Wooldridge, 2005). In other word, we would underestimate the effect of neighborhood environment on adolescents' weight.

Alpha index of street connectivity uses the concept of a circuit – a finite, closed path starting and ending at a single node (node is either an intersection or an end of a cul-de-sac). The alpha index is the ratio of the number of actual circuits to the maximum number of circuits. In other words, it equals to the ratio of observed to maximum possible route alternatives. It ranges from 0 to 1, with higher values representing a more connected network.

Following previous research (Berrigan and Troiano, 2002, King et al., 2005), we use the median year the homes in the census tract of residence were built as a proxy for *urban design*. Neighborhoods built after 1970 tend to have a "loops and lollipops" design that is less pedestrian friendly than the "warped parallel" design typical for 1950-1969 or "grid" design of pre-World War II neighborhoods (King et al., 2005). We use two urban design indicators reflecting whether the median home was built before 1950 or after 1969.

Pedestrian danger equals pedestrian fatalities from motor vehicle crashes per 100,000 of county population.

No physical disorder is an indicator variable that equals one if no physical disorder is observed by the interviewer on the street block where a family lives. Interviewers recorded their observation on the condition and upkeep of the buildings and street surface on the block, and the amount of garbage, broken glass, drug-related paraphernalia, condoms, beer containers, cigarette butts, etc. in the street and sidewalk using a 4-item Likert-type scale. These items were previously included in the Project on Human Development in Chicago Neighborhoods Study (Cronbach's Alpha equals 0.77 (Leventhal et al., 2004)).

Three measures reflecting the ***food environment*** equal the number of food outlets per 10,000 persons in the county of residence (Powell et al., 2007c, Sturm and Datar, 2005).

Restaurant density includes full service restaurants, limited service restaurants, snack shops, etc.

Food store density variables include *grocery store density*, *convenience store density*, and *specialty food store density*.

Socio-Economic Environment Measures

Economic advantage is approximated by the median value of owner-occupied housing units.

Economic disadvantage is measured by the Sampson neighborhood deprivation index (Sampson et al., 1997) – average across the following four items: percent female-headed household, percent households in poverty, percent households on public assistance, and percent of unemployed.

Lack of informal social control was assessed by the primary care giver using a 4-item Likert-type scale (Cronbach's Alpha equals 0.83 (Ardelt and Eccles, 2001)) that asked how likely it was that a neighbor would do something if someone was selling drugs to children in plain sight, if children were "getting into trouble", if a child was "showing disrespect to an adult", or if a child was removing property from a neighbor's apartment, house, etc. The higher values of the scale reflect greater perceived lack of informal social control in the neighborhood.

Crime index equals the total number of violent crimes (murder, rape, robbery, and aggravated assault) and property crimes (burglary, motor vehicle theft, and larceny) per 1,000 of county population.

Our main hypothesis is that neighborhood environment can either encourage or serve as a barrier to healthy lifestyle. For instance, unsafe neighborhoods provide a barrier to children's physical activity which may result in higher likelihood of being overweight. Alternatively, higher neighborhood walkability would encourage greater physical activity and would be preventive of being overweight. Also, living in the areas that have greater access to energy dense food would provide a barrier to healthy diet and children in such areas would be more likely to be overweight.

Covariates

A number of individual and family variables were included in the analysis: child age, gender, race and ethnicity (White; Black non-Hispanic; Hispanic and others); age of household head; number of children in the household; region of residence; the primary care giver's highest level of education attained (college degree; some college; high school diploma or GED; no high school diploma or GED), and maternal hours of work. An income to needs ratio was calculated as total family income divided by the Census Bureau poverty threshold. Total family wealth was measured as the total amount of money in real estate, bank accounts, bonds, stocks, vehicles, farms, businesses, mutual funds, IRAs, etc., net of mortgage and other debts. Mother's BMI was calculated based on self-reported height and weight.

Statistical analysis

Multivariate-adjusted odds ratios[2] (ORs) and 95% confidence intervals (CI) were calculated using a logistic regression model to examine the association between neighborhood environment and prevalence of overweight status in children. All analyses used sample weights. Since some of the children in the sample are siblings we estimate robust standard errors that are clustered within families (Hofferth and Curtin, 2005).

The association between neighborhood environment features and children's weight may not necessarily imply that neighborhood environment causes obesity (Merlo and Chaix, 2006, Oakes, 2004). For example, it is possible that overweight children reside with families that may

[2] The sample is dispersed geographically. The children included in the final sample reside in 506 different counties. At the same time, the sample has very low geographic clustering. About two thirds of the children in the sample reside in census tracts where their family is the only family participating in the survey. Due to the low level of geographic clustering we decided to utilize logistic regression model technique rather than multilevel model technique.

tend to move to the neighborhoods where the environment does not promote physical activity or healthy eating. Then the neighborhood environment would not be causally linked to children's weight even though it may be correlated with it.

To address this issue, we utilized the unique PSID-CDSII data structure. All core PSID sample families, including the CDSII sample families, were interviewed in 1999. The geocode link from the 1999 core PSID interview is used to determine whether families moved between the 1999 and the 2002-2003 interviews. We compare the probability of moving by the child's weight status. Then we compare whether children in non-mover families lived in the same type of neighborhoods as children in families that moved and whether movers moved into a different type of neighborhood from the ones they originally lived in.

Results

The sample is reduced from 2,907 to 2,482 children due to missing data. Table 2 shows that about 18 percent of the children in the sample are overweight[3]. About 16 percent of children are Black and 21 percent are Hispanic/other ethnicities. Table 1 shows that an average child resides in the area with about 1 convenience food store for every 10,000 population; 38 percent of children reside in the neighborhoods where no physical disorder was observed. About 52 percent of children reside in the neighborhoods that were built after 1969 – i.e. in the "loops and lollipops" era of street design.

The estimation results of the empirical model show that various individual, family and neighborhood factors are associated with children's weight. For example, girls are less likely than boys (OR=0.61, p<0.01) to be overweight. Higher maternal BMI (OR=1.07, p<0.01) and

[3] Overall, 21.62 percent of males and 15.34 percent of females are overweight in CDSII. The overweight prevalence for children of the same age in NHANES is 18.04 for males and 14.90 for females (Mainieri, 2006).

higher number of maternal hours of work (measured in 1,000 hours, OR=1.28, p<0.01) are associated with a higher probability of being overweight.

As Table 3 displays, we also find that the neighborhood environment is associated with children's weight. Children residing in the neighborhoods where physical disorder was not observed are less likely to be overweight (OR=0.53, p<0.01). Children residing in the neighborhoods that were built after 1969, i.e. the era of "loops and lollipops" street design are more likely to be overweight (OR=1.87, p<0.01). Higher convenience food stores density is also associated with a higher likelihood of being overweight (OR=1.31, p<0.05). We found no association between restaurant density and weight status of children[4].

The analysis also demonstrates the importance of the economic and social environment. Neighborhood economic disadvantage (OR=0.36, p<0.05) decreases the chances of being overweight for children. Lack of social control is associated with an increased likelihood of being overweight (OR=1.19, p<0.01).

Are these significant associations between the built environment and overweight status of children the result of selection? Table 4 shows no statistically significant difference in the probability of moving between the 1999 and 2002-2003 interviews for overweight and non-overweight children[5]. The bottom part of Table 4 concentrates on two built environment features that were significant in the logistic regression analysis and that were also available for the 1999 neighborhoods of residence: age of the neighborhood and convenience store density. Neither of these variables was related to the decision to move. Families tended to move to counties with

[4] We have also estimated specification that categorizes restaurant density into the density of full service restaurants, density of limited service restaurants, and density of snack shops. Note that this division is driven by type of service the restaurants provide rather than by type of food they serve. We found that neither type of restaurant density was associated with the weight status of children.
[5] The sample size in Table 3 goes down from 2,482 to 2,400 due to missing 1999 geocode link for some of the families.

convenience store density similar to the county they formally lived in. There was also a tendency to move to newer neighborhoods rather than the older neighborhoods they lived in. Thus, residential mobility patterns do not differ by overweight status in children. This is consistent with the idea that residential decisions of families are not related to the weight status of their children.

Discussion

The findings of the present study suggest that several aspects of the built environment may influence the children's weight. First, consistent with our hypothesis of *the preventive role of walkability* and findings of King and colleagues (King et al., 2005), we find that children residing in neighborhoods that are newer and that tend to have an urban design that is less pedestrian friendly are more likely to be overweight. Second, we consistent with our expectations, we find that a *higher density of convenience stores* that tend to have energy dense food is related to a higher probability of children being overweight. This result is supported by Powell and colleagues (Powell et al., 2007c) but is inconsistent with Sturm and Datar (Sturm and Datar, 2005) who examined a national sample of 5-8 year old children. Third, consistent with our hypothesis we find that *safety of the built environment* matters. Children living in neighborhoods where physical disorder was observed were more likely to be overweight. Consistent with some (Burdette and Whitaker, 2004, Burdette and Whitaker, 2005) but not all of the earlier evidence (Gomez et al., 2004, Lumeng et al., 2006, Weir et al., 2006), we find no association between pedestrian safety, crime, and weight status of children.

We find evidence suggesting that residential mobility may play a role in determining children's exposure to neighborhoods of different types. We find that when children move they tend to move to newer neighborhoods. However, we did not find evidence suggesting that the probability of moving or the type of neighborhood moved into varied between overweight and non-overweight children.

On the one hand, this may be interpreted as the evidence that selection does not necessarily play a significant role. On the other hand, it does not rule out the selection hypothesis completely. For example, selection decisions could have been made earlier in the life-cycle (before 1997).

Study Strengths

Most of the previous studies are either small geographic area studies (Burdette and Whitaker, 2004, Cohen et al., 2006, Gomez et al., 2004, King et al., 2005, Motl et al., 2005, Roemmich et al., 2006, Weir et al., 2006) or nationally representative studies that tend to concentrate on a very few neighborhood features at a time (Burdette and Whitaker, 2005, Ewing et al., 2006, Gordon-Larsen et al., 2006, Powell et al., 2007c). The present study uses a nationally representative sample and considers a wide variety of built environment measures. These measures are, with one exception, objective. The analysis of the relationship between the built environment and overweight status in children includes a large number of individual, family and neighborhood confounders. Finally, the study also examines whether the pattern of residential mobility may be related to overweight status of children.

Study Limitations

The study does not include some important built environment features, such as the availability of parks and recreation facilities. Also, the study is a cross-sectional one and the results cannot be interpreted as causal. Due to data availability, some environment features are measured at a county of residence rather than census tract of residence level which may, potentially, introduce measurement error. This measurement error may results in underestimating the effect of neighborhood environment on adolescents' weight (attenuation bias).

Conclusions

Higher convenience store density, physical disorder in the neighborhood, and living in a newer neighborhood is associated with a higher probability of being overweight for children.

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Table1: Description of built, economics and social environment characteristics

Variables	Description	Source	Geography level	Mean	Standard deviation
Built environment characteristics					
Urban Sprawl and Walkability					
Population density	Population in thousands of people per square mile of land	2000 Census	Census tract	4.63	12.29
Alpha index of connectivity	Actual to maximum possible number of circuits. A circuit is a finite closed path starting and ending at a single node.	2000 TIGER	Census tract	0.16	0.08
Urban design: neighborhood was built…					
…before 1950	Median home was built before 1950	2000 Census	Census tract	0.11	0.10
…between 1950-1969	Median home was built in 1950-1969	2000 Census	Census tract	0.37	0.23
…after 1969	Median home was built after 1969	2000 Census	Census tract	0.52	0.23
Pedestrian danger	Annual pedestrian fatality per 100,000 population	2002 FARS	County	1.72	1.36
No physical disorder	Dummy variable that equals one if physical disorder is not observed	PSID, observed by the interviewer		0.38	0.24
Food environment					
Restaurant density	Total number of restaurants, eating places, cafeterias and snack bars per 10,000 population	2002 Economic Census	County	14.88	4.18
Grocery store density	Total number of supermarkets and other groceries (except convenience stores) per 10,000 population	2002 Economic Census	County	2.37	1.04
Convenience store density	Total number of convenience stores per 10,000 population	2002 Economic Census	County	1.07	0.59
Specialty food store density	Total number of specialty food stores and markets per 10,000 population	2002 Economic Census	County	0.84	0.55
Social and economic environment characteristics					
Economic advantage	Median value of owner-occupied housing units (in $10,000)	2000 Census	Census tract	12.96	8.53
Economic disadvantage	Sampson neighborhood deprivation index	2000 Census	Census tract	0.32	0.24
Lack of informal social control	Neighbors are unlikely to interfere when they see other youth or adults engaged in wrongdoing.	PSID, perceived by primary care giver		0.67	1.17
Crime index	Total number of violent crimes and property crimes per 1,000 population	UCR of FBI	County	41.35	19.50

Table 2: Sample descriptive statistics

Variable	
Child overweight	0.18
Child Age	
mean	12
min	5
max	18
Child gender: female	0.50
Child race and ethnicity	
White	0.63
Black	0.16
Hispanic or other	0.21
Average income to need ratio	3.98
Mean total family wealth, in $10,000	18.21
Mother's BMI, mean	25.99
Primary care giver's highest education level achieved	
College degree	0.30
Some college	0.19
High school diploma or GED	0.27
No high school diploma or GED	0.24
Female headed household	0.21
Mean age of the household head	41

Table 3: Adjusted[a] odds ratios (OR, and 95%CI) from logistic regression model predicting the probability of being overweight by built environment characteristics.

Variable	OR[a]	95%CI
Built environment characteristics		
Urban sprawl and walkability		
Population density	1.00	(0.98, 1.01)
Alpha index of connectivity	5.52[d]	(0.29, 104.65)
Urban design: neighborhood was built…		
…before 1950	1.09	(0.68, 1.74)
…after 1969	1.87	(1.20, 2.92)**
Pedestrian danger	1.01	(0.90, 1.13)
No physical disorder[b]	0.53	(0.36, 0.77)**
Food environment		
Restaurant density	1.01	(0.96, 1.06)
Grocery store density	1.13	(0.99, 1.29)
Convenience store density	1.31	(1.05, 1.65)*
Specialty food store density	1.04	(0.73, 1.46)
Social and economic environment characteristics		
Economic advantage	0.97	(0.94, 1.00)
Economic disadvantage	0.36	(0.14, 0.93)*
Lack of informal social control[c]	1.19	(1.07, 1.33)**
Crime index	1.00	(0.99, 1.00)

* $p<0.05$; ** $p<0.01$;

[a] Adjusted for child age, gender, race, ethnicity; total family wealth and income to needs ratio; mother's BMI, primary care giver education, age, number of children in the household, whether household is female-headed, mother's annual hours of work, and region of residence.

[b] Interviewer's observation of physical disorder

[c] Primary care giver's perception of lack of informal social control

[d] Alpha index of connectivity takes values between 0 and 1. The odds ratio for alpha index seems to be high, however, it translates into a very modest marginal effect. In fact, marginal effect of one standard deviation increase in alpha index of connectivity, calculated at mean, equals 1.83 percent. For comparison, the marginal effect of moving out of neighborhood with physical disorder equals 7.57 percent.

Table 4: Probability and pattern of residential mobility by overweight status

	Overweight children			Non-overweight children		
# of children moved	167			635		
# of children did not moved	318			1,280		
% of children moved (weighted)	34.5			29.5		
	Means of environmental characteristics					
	Movers		Non-movers	Movers		Non-movers
	1999	2002-2003	1999/2002-2003	1999	2002-2003	1999/2002-2003
Urban design: neighborhood was built…						
…built before 1950	0.15	0.11	0.11	0.18	0.11	0.11
…built 1950-1969	0.31	0.25	0.34+	0.37	0.35	0.41+
…built after 1969	0.54	0.64*	0.55+	0.45	0.54*	0.48+
Convenience store density	1.08	1.15	1.10	1.00	1.05	1.06

* Significantly different from Movers in 1999 at p<0.05 (*) and p<0.01(**)
+ Significantly different from Movers in 2002-2003 at p<0.05 (+) and p<0.01(++)