Obesogenic Neighborhood Environments, Child and Parent Obesity

The Neighborhood Impact on Kids Study

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Background: Identifying neighborhood environment attributes related to childhood obesity can inform environmental changes for obesity prevention.

Purpose: To evaluate child and parent weight status across neighborhoods in King County (Seattle metropolitan area) and San Diego County differing in GIS-defined physical activity environment (PAE) and nutrition environment (NE) characteristics.

Methods: Neighborhoods were selected to represent high (favorable) versus low (unfavorable) on the two measures, forming four neighborhood types (low on both measures, low PAE/high NE, high PAE/low NE, and high on both measures). Weight and height of children aged 6–11 years and one parent (n=730) from selected neighborhoods were assessed in 2007–2009. Differences in child and parent overweight and obesity by neighborhood type were examined, adjusting for neighborhood-, family-, and individual-level demographics.

Results: Children from neighborhoods high on both environment measures were less likely to be obese (7.7% vs 15.9%, OR=0.44, p=0.02) and marginally less likely to be overweight (23.7% vs 31.7%, OR=0.67, p=0.08) than children from neighborhoods low on both measures. In models adjusted for parent weight status and demographic factors, neighborhood environment type remained related to child obesity (high vs low on both measures, OR=0.41, $p<0.03$). Parents in neighborhoods high on both measures (versus low on both) were marginally less likely to be obese (20.1% vs 27.7%, OR=0.66, p=0.08), although parent overweight did not differ by neighborhood environment. The lower odds of parent obesity in neighborhoods with environments supportive of physical activity and healthy eating remained in models adjusted for demographics (high vs low on the environment measures, OR=0.57, p=0.053).

Conclusions: Findings support the proposed GIS-based definitions of obesogenic neighborhoods for children and parents that consider both physical activity and nutrition environment features.
(Am J Prev Med 2012;42(5):e57–e64)

Introduction

Childhood obesity continues to be highly prevalent in the U.S.[1] There is higher prevalence among lower-income children,[2–4] but less research examining neighborhood built or physical environments in relation to childhood obesity. Reviews of the limited evidence on environmental factors note variability in the ages of the children studied, and differences across studies in the measures (e.g., parent report versus more objective measures) and environmental factors as contributing to inconsistent findings.[5] More evidence is needed, particularly given recent recommendations targeting changes in environment and policies to prevent childhood obesity.[6,7]

Studies exploring environment–childhood obesity associations have been more focused on physical activity than nutrition environmental factors, with some evi-

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0749-3797/$36.00
doi: 10.1016/j.amepre.2012.02.008

dence of obesity associations with walkability and access to parks/playgrounds.[5] One study found that further distance from a supermarket was related to higher child overweight,[8] whereas another study reported that having a convenience store located <0.25 miles from home was related to higher risk of overweight/obesity among younger girls.[9] A recent UK study reported that children aged 9–10 years with healthy food outlets (e.g., supermarkets) proximal to their homes had lower BMI *z*-scores than children without such availability. Conversely, children with proximal unhealthy food outlets (e.g., fast-food restaurants) had higher BMI *z*-scores.[10]

Among both adults and children, most studies have not simultaneously considered environment factors on both sides of the energy-balance equation.[11] The present

Table 1. Sample descriptives by neighborhood type

	Physical activity environment/nutrition environment			
	Low/low	Low/high	High/low	High/high
NEIGHBORHOOD CHARACTERISTICS				
Block groups *(n)*	119	90	97	130
Average percentage white	78	77	71	74
Median age (years)	38.2 (6.8)	37.0 (6.2)	34.8 (5.7)	37.0 (7.2)
Average family size	3.2 (0.4)	3.2 (0.3)	3.1 (0.5)	3.1 (0.5)
Median household income ($)	73,471 (22,280)	64,628 (22,953)	53,060 (20,157)	55,657 (19,685)
CHILD, PARENT, AND HOUSEHOLD CHARACTERISTICS				
Children *(n)*	173–189	156–168	171–179	181–194
Child age (years, median)	9.1	9.0	8.8	9.3
Child gender (% female)	48	49	50	55
Child ethnicity (% Hispanic)	14	19	20	16
Child race				
White	81	83	80	81
Black or African-American	5	1	3	2
Asian	4	6	2	3
Other or multiple races	10	10	15	14
Parent gender (% female)	87	83	87	88
Parent employment (hours/week)				
<15	45	48	49	49
15–35	25	20	18	26
≥36	30	32	33	25
Children aged <18 years in household *(n)*				
1	17	13	11	15
2	46	48	49	55
3	22	29	30	23
≥4	16	10	11	7
Household income ($)				
<50,000	9	14	19	15
50,000–100,000	38	34	40	37
>100,000	53	53	41	49

Note: Nonpercentage values are M (SD), unless otherwise noted.

study aims to determine whether neighborhoods with more- versus less-favorable physical activity and nutrition environments have different levels of child and parent overweight and obesity. It was hypothesized that neighborhoods with the combination of environments favorable to healthy eating and active living would have lower child and parent overweight and obesity than neighborhoods without such environmental support, after adjusting for individual- and neighborhood-level demographics.

Methods

Present analyses are from the baseline of a longitudinal cohort study titled Neighborhood Impact on Kids (NIK) that examined neighborhood and home environments in relation to obesity and related behaviors among children and parents.

Neighborhood Selection

All neighborhoods, defined as census block groups, were evaluated for physical activity and nutrition environments in King County (Seattle area) WA and San Diego County CA. Block groups were selected as the neighborhood unit because this is the lowest level of census geography at which demographic information is publicly available, and there is more built environment homogeneity at this level than at larger geographic levels such as census tracts.

Briefly, GIS methods were used to create environmental metrics and identify neighborhoods supportive and unsupportive of child and parent physical activity and healthy eating (see accompanying paper by Frank et al.[12] for GIS method details). High physical activity environments had (1) built environments that were more conducive to walking, with a higher than median summed *z*-score value on residential density, retail floor area ratio, land-use mix, and street connectivity for their respective county,[13] and (2) at least one high-quality park as assessed by the Environmental Assessment of Public Recreation Spaces tool[14] (scoring available on request from BES). Low physical activity environment neighborhoods had below-region median summed *z*-score walkability and no park within the block group or a 0.25-mile buffer around it.

High nutrition environment neighborhoods had a nearby (within the block group or a 0.5-mile buffer around the block group) supermarket and few fast-food outlets (≤16 for King County and ≤31 for San Diego County), whereas low nutrition environment neighborhoods had either no supermarket nearby or had a supermarket nearby but many fast-food outlets (>16 for King County and >31 for San Diego County). Criteria were developed to characterize four types of neighborhoods in terms of their physical activity and nutrition environments: high (favorable or supportive) on both environment measures; high PA/low (unfavorable or unsupportive) NE; low PAE/high NE; and low on both measures.

Recruitment

A commercial marketing firm provided names, addresses, and telephone numbers (land lines) for households with children aged 6–11 years from the block groups identified as part of the spatial sampling described above. Households were randomly selected within each neighborhood type and contacted. Approximately 1 week after a recruitment letter was sent to potential participants, a telephone call provided study details, evaluated eligibility, and assessed parent and child willingness to participate. Interested and eligible parent–child pairs were scheduled for an in-office or in-home measurement visit.

Participants were recruited from September 2007 to January 2009. Children and parents were required to (1) live in one of the identified neighborhoods (the child had to typically live there at least 5 days/week, with the participating parent); (2) be able to engage in at least moderate-intensity physical activity; (3) not have underlying medical conditions associated with obesity (e.g., Cushing's syndrome); or (4) be actively involved in medical treatment that has substantive impact on growth (e.g., growth hormone treatment). Children with a chronic illness known to affect growth (e.g., cystic fibrosis); <10th percentile BMI for age and gender based on parent report; with an eating disturbance indicative of substantial eating disorder psychopathology (e.g., self-induced vomiting); on a medically prescribed dietary regimen; or with a psychiatric problem that would interfere with participation, were excluded. Parents needed to be a legal guardian. Only one child per household was allowed to participate. If more than one child was eligible and interested, the child with the nearest birthday to the recruitment call date was recruited.

Participants

Attempts were made to contact 8616 households. Among these, 7094 had working residential phone numbers and 4975 were screened for interest and eligibility. Among screened families, 944 were interested and eligible and agreed to participate. Among families agreeing to participate, 730 families consented and had a measurement visit, although two parents refused to have their own weight and height measured. Demographic information for the participating child and parental/household information is provided in Table 1. Participants did not differ on any of these demographic characteristics by neighborhood environment type.

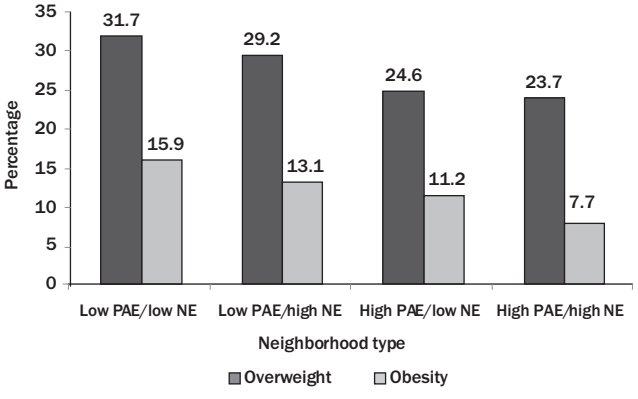

Figure 1. Child overweight and obesity by neighborhood type

Note: n=189 for low PAE/low NE, n=168 for low PAE/high NE, n=179 for high PAE/low NE, n=194 for high PAE/high NE.
NE, nutrition environment; PAE physical activity environment

Measures

Child and parent anthropometrics. Parents and children had their height and weight measured by a trained research assistant. Using a digital scale (office: Detecto 750; home: Detecto DR400C), weight was measured three or more times until three of four consecutive weight readings were within 0.1 kg of each other, with the average of these readings used. Using a stadiometer (office: 235 Heightronic Digital Stadiometer; home: portable Seca 214), height was measured multiple times to the nearest 0.1 cm until three of four consecutive measures were within 0.5 cm of each other, and the average of these readings was used. Child overweight was defined as BMI ≥85th percentile and child obesity as BMI ≥95th percentile for age and gender using CDC 2000 growth charts.[15] Parent overweight was defined as BMI ≥25 and obesity as BMI ≥30.

Individual and household demographics. At or soon after the measurement visit, parents completed a survey (online or paper) that included items about household and parent and child demographics. Individual-level demographic characteristics included child and parent age, gender, race, and ethnicity, as well as parent education and employment status. Household-level characteristics included number of children aged <18 years living in the household and household income. Surveys were completed by 700 parents (95.9%), with 19 parents refusing to respond to the household income item (highest item refusal response rate: see Table 1 for sample sizes by neighborhood environment type), leaving 681 children and 679 parents included in the demographically adjusted models.

Neighborhood demographics. Demographic characteristics of the participants' census block groups were gathered from the 2000 U.S. Census, including median age; average family size (among family households); percentage white; and median household income (Table 1). The current study was approved by the IRBs at Seattle Children's Hospital, San Diego State University, and Emory University. Parents provided written consent and children assented to participate.

Analyses

In addition to descriptive statistics, chi-square tests for trend were used to compare proportions of overweight/obese children/adults across neighborhood types. Separate multivariable logistic regression models were then conducted to examine separately child and adult overweight/obese status, with parent BMI included in the child analyses. Metropolitan area (San Diego, Seattle) was entered, but was not significant in any model. Clustering by block group was not done because 69.2% of participants were the only participants in their block group. All predictors were decided a priori based on existing literature or expert knowledge. Significance was defined as $p \leq 0.05$.

Results

Child BMI *z*-score and parent BMI were highly correlated ($r=0.33$, $p<0.001$) In this cohort, 17% of non-

Table 2. Child overweight and obesity related to neighborhood type and individual and neighborhood demographic characteristics

	Overweight OR (95% CI)	Obesity OR (95% CI)
NEIGHBORHOOD CHARACTERISTICS		
Low PAE/high NE[a]	1.09 (0.66, 1.82)	1.07 (0.55, 2.08)
High PAE/low NE[a]	0.72 (0.42, 1.26)	0.58 (0.27, 1.24)
High PAE/high NE[a]	0.70 (0.41, 1.21)	0.41* (0.19, 0.90)
White, %	0.87 (0.18, 4.33)	0.84 (0.10, 7.00)
Median age	1.01 (0.97, 1.05)	0.99 (0.94, 1.05)
Average family size	0.84 (0.41, 1.71)	0.85 (0.33, 2.19)
Median household income	1.00 (.99, 1.01)	1.00 (0.98, 1.02)
CHILD, PARENT, AND HOUSEHOLD CHARACTERISTICS		
Child age	1.11 (0.98, 1.26)	1.05 (0.88, 1.25)
Child gender (female[b])	0.68* (0.47, 0.99)	0.88 (0.53, 1.46)
Child race (white[c])	0.98 (0.61, 1.57)	0.86 (0.45, 1.63)
Child race (Hispanic[d])	1.10 (0.66, 1.86)	0.95 (0.48, 1.88)
Parent age	1.00 (0.97, 1.04)	1.04 (0.99, 1.08)
Parent education	0.94 (0.77, 1.16)	0.92 (0.70, 1.20)
Parent BMI	1.11* (1.07, 1.15)	1.12* (1.07, 1.16)
No. of children aged <18 years in household	0.78* (0.63, 0.97)	0.80 (0.60, 1.07)
Household income($)[e]		
50,000–100,000	0.75 (0.33, 1.72)	0.97 (0.36, 2.61)
>100,000	0.51 (0.19, 1.36)	0.39 (0.11, 1.32)

[a]Ref=low PAE/low NE neighborhood
[b]Ref=male
[c]Ref =nonwhite
[d]Ref=non-Hispanic
[e]Ref=household income <$50,000
*$p \leq 0.05$
NE, nutrition environment; PAE, physical activity environment

overweight parents have an overweight child, whereas 35.1% overweight parents have an overweight child (OR=2.64, 95% CI=1.83, 3.86, $p<0.001$); 8.2% of non-obese parents have an obese child, whereas 23.2% of obese parents have an obese child (OR=3.36, 95% CI=2.06, 5.48, $p<0.001$).

Child Overweight and Obesity by Neighborhood Environment Type

The proportion of overweight children was lower when neighborhood environments were more supportive of healthy eating and physical activity ($\chi^2=3.89$, df=1, $p=0.049$; see Figure 1). The most substantial difference in child overweight levels was between neighborhoods low versus high on both measures. Children in neighborhoods high on both physical activity and nutrition environments had 37% lower odds of being overweight than children in neighborhoods low on both measures, but the difference only approached significance ($p=0.08$).

Similarly, the proportion of obese children was lower when neighborhood environments were supportive of healthy eating and physical activity ($\chi^2=6.30$, df=1, $p=0.012$; see Figure 1). Children in neighborhoods high on both measures had 56% lower odds of being obese than children in the neighborhoods low on both measures ($p=0.02$), the neighborhood type comparison that was most substantially different.

Child Models Adjusting for Demographic Factors

As seen in Table 2, none of the neighborhood characteristics were significantly related to the likelihood of child overweight, although neighborhood environment type was in the expected direction (OR=0.70 for neighborhoods high vs low on both measures, $p=0.20$). Among the individual- and household-level characteristics, being female and having more children in the household were related to lower odds of child overweight. Neighborhood type remained significantly related to the likelihood of a child being obese in the adjusted model, even after parent weight status and neighborhood, individual, and household demographic characteristics were in the model. In the adjusted model, children in high physical activity and nutrition environment neighborhoods had 59% lower odds of being obese compared to children in neighborhoods low on both measures ($p<0.03$).

Parent Overweight and Obesity by Neighborhood Type

There was no trend in parent overweight ($\chi^2=1.56$, df=1, $p=0.21$; see Figure 2) or obesity ($\chi^2=1.83$, $p=0.18$) by neighborhood environment type, although the lower likelihood of parent obesity in the neighborhoods high versus low on both the physical activity and nutrition measures approached significance (OR=0.66, $p=0.08$).

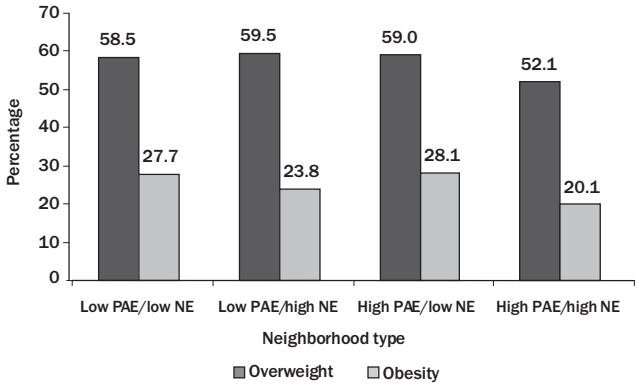

Figure 2. Parent overweight and obesity by neighborhood type

Note: $n=188$ for low PAE/low NE, $n=168$ for low PAE/high NE, $n=178$ for high PAE/low NE, $n=194$ for high PAE/high NE.
NE, nutrition environment; PAE, physical activity environment

Parent Models Adjusting for Demographic Factors

In adjusted models, parent overweight was not related to neighborhood environment type. Parents living in neighborhoods with higher average family size were more likely to be overweight (see Table 3). Individual-level demographics were also related to parents being overweight: age and working more hours per week were positively related to overweight; being female and having a higher education were negatively related to being overweight.

In adjusted models, parental obesity was related to neighborhood environment type, with parents in high physical activity and nutrition environment neighborhoods having 43% lower odds of being obese than parents in neighborhoods low on both measures ($p=0.053$). Other neighborhood characteristics relating to higher odds of parent obesity included higher percentage white and higher average family size, whereas higher median income for the neighborhood and higher parent education were associated with lower parent obesity odds.

Discussion

Both child and parent obesity were lowest in neighborhoods with environments that were most favorable to both healthy eating, defined as supermarket proximity and/or lower fast-food restaurant density, and physical activity, defined as having built environments more conducive to walking and access to a higher-quality park. Neighborhoods with built environments unfavorable for both healthy eating and physical activity had the

Table 3. Parent overweight and obesity related to neighborhood type and individual and neighborhood demographic characteristics

	Parent overweight OR (95% CI)	Parent obesity OR (95% CI)
NEIGHBORHOOD CHARACTERISTICS		
Low PAE/high NE[a]	0.92 (0.58, 1.47)	0.74 (0.44, 1.26)
High PAE/low NE[a]	0.85 (0.52, 1.40)	0.88 (0.51, 1.50)
High PAE/high NE[a]	0.74 (0.45, 1.22)	0.57* (0.33, 1.01)
Percentage white	0.35 (0.07, 1.66)	5.16* (1.01, 26.47)
Median age (years)	1.02 (0.98, 1.05)	1.01 (0.97, 1.04)
Average family size	1.95* (1.10, 3.78)	2.50* (1.27, 4.91)
Median household income	0.99 (0.98, 1.00)	0.98* (0.97, 0.99)
PARENT AND HOUSEHOLD CHARACTERISTICS		
Parent age (years)	1.04* (1.01, 1.08)	1.02 (0.99, 1.06)
Parent gender (female[b])	0.56* (0.33, 0.94)	1.22 (0.70, 2.13)
Parent race (white[c])	1.31 (0.77, 2.24)	0.83 (0.47, 1.47)
Parent race (Hispanic[d])	1.53 (0.86, 2.71)	1.26 (0.71, 2.25)
Parent education	0.76* (0.62, 0.93)	0.77* (0.62, 0.94)
Parent employment[e] (hours/week)		
15–35	1.46 (0.96, 2.25)	0.75 (0.45, 1.25)
≥36	1.60* (1.06, 2.42)	1.38 (0.89, 2.15)
No. of children aged <18 years in household	1.08 (0.89, 1.32)	0.97 (0.78, 1.20)
Household income[f] ($)		
50,000–100,000	1.97 (0.88, 4.42)	1.72 (0.73, 4.04)
>100,000	1.68 (0.67, 4.24)	1.46 (0.53, 3.98)

[a]Ref=low PAE/low NE neighborhood
[b]Ref=male
[c]Ref=nonwhite
[d]Ref=non-Hispanic
[e]Ref=<15 hours/week
[f]Ref=household income <$50,000.
*$p \leq 0.05$
NE, nutrition environment; PAE, physical activity environment

highest percentage of childhood and parent obesity. These differences persisted even after accounting for parent weight status (in the analyses regarding child weight status) and various neighborhood-level and individual- and household-level demographic factors. Findings using child and parental overweight as thresholds were in a similar direction, although the associations were not as strong as for obesity.

Current results offer an initial GIS-based definition of "obesogenic neighborhood environments," a commonly used term to describe a variety of environmental features, but this is among the first studies to test an empirically based definition, and it was shown to be related to child and adult obesity. Both physical activity and nutrition environments were considered and incorporated several environmental indicators that have been widely discussed and studied.[16] The physical activity environment definition considered environments that supported both active transportation and active recreation. The nutrition environment definition included access to both healthy and less-healthy food outlets.

Although present criteria for neighborhood types may not currently be easy to replicate because of required use of both archival and newly collected data (e.g., park-quality evaluations), the criteria were quantitative, and data such as these could become more commonly collected if confirmed to be related to obesity and other health outcomes. The specific definitions or thresholds may not be optimal, since they differed by region and had to be adjusted to identify a sufficient number of block groups for recruitment of children aged 6–11 years. Future research can test alternative definitions of physical activity environment and nutrition environment.

Present findings are consistent with emerging evidence about neighborhood environments and child overweight/obesity. In the 2007 National Survey of Children's Health sample of children aged 10–17 years, parents' report of less-favorable built environments for physical activity (e.g., no sidewalk access, no access to parks/playgrounds) was related to higher prevalence of child overweight and obesity, with 19.7% of children in the least-favorable neighborhood environments for physical activity being obese versus 14.6% of children in the most-supportive built environments.[2]

Current findings of lower parent obesity prevalence in neighborhood environments with higher walkability are consistent with prior evidence among adults[11,17,18] and other findings that adult obesity was lower in neighborhoods with supermarket availability.[19,20] Results provide empirical support for recommendations from multiple authoritative groups to markedly improve neighborhood built environments and local policies that affect the likelihood of children's and parent's healthy eating and physical activity.[6,7] It is notable that the child overweight (31.7%) and obesity (15.9%) estimates in the least-favorable neighborhoods in the present study are comparable to the most-recent NHANES prevalence estimates for overweight (32.6%) and obesity (18.0%) among children aged 6–11 years in the U.S.[1]

Socioeconomic factors were associated with parent overweight and obesity in mostly expected directions. However, socioeconomic characteristics of the neighborhood and household were not related to child overweight or obesity in this sample. It could be that neighborhood physical activity and nutrition characteristics are more important predictors, particularly among this relatively affluent and well-educated sample. Alternately, spatial sampling methods were used to ensure a mix of neighborhoods that met these built environment characteristics with adequate numbers of respondents per neighborhood. Therefore, study participants and their neighborhoods were not necessarily representative of the population or study area. The present design and analyses can be considered a validation of the spatial sampling approach used in the current study, rather than a representative sampling of factors related to child and adult weight status.

Strengths of the present study included measurement of both child and parent BMI, a priori and objective measurement of neighborhood environments using GIS, generalization across two regions of the U.S., and consideration of neighborhood-level as well as individual- and household-level demographics. Limitations included the cross-sectional design, relatively low response rate relative to initial contacts, relatively affluent and well-educated sample, and aggregation of environmental characteristics based on overall block group characteristics to individual children and parents.

Different fast-food restaurant density levels were used in King County versus San Diego County areas, in part because of the substantially greater number of restaurants in San Diego. This relative measure makes comparisons to other areas difficult, but it is not clear at this point what level of restaurant quality or quantity differentiates between healthy versus unhealthy dietary quality and weight status. Relative metrics of built environment for walkability were similarly constructed within region.

In addition, neighborhood and the corresponding built environment was defined by block group in which the children lived, rather than their actual activity space or places where they shopped for food and/or ate.[21] Replication of present findings is needed, including testing relative versus absolute of built environment (e.g., testing uniform and absolute thresholds of park proximity versus relative park proximity within a region), as are more intervention studies that evaluate effects of change in built environment and policy.

A key contribution was the validation of an initial GIS-based definition of obesogenic and obeso-protective environments. There is some suggestion in the present study that physical activity environment may be more important than nutrition environment for child weight status, at least as operationalized herein, but overall findings suggest the importance of examining the combination of nutrition and physical activity environments. Future research with larger samples and perhaps different designs (e.g., to control for specific characteristics of walkability) is needed to more fully examine the relative contribution of nutrition and physical activity environments.

Conclusion

The magnitude of the difference in obesity rates between the most obesogenic and least obesogenic neighborhood types was notable, about 8% for children and 7% for adults. Present findings suggest that environmental changes could have important effects on obesity rates of children and adults. There is concern that many children and their caregivers in the U.S. live in unsupportive environments that fail to provide better access to healthy nutrition and physical activity opportunities.[22]

The authors would like to thank the families who participated in the Neighborhood Impact on Kids (NIK) project.

Funding came from the NIH National Institute of Environmental Health Sciences (ES014240), USDA 2007-55215-17924, and by grants to the Seattle Children's Pediatric Clinical Research Centers, which is supported by grants UL1 RR025014, KL2 RR025015, and TL1 RR025016 from the NIH National Center for Research Resources.

The publication of this theme article was supported by a grant from the Robert Wood Johnson Foundation.

No financial disclosures were reported by the authors of this paper.

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