Neighborhood Environment and Adiposity among Older Adults: the Cardiovascular Health of Seniors and the Built Environment Study

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Keywords: older adults, built environment, adiposity, cardiovascular disease

Abstract

Background. Individual neighborhood factors are associated with obesity-related health behaviors and rates; however, there remains a paucity of information characterizing whole environments in these relationships and limited information on the effect for older adults.

Methods. Adults, aged 60 or older living in New York City, were enrolled into the Cardiovascular Health of Seniors and the Built Environment between January 2009 and June 2011. Walking audits of all streets within 300-meter buffer zones around residential addresses were conducted resulting in the assessment of 34 different neighborhood features hypothesized to be associated with obesity through physical activity and diet. Outcomes included objective measures of body fat mass (FM), waist circumference (WC), and body mass index (BMI). Stratified linear regression models were used to calculate geographic differences in associations between neighborhood resources and adiposity by gender and age categories in areas where Black, White and Latino residents lived.

Results. For women 60-69 years of age living in black areas, neighborhood features resulted in a higher FM than the average Brooklyn neighborhood (Difference (D) =2.15, 95% CI [1.15, 3.15]). Conversely, for women of the same age living in white and Latino areas, a lower prevalence of FM was observed: white areas: (D= -2.01, 95% CI [-3.62, -0.40]); Latino areas: (D= -1.43, 95% CI [-2.72, -0.14]). The direction of the effects remained similar for other age groups, although the estimates were less precise. Estimates of FM were inconsistent across age groups for men living in each of the areas. Other measurements of adiposity showed similar results.

Conclusions. The composition of neighborhood features in white and Latino residential areas is protective of adiposity, whereas features located in black areas appear to place residents at greater risk.

1. Background

The United States (U.S.) Public Health Service has identified obesity as a leading health concern.[1] Although the prevalence of obesity among adults in recent years appears to have leveled, currently 36.5% of American adults are obese and higher rates are observed for older adults, particularly for older women (38.8%).[2] Disparities in obesity prevalence exist by gender and race/ethnicity.[3] The prevalence of obesity among non-Hispanic white women is the lowest (35.5%) followed by Hispanic (45.7%) and non-Hispanic black women (56.9%).[2] The prevalence for each of these race/ethnicity categories is lower for men.[2] Obesity has both health and economic consequences, as individuals who are obese are at greater risk of developing co-morbidities.[4-6] The cause of obesity is likely to be multi-factorial, resulting from the interaction of environmental and behavioral factors. Although genetic factors may be important for determining an individual's susceptibility to becoming obese, given the short time period during which the sharp increase has occurred, individual exposure to environmental factors, such as the contextual effect of residential areas, are likely to have a more proximal role as component causes of the obesity epidemic.[7]

Environmental factors affect obesity through their influence on an individual's behavior, specifically, dietary intake and physical activity. Local food availability, at the neighborhood-level, has recently received attention as a possible environmental determinant of dietary intake.[8-9] Some investigators have documented disparities in the costs and availability of foods.[10-13] An even larger literature has documented disparities in local food environments along race and class lines.[14-31] These disparities are associated with dietary intake of recommended foods and nutrients.[32-35] Although many of these studies have been cross-sectional, the consistency of findings across studies has led to interventions for changing: schools [36-38]; work places [38-39], and neighborhood environments.[40-42] A similarly compelling literature has documented associations between land use and physical activity.[43-46,69]

Older adults are of particular concern, because advanced age is associated with diet and physical activity-related chronic diseases.[47-49] Several U.S. health agencies recognize the various factors that influence older adults' ability to maintain healthy diets.[50-53] However, there remains a scarcity of data documenting the relationship between neighborhood environments and health for older adults with focus mainly on physical activity.[54-61] Therefore, we designed a study to measure the effect of neighborhood features as component causes of obesity for the elderly population. This study is based on evidence that older adults, in particular, rely on their immediate neighborhood for activities of daily living.[62-63] We hypothesize that neighborhood features are a component cause of obesity and that the combination of these features becomes sufficient to lead to excess body weight.

2. Methods

Older adults were enrolled into the Cardiovascular Health of Seniors and the Built Environment study between January 2009 and June 2011 (n=1,453). Participants were sampled from New York City (NYC) Community Centers serving older adults located in all areas of Brooklyn and selected neighborhoods in Queens (along the Brooklyn/Queens border). Once enrolled, buffer zones (BZ) with a radius of 300 meters (slightly under 1000 feet) around participants' residential addresses were created using ArcGIS v9.3 (Environmental

Systems Research Institute (Esri); Redlands, CA). NYC Department of City Planning (DCPLION-2009) street segment files were layered onto the BZs, resulting in maps of whole and partial street segments. Street segments are typically road lengths between two adjacent intersections or an intersection and a dead-end. Continuous roads, such as freeways, are also segmented. For simplicity, street segments are referred to as *streets*. The study has been approved by the Mount Sinai Institutional Review Board.

2.1. Walking audit

There were a total of 82,907 streets located in Brooklyn (n=30,484) and Queens (n=52,423). Study participants' BZs included 22,739 streets located in all 18 Brooklyn Community Districts and three Queens Community Districts (QCD-5, QCD-9, QCD-10), resulting in the evaluation of 66% of all Brooklyn and 5% of Queens streets. Community districts, on average, cover 3.9 square miles and the populations within districts vary by race/ethnicity and wealth. On average, 15,176 adults at least 65 years old reside in each district.[64] The race/ethnic distribution of the study sample reflects the distributions of the community districts within 10% for most districts.

Streets identified within BZs were highlighted on paper maps and assigned to trained auditors who through a walking audit documented the features located on each street. Auditors were instructed to document the entrances of specific types of places on both sides of the streets. Most features were coded only once where the main entrance was found; however, features such as parks (where entrances were found on a number of segments) were documented on all buffering streets. All decisions about the type of establishment or land use were made based on observations from the street.

Some streets were excluded from the walking audit because they were either vehicular only, such as highways (e.g., Brooklyn Queens Expressway) or another type of street where features of interest were not likely to be located (e.g., Brooklyn Bridge). Additional excluded streets were coded in the DCPLION file as railroads, private streets, alleys, paths, connectors, exit/entrance ramps, or faux streets. In addition, additional streets were identified during the walking audits, resulting in a total of 4,330 streets assumed to contain no features of interest and therefore excluded from the list of streets for the walking audit. This resulted in 16,047 Brooklyn and 2,362 Queens streets audited by walking.

The walking audit protocol called for documenting all buildings and land use within each BZ resulting in a complete census of all establishments and land use. Thirty-four neighborhood features were audited and secondary datasets from the NYC Department of Transportation and Metropolitan Transit Authority were used to determine the location of subway and bus stops, as well as traffic controls. Descriptions of the food environment features have been described previously.[70] Descriptions of the other features are included in the appendix. All audited street features were entered electronically into a street segment database. The protocol called for all streets to be audited within a six-month window of the baseline interview.

2.2. Outcome measures

The three outcome variables were; (a) fat mass (FM), which assessed general adiposity; waist circumference (WC), a measure of central adiposity; and (c) body mass index (BMI), a measure of weight adjusted for height. Trained staff collected data on all these variables during the baseline interviews. FM and weight were measured using the Tanita Body Composition Analyzer (TBF-300A). Standing height was measured using a stadiometer with participants in bare feet. Waist girth was measured using the Gulick II 150 and 250 cm anthropometric tape with participants standing erect and weight distributed equally over both feet. BMI was calculated by dividing weight measured in kilograms (kg) by the square of height measured in meters.

2.3. Statistical analysis

We have developed regression models to predict fat mass, waist circumference and BMI under different neighborhood conditions. For each participant, the value for a neighborhood component feature (ex. supermarkets) was obtained by summing that independent variable across all streets within a participant's buffer zone. Because some buffer zones have more street segments, the number of each feature was divided by the total audited street length for the buffer zone. In addition, in order to adjust for bias that may have arisen from differential proportions of missed street audits, for eligible streets that were missed during the walking audits (an average of 4.3 streets per participant), the total number of each feature was calculated based on the average of that feature on measured streets within that buffer zone, then imputed proportionally based on street length. The majority (87.2%) of the study sample had features on at least one street imputed. Imputed streets were generally shorter segments (average length 360 meters versus 13,728 meters for all streets). Finally, a derived total for each feature for each participant was calculated by summing the measured number and the imputed number of each feature within each buffer zone.

Univariate analyses of the study population and bivariate analyses of features of buffer zones by geographic areas were followed by multivariable modeling of the effect of neighborhood features on adiposity. Linear regression models were stratified by age category and gender because of differences in obesity rates among these groups. The product of the model coefficients and centered means for each component feature were summed to calculate the area effect compared to the overall geographic area sampled. Stratified analyses excluded individuals 90 years or older as well as 'other race group' due to lack of statistical power. All analyses were conducted using SAS version 9.2 (SAS Systems, Cary NC).

3. Results

3.1. Description of study population.

Black, White and Latino participants are included in the study sample plus one 'other race group' consisting of Asians, Native Americans and other race/ethnicities. Black Americans represented the highest proportion in the sample (43.8%) followed by White Americans (30.1%) (Table 1). The majority of the study sample is 60-79 years old (75.2%) and women (76.1%). Most participants were living alone due to being single, separated, divorced or widowed (73.3%); high school educated or lower (63.1%); retired (86.2%); living on annual incomes $30,000 per year or less (63.5%); and have lived in their current neighborhood for decades. Regarding adiposity, the average FM for the study sample was 30.5 kg; average waist girth was 98.3 cm; and average BMI was 30.1 kg/m^2.

Table 1. Description of study population (1,431)

Race N, (%)		
Black	627 (43.8)	
White	431 (30.1)	
Hispanic	330 (23.1)	
Other	43 (3.0)	
Age (years), N (%)		
60-69	509 (35.6)	
70-79	567 (39.6)	
80-89	315 (22.0)	
90-99	40 (2.8)	
Gender, N (%)		
Women	1089 (76.1)	
Men	342 (23.9)	
Marital Status, N (%)		
Single	279 (19.5)	
Married	292 (20.4)	
Separated	90 (6.3)	
Divorced	224 (15.7)	
Widow(er)	456 (31.9)	
Living With Partner	15 (1.0)	
Not Reported	75 (5.2)	
Education - Highest Grade Level, N (%)		
Elementary	155 (10.3)	
Middle School	188 (13.1)	
High School	570 (39.8)	
Trade School	80 (5.6)	
University/College	311 (21.7)	
Other	40 (2.8)	
Not Reported	87 (6.0)	
Annual Income, N (%)		
less than $10,000	401 (28.0)	
$10,001 - $20,000	370 (25.9)	
$20,001 - $30,000	138 (9.6)	
$30,001-$50,000	121(8.5)	
$50,001 or more	69 (4.8)	
Not Reported	332 (23.2)	
Retired, N (%)		
Yes	1234 (86.2)	
No	120 (8.4)	
Not Reported	77 (5.4)	
Lived in Current Neighborhood, N, Mean (SD)		
Years	1285	31.0 (19.2)
Adiposity, N, Mean, (SD)		
Fat mass (kg)	1324	30.5 (14.3)
Waist Circumference (cm)	1366	98.3 (15.2)
Body Mass Index (kg/m^2)	1376	30.1 (6.5)

3.2. Description of residential environments

Participants had an average of 59 street segments within their BZs (Table 2). There was little variation in the number of streets within BZs among Black areas (BAs), White areas (WAs), and Latino areas (LAs), with LAs having the greatest number of streets, 65.56, versus 57.02 and 57.82, for WAs and BAs respectively (Table 2). The average number of streets assumed to have no features and the number of streets with imputed features was similar between the areas.

Regarding food environments, LAs contained the greatest number of supermarkets, while WAs had fewer bodegas, full service restaurants, and small grocery stores compared to the other areas (Table 2). The number of convenience stores and franchised fast food stores were similar among areas, but there were fewer food vendors in BAs. A larger number of specialty food stores were located in LAs, as were bars and liquor stores. Regarding transportation, there were a greater number of bus stops and subway stops in BAs and LAs compared to WAs. More public parking lots were in BAs and LAs but the number of industrial parking lots was greater in LAs.

In terms of physical activity opportunities, more parks were located in LA whereas gyms were more prevalent in WAs. However, BAs and LAs had the greatest number of other physical activity opportunities. The fewest banks, libraries, medical facilities, post office mail boxes, and post offices were located in BAs. WAs had the fewest schools and places of worship. All areas contained a large number of businesses offering general service or general retail, but these types of businesses were more prevalent in LAs. LAs also carried a larger burden of the factories and industrial places with twice as many as BAs and three times as many as the WAs. Finally, in terms of other land use, the number of vacant residential buildings was similar between BAs and LAs and somewhat more common compared to WAs. Vacant commercial buildings and land were common in both BAs and LAs and also in greater proportion than in WAs. General office space was sparse in all areas sampled, although somewhat more frequent in WAs.

3.3 Associations with adiposity

Women, 60-69 years of age, who live in BAs exhibited a FM 2.15 kilograms higher compared to residents of the average Brooklyn neighborhood (Table 3). For women of the same age living in WAs, a 2.01 kg decrease in FM was predicted. A decrease in FM was also predicted for women living in LAs although the effect was somewhat smaller (Difference (D) = -1.43 kg, 95% CI [-2.72, -0.14]). The direction of the effects observed for older aged women living in BAs and WAs remained similar to the 60-69 age group, although the estimates were less precise. For women living in LAs, lower FM was observed for the 80-89 age group, but higher for the 70-79 year old women. Estimates of FM were also inconsistent across age groups for men living in each of the areas.

Table 2. Means and standard deviations (SD) of the derived number of each feature and number of streets per buffer zone by area

	Black Area		White Area		Latino Area	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
No. streets within buffer zone	57.82	23.77	57.02	24.05	65.56	27.36
No. streets assumed no features	12.70	17.85	12.62	16.71	13.70	21.79
No. streets with imputed features	2.81	7.53	3.29	6.22	2.85	5.96
Food Environment Features						
Supermarket	1.04	1.13	0.82	1.17	1.21	1.15
Bodega	5.11	3.91	2.63	3.04	6.11	4.72
Convenience Store	0.37	0.80	0.51	1.05	0.40	0.89
Franchised Fast Food	0.98	1.53	0.76	1.28	0.92	1.57
Food Vendor	0.30	1.08	1.01	2.70	1.48	3.49
Full Service Restaurant	6.26	6.04	5.78	7.64	10.54	8.74
Small Grocery Store	3.55	3.55	2.43	2.86	5.11	4.88
Specialty Food Store	2.12	2.95	3.76	4.04	4.37	3.51
Bar/Tavern	0.47	1.06	0.70	1.46	1.00	1.48
Liquor Store	0.77	1.05	0.73	1.07	1.15	1.11
Transportation Features						
Bus Stop	11.99	5.10	8.67	4.83	11.53	5.39
Subway Stop	1.09	1.66	0.84	1.41	1.45	1.75
Public Parking Lot	4.34	4.30	1.57	2.60	5.39	5.31
Industrial Parking Lot	0.51	1.07	0.58	2.06	1.10	2.27
Traffic -Allway Stop	3.95	5.55	3.42	4.92	4.57	5.95
Traffic - Signal	44.11	20.02	36.62	23.26	47.74	22.82
Traffic - Stop on Minor	23.25	17.27	27.76	19.07	27.36	18.85
Physical Activity Environment Features						
Park Entrance	4.78	5.11	3.09	5.29	5.16	4.83
Gym	0.21	0.66	0.46	0.85	0.40	0.88
Other Physical Activity	2.80	3.13	1.38	2.44	3.36	3.18
Neighborhood Infrastructure Features						
Bank	0.46	1.08	1.53	2.69	0.76	1.24
Library	0.11	0.39	0.14	0.40	0.18	0.43
Medical	4.27	5.03	7.74	7.73	7.94	7.15
Post Office	0.11	0.42	0.14	0.38	0.24	0.61
Post Office Mailbox	1.07	1.61	1.50	1.83	1.08	1.46
School	4.62	3.10	2.80	2.54	3.82	2.59
Place of Worship	8.65	6.79	4.18	4.94	7.02	5.16
General Service	24.52	19.13	24.43	20.86	35.66	21.73
General Retail	10.89	18.20	15.07	19.34	23.15	27.06
General Office Space	0.71	1.89	1.22	2.19	1.08	2.14
Other Land Use Features						
Industrial/Factories	4.32	6.84	3.04	7.76	9.84	13.24
Vacant Residential	1.90	2.66	1.53	2.73	1.94	2.47
Vacant Commercial	9.78	11.67	6.68	9.41	13.96	15.20
Vacant Land	8.67	8.75	2.78	4.42	9.82	8.59

Table 3. Age and gender stratified differences (D) in adiposity by type of residential neighborhood compared to Brooklyn, NY

	BLACK AREAS		WHITE AREAS		LATINO AREAS	
	D	95% CI	D	95% CI	D	95% CI
BODY FAT MASS (kg)						
Women						
60-69 year old	2.15	(1.15, 3.15)	-2.01	(-3.62, -0.40)	-1.43	(-2.72, -0.14)
70-79 year old	0.66	(-0.16, 1.48)	-1.15	(-2.33, 0.03)	0.58	(-0.60, 1.76)
80-89 year old	2.18	(0.85, 3.51)	-1.45	(-3.10, 0.20)	-2.14	(-4.43, 0.15)
Men						
60-69 year old	0.43	(-1.06, 1.92)	-1.15	(-3.84, 1.54)	0.88	(-1.59, 3.35)
70-79 year old	-1.05	(-2.97, 0.87)	1.58	(-1.14, 4.30)	0.00	(-2.53, 2.53)
80-89 year old	2.79	(-5.15, 10.73)	-4.27	(-18,52, 9.98)	-0.78	(-8.44, 6.88)
WAIST CIRCUMFERENCE (cm)						
Women						
60-69 year old	2.09	(0.86, 3.32)	-2.93	(-4.89, -0.97)	-0.16	(-1.77, 1.45)
70-79 year old	0.74	(-0.14, 1.62)	-1.15	(-2.42, 0.12)	0.15	(-1.14, 1.44)
80-89 year old	0.69	(-0.70, 2.08)	-1.97	(-3.68, -0.26)	1.39	(-0.96, 3.74)
Men						
60-69 year old	0.19	(-1.61, 1.99)	-0.93	(-3.42, 1.56)	0.93	(-1.36, 3.22)
70-79 year old	-1.62	(-3.27, 0.03)	1.56	(-0.75, 3.87)	0.98	(-1.35, 3.31)
80-89 year old	2.66	(-3.36, 8.68)	-8.60	(-19.42, 2.22)	5.88	(0.02, 11.74)
BODY MASS INDEX						
Women						
60-69 year old	0.54	(0.03, 1.05)	-0.61	(-1.43, 0.21)	-0.31	(-0.98, 0.36)
70-79 year old	0.20	(-0.23, 0.63)	-0.74	(-1.37, -0.11)	0.63	(0.02, 1.24)
80-89 year old	0.39	(-0.24, 1.02)	-0.77	(-1.53, -0.01)	0.29	(-0.75, 1.33)
Men						
60-69 year old	0.13	(-0.87, 0.61)	-0.24	(-1.06, 0.58)	0.58	(-.40, 1.56)
70-79 year old	-0.19	(-0.82, 0.44)	0.97	(0.07, 1.87)	-1.13	(-1.91, -0.35)
80-89 year old	0.86	(-1.94, 3.66)	-1.85	(-6.83, 3.13)	0.65	(-1.90, 3.20)

Effects were observed in a similar direction for central adiposity. For women aged 60-69 years living in BAs, a 2.09 cm increase in WC was associated with area features compared to other areas of Brooklyn. For similar aged women living in WAs, a decrease in WC was associated with area features (D= -2.93, 95% CI [-4.89, -0.97]). Effects were observed in the same direction for women in the older age groups although effects were somewhat attenuated and less precise. The effect of neighborhood features on WC for women living in LAs were weak and more inconsistent across age groups. Although the effects observed for men 60-69 years of age living in BAs and WAs were in the same direction as women of the same age, the effects were smaller and less precise. The effect observed for men living in LAs was greater than for women of all ages, but estimates were also imprecise.

Finally, measurements of BMI were somewhat inconsistent with the effects observed for the other measures of adiposity. For instance, an increase in BMI was observed for women 60-69 years old living exposed to features located in BAs (D=0.54, 95% CI [0.03, 1.05]), a somewhat smaller effect than FM given that one unit increase of BMI is roughly equivalent to 5-8 pounds of weight depending on height.[65] However, for all age groups, women living in BAs have a greater BMI. For women of the youngest age group, living in WAs is associated with a higher BMI although the older age groups are consistent with other measurements of adiposity, demonstrating a protective effect from the neighborhood environment (70-79: D=0.74, 95% CI[-1.37, -0.11]; 80-89: D=0.77, 95% CI [-1.53, -0.01]. For women living in LAs, the effect of neighborhood features varied by age group, with the 70-79 year old group showing the strongest effect (D=0.63, 95% CI [0.02, 1.24]. For men, the effect of neighborhood features varied by age group for each type of neighborhood.

4. Discussion

The findings from this study support the assertion that neighborhood area resources are associated with population distribution of adiposity for older adults. Studies measuring associations between neighborhood built environments and obesity have been more inconsistent that those measuring more proximal relationships with the environments such as food intake.[66] However, most measures of neighborhood environments in previous studies have been obtained from secondary data sets; developed as proxies for component features; and/or based on the measurement of neighborhood features affecting only one side of the energy balance equation. Moreover, there is an interest in focusing on single component features sufficient and necessary to produce obesity, which seems implausible. Our study is a departure from this framework, as we have instead characterized all component features of urban environments in order to measure the effect of whole neighborhoods. We hypothesize that the collection of neighborhood features creates a configuration of exposure that is a function of the sum of its parts when considering distal multi-factorial outcomes of health, such as obesity.

These findings are important because this is one of the first studies to conduct primary data collection on the breadth of neighborhood features and to focus the effects on older adults. The elderly population is the fastest growing sub-population in the U.S. with roughly one in five Americans estimated to be over the age of 65 by 2030.[67] Therefore, understanding how neighborhood environments promote disease over time and prevent older adults from maintaining recommended healthy lifestyles will significantly affect health care for a large number of Americans. These findings are also important because the magnitude of the effects observed in this study are clinically significant. For instance, an increase of 1.2 - 3.2 kilograms of fat mass in areas where for black participants live becomes clinically significant in the context of disease management where small reductions in weight loss have been shown to be associated with improvements in clinical profiles.[68]

Other investigators have documented associations between local food environments and health outcomes such as body weight.[71] Although there is inconsistency in longitudinal studies, a summary of predominately cross sectional studies published from 2006-2012 measuring associations between the presence of supermarkets and obesity show consistent evidence in favor of this relationship. The environmental influence of healthy foods is put into context with behaviors in a conceptual model describing interdependencies which have been extrapolated to other environmental/behavioral relationships such as: the availability of alcohol and cigarettes and consumption[72-75] and physical activity spaces and exercise.[76-77] However, a limitation of this area of public health research is a definition of "healthy environments". Studies generally focus on the proximity or density of a single type of retailer or area feature, when in fact people are typically making health decisions within the context of multiple exposures. Therefore it is unequivocally accepted that free choice is a component factor in the development of disease. But the concept that some people live in 'healthy environments' making the ability to make healthy choices easier is the central premise surrounding these built environment studies. Nevertheless, it remains unclear what are the component features of a residential environment that would promote walking as a mode of transportation or assure healthy food purchases, for example. This lack of knowledge is due in part to the fact that few studies are measuring whole environments. Built environment investigations have been reduced to questions of distance and density without acknowledging competing environmental stressors that influence behaviors. A recent qualitative study shadowed older adults during their regular food shopping and characterized the many interpersonal, social and environmental factors that influenced adaptive behaviors involved in this routine behavior of food purchases.[78] Although our study also utilizes the density of area features to define residential environments, we have purposefully combined the competing environmental components to describe whole environments. Given this approach to characterize 'healthy environments', these findings indicate that urban black, white, and Latino areas produce different results with regards to population distribution of adiposity for older adults and the effects of residential environments are more profound for women and the youngest age group of older adults.

Theses study conclusions need to be taken in context of potential biases that may have affected the findings. First, the study sample is taken from a diverse population of older adults who utilize services at community centers. Therefore, these findings may not be generalizable to all older adults. Second, differences between gender and age groups may reflect different neighborhood utilization patterns or pre-existing conditions, not fully explored within this cross sectional analysis. Third, misclassification may have occurred if neighborhood environments were assessed or coded incorrectly. We aimed to minimize these errors with staff trainings; however, if misclassification did occur, it is likely to be non-differential by area and, hence, most likely would underestimate these effects. Fourth, the variation between participants in the number and length of streets may influence findings; however, modeled outcomes adjusted for the street length did not affect results. Fifth, the prediction models are based on cross-sectional data and hence do not include information about the induction period whereby neighborhood environments initiate disease nor can the direction of the effect be determined. However, it can be postulated that effects presented in this manuscript represent chronic cumulative exposure since over 50% of the study sample has lived in their current neighborhood for more than thirty years. Conversely, it is also possible the observed associations are a snapshot of more acute effects that may be repeated over time and hence, these effects would underestimate effects associated with long-term repeated exposure.

Acknowledgements: Sources of Financial Support: National Heart, Lung and Blood Institute of the National Institutes of Health (R01 HL086507).

Conflict of interest statement: No conflicts of interest or financial disclosures were reported by the authors of this paper.

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Appendix. Neighborhood Features Audited and Possible Roles in the Promotion or Prevention of Obesity

Type of Feature	DEFINITION	Possible in the Obesity Causal Pathway
Bank	Commercial banks such as Citibank, U.S. Bank or any bank with full banking services or places where the commercial bank only offers ATMs services. Cash-Checking services or tax services are also not included.	The availability of **Banks** will promote physical activity because activities of daily living can be conducted within walking distance.
Library	Only public libraries (New York, Brooklyn, or Queens Borough Public Library branches).	The availability of **Libraries** will promote physical activity because entertainment/resources can be found within walking distance.
Post Office	U.S. Postal Service Office. Places such as UPS, Fed Ex and DHL are not included.	The availability of **U.S. Postal Offices** will promote physical activity because activities of daily living can be conducted within walking distance.
Mail Box	Any blue U.S. Postal Service mail box (not the green "storage" mail boxes).	The availability of **U.S. Postal Mailboxes** will promote physical activity because activities of daily living can be conducted within walking distance.
Health Care	Any place where medical services are provided such as doctor or dentist office. Also pharmacies, both independent and chain drugstores such as Duane Reade, CVS, and Walgreens, hospitals or other facilities related to health care are included.	The availability of **Health Care** related resources would promote physical activity because activities of daily living can be conducted within walking distance.
Place of Worship	Places where religious services are held (ex. churches, temples, synagogues, mosques, Kingdom hall of Jehovah's Witnesses).	The availability of **Places of Worship** will promote physical activity because for those that attend religious services, those services can be found within walking distance.
Retail Stores	Places whose main function is to sell non-food items (ex. clothing, furniture, electronics, books, stationary) If a store provides both service and retail, stores were defined as Retail.	The availability of **Retail Stores** will promote physical activity because activities of daily living can be conducted within walking distance.

School	Any public or private place that provides continual education (ex. school, day care, college, university, private/religiously-affiliated school). Places providing short term learning such as adult learning centers, driving school, and test preparation centers were not included	The availability of **Schools** will promote physical activity because grandchildren can be escorted to school within walking distance.
Service Industry	Any place offering services (ex. laundromats, beauty parlors, barber shops, motels, etc). This category also includes not-for profit and non-faith-based community services such as senior centers, urban youth centers, and community centers.	The availability of **Service Industry** will promote physical activity because activities of daily living can be conducted within walking distance.
Bus Stops	The locations of bus stops were provided from secondary data sources.	The availability of **Bus Stops** will promote physical activity because use of public transportation requires walking.
Subway Stops	The locations of subway stops were provided from secondary data sources.	The availability of **Subway Stops** will promote physical activity because use of public transportation requires walking.
Bodega	Small stores selling food items ranging from beer, soda, and snack food and sometimes canned goods, dairy, and other food items.	The availability of **Bodegas** will prevent healthy eating because the majority of foods within these stores do not promote good nutrition.
Convenience Store	A store that is similar to a Bodega but contains mainly beer, sodas and snack foods and is often, but not always, attached to a gas station (ex. Seven 11).	The availability of **Convenience Stores** will prevent healthy eating because the majority of foods within these stores do not promote good nutrition.
Food Vendor	A street vendor selling *only* food, whether meals, pretzels, candy, coffee/pastries, etc.	The availability of **Food Vendors** may promote or prevent healthy eating depending on the type of food sold (ex.Green Cart versus hot dogs).
Franchised Fast Food	Any chain fast food restaurant (ex. McDonalds, Burger King, Taco Bell).	The availability of **Franchised Fast Food** will prevent healthy eating because the majority of foods within these restaurants do not promote good nutrition.

Liquor Store	Any store where the only type of beverage sold is alcoholic.	The availability of **Liquor Stores** may promote or prevent healthy eating depending on the type of food purchased (ex. red wine versus grain alcohol).
Restaurant	Full service and limited service restaurants where customers can sit at tables. This includes a heterogeneous group of food service places from places such as coffee shops, pizza shops and ethnic restaurants to high-end restaurants.	The availability of **Restaurants** may promote or prevent healthy eating depending on the type of food purchased.
Small Grocery Store	Food stores that are smaller than supermarkets and also carry a larger selection of food than bodegas. In general, these stores are not chain stores, although Union Market, for instance, where there are two locations is a small grocery store.	The availability of **Small Grocery Stores** will promote healthy eating because the majority of foods within these stores promote good nutrition. However they may be more expensive than similar foods found at Supermarkets.
Specialty Food	These are food establishments that specialize in one type of food such as: Dunkin Donuts, Baskin Robbins, Starbucks, take-out only restaurants, ethnic food grocery stores, or fruit and vegetable stores.	The availability of **Specialty Food Stores** will prevent healthy eating because the majority of foods within these establishments do not promote good nutrition.
Supermarket	Any large chain food store that sells a large selection of foods such as: C-town, Associated, Pathmark, Food Emporium, Key Food, Gristedes, Gourmet Garage, Trader Joes, or Fairway.	The availability of **Supermarkets** will promote healthy eating because the majority of foods within these stores promote good nutrition.
Tavern/ Bar	Any place where the main purpose of the establishment is to serve alcoholic beverages and includes lounges, bars, pubs, taverns, and clubs.	The availability of **Bars and Taverns** will prevent healthy eating because the majority of beverages sold within these establishments do not promote good nutrition.
Gym	Any place that is a private or public gym, sports club, or activity center.	The availability of **Gyms** will promote physical activity because these facilities are intended for exercise.
Other Physical Activity Resource	Any space, probably indoor, that may offer opportunities for physical activity that cannot be classified as either a Park or Green Space or Gym.	The availability of **Other Physical Activity Resources** will promote physical activity because these facilities are intended for exercise.

Park or Green Space	Any space that is intended for recreation such as parks, basketball courts, tennis courts, community pools, tracks, playgrounds – including those attached to a public school and public housing. Also included are community gardens and any open 'play' space with the intent of being public.	The availability of **Parks and Green Spaces** will promote physical activity because these places are intended for recreation and walking.
Commercial Parking Lot	Parking lots that are used for city buses, school buses, etc.	The availability of **Commercial Parking Lots** will prevent physical activity because the industrial nature of the lots may decrease aesthetics and possibly safety for neighborhood walking.
Factory/ Warehouse	Places that appear to be used for industrial purposes.	The availability of **Factories and Warehouses** will prevent physical activity because the industry will decrease aesthetics and possibly safety for neighborhood walking.
Office Space	Buildings that are clearly used for offices, but the type of business is unclear.	The availability of **Office Spaces** may promote or prevent physical activity depending on the nature of the office space use.
Public Parking Lot	Parking lots intended for residential use.	The availability of **Public Parking Lots** will prevent physical activity because their presence suggest a reliance on car travel.
Vacant Commercial Space	Storefronts that have been boarded up and/or have "For Sale" signs.	The availability of **Vacant Commercial Space** may prevent physical activity due to decreasing places to patron as well as the decreasing the aesthetics and possibly safety for neighborhood walking.
Vacant Land	Undeveloped plots of land that are typically boarded up or fenced in.	The availability of **Vacant Land** may prevent physical activity due to decreasing places to patron as well as the decreasing the aesthetics and possibly safety for neighborhood walking.
Vacant Residential Buildings	A building that appears to be condemned.	The availability of **Vacant Residential Buildings** may prevent physical activity due to decreasing the aesthetics and possibly safety for neighborhood walking.

Traffic Control: All Way Stop	These data are provided by secondary data sources. This is a traffic control at a 4-way intersection where all streets have stop signs	The presence of **All Way Stops** may promote physical activity by slowing down traffic.
Traffic Control: Stop Sign on Minor Road	These data are provided by secondary data sources. This is a traffic control where only roads intersecting with major roads have stop signs	The presence of **Stop Signs on Minor Roads** may promote physical activity by slowing down traffic.
Traffic Control: Traffic Signals	These data are provided by secondary data sources. This is a traffic control where there is a traffic signal at an intersection.	The presence of **Traffic Signals** may promote physical activity by slowing down traffic.