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Geographic variation in the relationship between body mass index and the built environment

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Abstract

Studies examining associations between weight status and neighborhood built environment (BE) have shown inconsistent results and have generally focused on urban settings. However, many Americans do not live in metropolitan areas and BE impacts may be different outside of metropolitan areas. We sought to examine whether the relationship between body mass index (BMI) and neighborhood BE exists and varies by geographic region across small towns in the United States. We conducted telephone surveys with 2,156 adults and geographic information systems data in nine towns located within three geographic regions (Northeast, Texas, Washington) in 2011 and 2012. Multiple regression models examined the relationship between individual BMI and BE measures. Most physical activity variables were significantly associated with lower BMI in all geographic regions. We saw variation across geographic region in the relationship between characteristics of the BE variables and BMI. Some perceived and objectively-measured characteristics of the BE were significantly associated with adult BMI, but significant relationships varied by geographic region. For example, in the Northeast, perceived attractiveness

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of the neighborhood as a reason for why they chose to live there was associated with lower BMI; in Texas, the perceived presence of a fast food restaurant was negatively associated with BMI; in Washington, perceived presence of trees along the streets was associated with lower BMI. Our findings suggest that regional variation plays a role in the relationship between adult BMI and BE characteristics in small towns. Regardless of geographic location, interventions should encourage utilitarian walking and other forms of physical activity.

Introduction

Research on the relationship between the built environment (BE) and indicators of health such as body mass index (BMI) have generally focused on metropolitan areas (cities and suburbs) within one specific geographic location. For example, a New York City study found that higher access to neighborhood parks and higher park cleanliness were both associated with lower adult BMI.(1) Another New York City study found a relationship between certain aspects of the BE – having proximal sidewalk cafés, landmark buildings, and street trees being associated with lower BMI; proportion of cleaner streets being associated with higher BMI.(2) Some of these relationships were expected; some were unexpected.

Other studies of metropolitan areas that have found significant relationships between the BE and BMI include locations such as Atlanta and the metropolitan areas in Texas. Higher land-use mix around one’s home was associated with lower BMI among Atlanta, Georgia residents.(3) Higher intersection density (street connectivity), higher number of private exercise facilities around the home and workplace, and shorter distance to the closest city center, was associated with lower BMI in metropolitan areas of Texas.(4)

However, many Americans do not live in metropolitan areas and BE impacts may be different outside of metropolitan areas. Among the most recent available (2015) list of principal cities of metropolitan and micropolitan statistical areas, almost half – 45.8% (N=579) – of the cities listed were in micropolitan statistical areas.(5) Compared to rural and urban areas, small towns may offer a different mix of land use or density including BE destinations for physical activity such as parks and recreational areas that could affect BMI. Alternatively, compared to urban areas, small towns require a higher reliance on cars and may offer more limited BE opportunities for active travel (walking or cycling) to a destination.(6) The comparisons of the relationship between BE and BMI to date have primarily focused on the comparison of urban to rural areas. They have also been limited to youth.(7–9) Further, the findings regarding BE and BMI have been inconsistent and these relationships may differ in different parts of the country.

In addition to geographic location limitations, the studies regarding the relationship between the BE and BMI to date have inconsistently controlled for individual factors known to be associated with BMI. Some studies controlled for some socioeconomic characteristics,(1, 3, 4, 10–17) comorbidities,(10, 11, 15) and health status.(1, 11, 12) Some have included behaviors associated with weight status such as physical activity.(4, 12, 14, 15, 18) However, few studies have included other behaviors associated with weight status such as screen time(18) and food consumption.(15, 18)

We had a unique opportunity to examine perceived and objective BE characteristics of nine small towns among adults living in three regions of the country: Washington, Texas, and the Northeast. We sought to determine if the relationship between BMI and characteristics of the BE is similar or varies based on geographic region. This question has important implications for the generalizability of findings and local policy decisions regarding land use planning in the context of public health initiatives. In consideration of other factors related to BMI we controlled for participant characteristics and behaviors including socio-demographic factors (age, gender, income, education) and lifestyle characteristics (physical activity, screen time, consuming meals away from home).

Methods

In 2011 and 2012 we conducted cross-sectional survey and geographic data collection for 2,156 adults collected living in nine small towns located within micropolitan statistical areas in three distinct geographic regions of the United States, Washington, Texas and the Northeast (New Hampshire and New York). The study was approved by human subjects review committees from the University of Washington, Dartmouth College, and Texas A&M University.

Participant Recruitment

Sampling and recruitment is described in more detail in Doescher et al.(20) The survey, available in either English or Spanish, was conducted by telephone using trained telephone interviewers over four months in 2011.(20) Eligibility criteria included age 18 or older, residing at the address for at least 1 year, and being able to walk without special equipment for 5 minutes. A total of 2,152 surveys were completed (ranging from 217 to 303 per town) for a total response rate of 18.8% of the potentially reachable numbers (excluding invalid or out-of-scope numbers such as business numbers). Excluding unreachable persons (e.g., no answer or answering machine) in addition to the invalid or out-of-scope numbers, the response rate was 29.5%. All participants provided informed consent and were offered $10 Visa gift cards in appreciation for their time.

Outcome measure: BMI

BMI, calculated from reported height and weight, was treated as a continuous variable. Of the 2152 surveys, 127 had missing BMI data. The final sample size of complete BMI data was 2025 (Table 1). As described below, the multivariate analysis excludes 21 subjects with BMI less than 18.

Individual characteristics and behaviors

Survey questions were based on existing surveys from peer-reviewed research including the Walkable and Bikable Communities Project survey,(21) with some improvements to items based on past experience; some walking items were derived from the International Physical Activity Questionnaire.(22) Other sources included the Neighborhood Environment Walkability Scale,(23) the National Health Interview Survey, the Behavioral Risk Factor Surveillance System survey,(24) and the Rural Active Living Perceived Environment Support Scale.(25) Other survey-based data included gender, age, education, annual household income, hours spent per week watching television or other screens, meals per week eaten out, and multiple measures of physical activity. To calculate utilitarian walking, we used the responses to questions that asked how many times in the past month respondents walked from their homes to specific destinations such as grocery stores, banks, and restaurants, and how many minutes those walking trips lasted. To calculate recreational walking, we used the responses to the questions that asked how many times in the past month respondents walked at recreational locations such as neighborhood streets, trails and malls, and how many minutes these walking trips lasted. For analyses, minutes of walking per week were categorized into 0 minutes, 1–149 minutes, or 150 or more. Missing data on income were imputed into the median category of the study sample.

Perceived BE characteristics

We used the survey to capture people's perception of the attractiveness and other features of their neighborhood such as having trees along the streets, and the presence or absence of specific destinations. For a variety of potential non-residential destinations, we asked, "Is there a [destination] within a 20-minute walk from your home?" Destinations included: convenience store, grocery store, fast food, coffee place, shopping center or mall, bank or credit union, post office, bus stop, park or natural area.

Objective BE characteristics

Objective BE data were developed for each town based on existing local data available within a Geographic Information System (GIS) and additional BE data from aerial photos, on-line maps (Google Maps, Bing Maps), websites (town, county, listers/assessors, tourism, recreational, transportation), and local knowledge.(26) We developed GIS measures in the following domains: generalized land use (e.g., residential, commercial), destination land use (e.g., stores, banks, schools, parks), density (e.g., residential, employment), transportation system (e.g., streets, sidewalks, crosswalks, public transit), economic environment (e.g., property value), regional location (in relation to the central business district), and natural environment.(26) All buffer-based measurements (e.g. total number of banks, average residential unit density) were taken from a 1 km street-network "sausage" buffer(27) around each survey respondent's home. All proximity measures (e.g. distance to the closest park) were measured along the road network and limited to 2 km from respondents' homes.

To represent the proximal presence or absence of a specific destination, we created a dichotomous variable (coding scheme: 0 = absence within buffer; 1 = presence within buffer). Most of the destinations mentioned below (e.g., a park) are self-explanatory. We defined the measure of *dessert destinations in a buffer* as the number of stores and restaurants whose primary product for sale was a dessert (e.g., candy shop, donut shop, ice cream shop).

Statistical Analysis

Analysis was conducted using Stata.(28) We used multiple regression models to examine the relationship between BE characteristics and body mass index controlling for gender, age, race, education, income, physical activity, sedentary activity, and eating out. Age was represented both as a continuous variable and as an age-squared term to examine a possible non-linear relationship.(15) We had tested for a town-level clustering effect however it was not significant, so we did not perform mixed-effects modeling in the multivariate models. We created models for each region that combined the small towns within each region. We initially created a base model of the individual factors that included any variable that was statistically significant ($p<0.05$) in any region. Variables were only excluded if they were not significant in any of the three regions. We used the same base models for each region. The final base models of these individual factors are shown in Table 2. To develop the confirmed base models, we used a stepwise procedure that led to dropping the following variables because they were not statistically significant: ethnicity, race, marital status, employment status, number of children. With the confirmed base models, we then performed a one-by-one test for each of the BE variables to identify the statistically significant variables. We then identified significant variables by testing groups of variables in each BE domain. Finally, all significant variables that maintained statistical significance in the previous steps were entered together into the final multivariate models, and final models were developed. Therefore, after starting with 17 socioeconomic and other individual characteristic variables, 41 subjective environmental variables, and 202 objective environmental variables, through the process described above, five socioeconomic and other individual characteristic variables, 33 subjective environmental variables, and 198 objective environmental variables were dropped due to lack of statistical significance, multicollinearity, and conceptual consideration. Three separate final models were then developed for the three regions. Starting with the full sample size of 2025 (Table 1), as we added models to the regression model we had a decrease in the number of observations included (listwise deletion; Tables 2 and 3). The regression models shown in Tables 2 and 3 also exclude subjects with BMI lower than 18.

Results

Among the 2,025 respondents, the mean BMI was 27.0 (standard deviation 5.3, range 14.8–54.8). With the sample that excluded subjects with BMI less than 18, the mean BMI was 27.1 (standard deviation 5.2, range 18–54.8). Other sample characteristics across the full sample and by region are described in Table 1. Across all regions, adding both perceived and objectively-measured characteristics of the BE increased the R-squared values from the base model to the final model. In the Northeast, the R-squared value increased by 0.0317, in Texas it increased by 0.0530, and in Washington it increased by 0.0406.

Most physical activity variables, including more utilitarian walking and non-walking physical activity, were significantly associated with lower BMI in all geographic regions (Tables 2 and 3). Difficulty in walking was associated with higher BMI in all geographic regions (Tables 2 and 3). More recreational walking was significantly associated with higher BMI in the Northeast and in Washington, whereas it was associated with lower BMI in Texas (Tables 2 and 3). Meals out and sedentary activity were significantly associated with higher BMI in the Northeast only (Tables 2 and 3). Age had a non-linear (e.g., upside down U-shape) relationship with body mass index; as age increased, body mass index was positively associated until middle age and then negatively associated thereafter.

Some perceived and objectively-measured characteristics of the BE were significantly associated with adult BMI, but significant relationships varied by geographic region (Table 3):

- In the Northeast, perceived attractiveness of the neighborhood as a reason for why they chose to live there was associated with lower BMI; perceived presence of unattended dogs and a park or natural recreation area were associated with higher BMI. None of the objective neighborhood BE measures were significantly related to BMI among Northeast residents.
- In Texas, among the perceived BE measures, the presence of a fast food restaurant was negatively associated with BMI and the presence of a religious institution was positively associated with BMI. From the objective BE measures, both greater percentage of single family residential land use and median single family home values were associated with lower BMI; presence of proximal dessert destinations was associated with higher BMI.
- In Washington, perceived presence of trees along the streets, a grocery store/supermarket, and trails/paths/running tracks in one's neighborhood were associated with lower BMI. From the objective BE measures, only the variable of slope, steeper (>5% or >1:20) mean slope of the buffer area was associated with lower BMI.

We did not find any characteristics of one's home neighborhood BE that were significantly associated with one's BMI across all three regions. We also conducted a sensitivity analysis to determine if excluding two key behavioral variables associated with BMI (physical activity, meals eaten out) would change the observed relationships between the BE characteristics and BMI. Excluding meals out and physical activity did not change the directionality, magnitude, or significance of the relationships between the BE variables and BMI except in one instance whereby in Texas the destination variable of religious institution became less significant (p=0.078).

Discussion

Our findings suggest that while BE characteristics are associated with BMI in adults, these relationships between BMI and both perceived and objective characteristics of one's neighborhood BE varied and were non-overlapping across geographic region, despite similar methodologies for measuring perceived and objective neighborhood BE across these regions. This observed variation could help explain the inconsistent findings comparing studies that have studied the relationship between BMI and the BE in single geographic areas. Another possibility is small towns are highly heterogeneous and will not likely respond to a one-size-fits-all intervention approach regarding environmental approaches toward reducing BMI. Within the NE and WA regions we saw more perceived environment correlates of BMI, with slope being the only objective environment correlate of BMI in the WA region and none of the examined objective environment correlates in NE. In contrast, the TX region findings suggested numerous correlates from both objective and perceived BE constructs. Further studies need to examine if this variation also occurs in rural areas and/or urban areas across different regions. This regional variation may explain why interventions to address obesity have had inconsistent results. It may also explain why some studies have found a relationship between the BE and BMI and others have not. Our study was unique in that it focused on towns in micropolitan counties rather than more isolated rural nonmetropolitan areas or more highly urbanized metropolitan locations.

In the Northeast, most of our significant findings were in the expected direction. Expected significant associations with lower BMI included: utilitarian walking, income, physical activity excluding walking, choosing to live in a neighborhood because of its attractiveness. Expected significant associations with higher BMI included: difficulty walking, screen time, meals out, unattended dogs being a problem in the neighborhood. We saw two unexpected significant associations with higher BMI: recreational walking and perceiving the presence of a park or natural recreation area. We did not see any unexpected significant associations with lower BMI.

In Texas, most of the significant findings were in the expected direction. Expected significant associations with lower BMI included: utilitarian walking, education, physical activity excluding walking, recreational walking, greater percentage of single family residential land use, higher median appraised value of single family residential parcels. Expected significant associations with higher BMI included: difficulty walking, presence of dessert destinations. We saw an unexpected significant association with lower BMI: perceived presence of a fast food restaurant.

In Washington, all the significant findings were in the expected direction. Expected significant associations with lower BMI included: utilitarian walking, income, physical activity excluding walking, perception of having trees along one's neighborhood, perceived presence of a grocery store or supermarket, perceived presence of a trail, path, or running track; higher mean slope of the natural environment. Expected significant associations with higher BMI included: difficulty walking and recreational walking. We did not see any unexpected significant associations with BMI in either direction.

Study limitations and strengths

This study was limited by sample size; larger studies may find that additional factors might matter in a location. This study was limited in being cross sectional; we do not know the directionality of these relationships. Longitudinal studies could help us determine if a change such as adding trees along the street in a neighborhood and adding a grocery store or supermarket could contribute to lower body mass index in all or only some parts of the United States. The limited longitudinal studies to date that have examined impacts of environmental changes have had mixed results. Some studies have not found a relationship between BE and BMI over time. For example, a longitudinal study of older women living in the Portland, Oregon area did not find a change in BMI after changes in the neighborhood BE.(29) Another non-intervention, but longitudinal study of urban adults living in six locations across the country found that increased density of walking destinations and population density, combined with lower percent residential development over time were associated with increases in BMI, whereas increases in percent retail, street connectivity, and increased distances to bus transportation were not associated with changes in BMI.(30) In contrast, a study of older women living in California, Massachusetts, and Pennsylvania found that density of physical activity facilities were associated with lower odds of overweight and obesity.(31) Another study of adult males living in South Wales concluded that higher density of retail land use, churches, and recreation and leisure facilities lowered BMI over time.(10)

This study was also not representative of the entire country. However, these three regions offer adequate diversity in their BE characteristics and in their demographics to suggest that regional differences matter. Another limitation is that height and weight used to calculate BMI, as well as behaviors such as physical activity were self-reported. However, we do not have a reason to believe that reporting of physical activity would be differentially biased by geographic location. Similarly, subjective perceptions of the BE such as whether trees exist in one's neighborhood could be subject to bias. However, it was not feasible to gather objective data on BMI and behavioral variables for this multi-region study, and we did consider objective measures of the BE derived from GIS. Further, we do not have a reason to believe that residents who live in one part of the country would vary in their reporting or perception of BE characteristics compared to residents in another part of the country.

We were also unable to control for all possible confounding variables, such as overall diet quality, although we did have a measure of frequency of meals eaten out per week and the sensitivity analysis suggested consistency in the observed significant environmental factors related to BMI. We did not examine all possible BE variables and did not look at combination of BE factors. Our measures included some aspects of the BE environment that people can use for outdoor recreation, including availability of a trail, path, park/natural recreation area, and mean slope within the buffer. Future studies could look at additional aspects of the BE environment related to outdoor recreation. For example, one study, which used county-level data across the United States, found that temperature and light mattered for weight status: they saw higher levels of obesity in areas that were hot in July and cold in January, and in areas that were dark or rainy in January.(32) They found that wind, trees, waterfront, hills, and mountains when considered on a county level were not associated with obesity.(32) Among the BE environment factors related to outdoor recreation that we were able to measure, we found that mean slope was associated with lower BMI only in Washington, a trail/path/running track was associated with lower BMI also only in Washington, and a park or natural recreation area was associated with higher BMI only in the Northeast.

Conclusion

The relationship between adult BMI and the BE is complex. Our findings suggest that regional variation plays a role in the relationship between adult BMI and characteristics of the BE in small towns. Among the significant BE variables, more of them represented perceptions of the BE rather than the actual/measured environment. Further, among the actual/measured BE variables, some cannot be easily changed (e.g., slope of land). Therefore, future studies are also needed to determine the extent to which perceptions of the BE may be changed, and if those changes would help to lower BMI in all or only some regions of the United States. Our study also suggests that future policies and interventions should encourage utilitarian walking and other forms of physical activity regardless of geographic location. This suggestion is consistent with the current Surgeon General's *Call to Action to Promote Walking and Walkable Communities*.(33) In our study, utilitarian walking was associated with lower BMI across all regions, and this relationship was statistically significant in the Northeast and in Washington. Finally, our findings should serve as a reminder to physicians and other health providers that adults who have difficulty in walking need support in overcoming their barriers to physical activity regardless of geographic location.

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Highlights

- Focused on towns in micropolitan counties rather than metropolitan areas.
- The relationship between body mass index and the built environment varies by region.
- Regardless of location, interventions should encourage utilitarian walking.
- Regardless of location, adults with barriers to walking need support.

Table 1

Descriptive Statistics. Data collected in 2011 and 2012.

Variable	Total		Northeast		Texas		Washington	
	Freq. or Mean	% or S.D.	Freq. or Mean	% or S.D.	Freq. or Mean	% or S.D.	Freq. or Mean	% or S.D.
Total	2,025	100	693	100	682	100	650	100
Body Mass Index (BMI)								
	26.97	5.26	26.39	5.18	26.91	5.20	27.63	5.35
Gender								
Male	813	40.15	273	39.39	275	40.32	265	40.77
Female	1,212	59.85	420	60.61	407	59.68	385	59.23
Age	57.82	15.57	57.63	13.64	60.47	15.89	55.24	16.53
Age squared	3584.84	1770.29	3511.78	1595.77	3909.35	1832.14	3324.03	1830.81
Race								
Non-white	307	15.16	46	6.64	135	19.79	126	19.38
White	1,718	84.84	647	93.36	547	80.21	524	80.62
Education								
(5-categories coded 1–5; treated as continuous)	3.32	1.19	3.47	1.18	3.38	1.17	3.08	1.18
Income								
(9-categories coded 1–9; treated as continuous)	5.41	2.01	5.68	2.03	5.55	1.90	4.97	2.03
Screen Time (Hours/week)	16.80	13.56	15.82	13.02	18.16	14.35	16.43	13.18
Meals Out (Meals/week)								
0	419	20.95	145	21.14	96	14.31	178	27.68
1	472	23.60	171	24.93	129	19.23	172	26.75
2 – 3	626	31.30	212	30.9	233	34.72	181	28.15
4+	483	24.15	158	23.03	213	31.74	112	17.42
Difficulty walking								
Not at all	1,859	91.80	642	92.64	629	92.23	588	90.46
Somewhat difficult	166	8.20	51	7.36	53	7.77	62	9.54
Physical activity excluding walking	3.09	2.28	3.24	2.25	2.91	2.29	3.12	2.29
Recreational walking (min/week) (3-cat)								

Variable	Total		Northeast		Texas		Washington	
	Freq. or Mean	% or S.D.	Freq. or Mean	% or S.D.	Freq. or Mean	% or S.D.	Freq. or Mean	% or S.D.
0	413	20.40	114	16.45	167	24.49	132	20.31
1 – 149	1,050	51.85	353	50.94	365	53.52	332	51.08
150+	562	27.75	226	32.61	150	21.99	186	28.62
Utilitarian walking (min/week) (3-cat)								
0	587	28.99	172	24.82	280	41.06	135	20.77
1 – 149	999	49.33	333	48.05	323	47.36	343	52.77
150+	439	21.68	188	27.13	79	11.58	172	26.46
Why to choose where to live: Attractiveness of the neighborhood								
Yes	1,712	84.54	589	84.99	595	87.24	528	81.23
No	283	13.98	88	12.70	85	12.46	110	16.92
Neighborhood Perception: There are trees along the streets in my neighborhood.								
Agree	1,888	93.23	657	94.81	647	94.87	584	89.85
Disagree	136	6.72	36	5.19	35	5.13	65	10.00
Neighborhood Perception: Unattended dogs are a problem in my neighborhood.								
Agree	311	15.35	53	7.65	116	17.01	142	21.84
Disagree	1,706	84.25	639	92.21	563	82.55	504	77.54
Presence of Destination: A grocery store or supermarket								
Yes	1,087	53.68	358	51.66	295	43.26	434	66.77
No	928	45.83	332	47.91	385	56.45	211	32.46
Presence of Destination: A fast food restaurant								
Yes	1,056	52.15	270	38.96	347	50.88	439	67.54
No	953	47.06	417	60.17	331	48.53	205	31.54
Presence of Destination: A trail, path, or running track								
Yes	1,360	67.16	524	75.61	395	57.92	441	67.85
No	645	31.85	161	23.23	285	41.79	199	30.62
Presence of Destination: A park or natural recreation area								
Yes	1,371	67.70	471	67.97	357	52.35	543	83.54
No	637	31.46	218	31.46	320	46.92	99	15.23

Variable	Total		Northeast		Texas		Washington	
	Freq. or Mean	% or S.D.	Freq. or Mean	% or S.D.	Freq. or Mean	% or S.D.	Freq. or Mean	% or S.D.
Presence of Destination: A religious institution								
Yes	1,459	72.05	508	73.30	435	63.78	516	79.38
No	549	27.11	183	26.41	241	35.34	125	19.23
Percentage of Single Family Residential Land Use: (Total area of residential, single family within buffer/Buffer area)*100								
	36.59	13.61	35.55	15.23	39.02	13.32	35.12	11.66
Destination (individual): Presence of dessert destinations within buffer (1+ vs. 0, ref.)								
0	1,632	80.59	581	83.84	562	82.40	489	75.23
1+	372	18.37	91	13.13	120	17.60	161	24.77
Economic Environment: Median appraised value of single family residential parcels within buffer (log-transformation)								
	11.68	0.52	11.89	0.43	11.46	0.65	11.70	0.31
Natural Environment: Mean slope within buffer (5.1+ vs. 0 – 5.0, ref.)								
0 – 5.0	1,520	75.06	295	42.57	682	100.00	543	83.54
5.1+	484	23.9	377	54.40	0	0.00	107	16.46

Table 2

Base models of for each region. Data collected in 2011 and 2012.

Northeast region Obs.: 623 | F (15, 607): 10.50 | Adj-R^2: 0.1863 | AIC: 3710.700 | BIC: 3781.653

Texas region Obs.: 606 | F (15, 590): 9.41 | Adj-R^2: 0.1725 | AIC: 3606.610 | BIC: 3677.120

Washington region Obs.: 581 | F (15, 565): 4.30 | Adj-R^2: 0.0786 | AIC: 3568.307 | BIC: 3638.143

Variables		Northeast Region				Texas Region				Washington Region			
		Coef.	P-value	95% Conf. Interval		Coef.	P-value	95% Conf. Interval		Coef.	P-value	95% Conf. Interval	
				Lower	Upper			Lower	Upper			Lower	Upper
Gender (Female vs. Male, ref.)		−1.376**	0.001	−2.154	−0.599	−1.289**	0.002	−2.086	−0.492	−0.647	0.148	−1.526	0.231
Age (Continuous)		0.327**	0.000	0.149	0.506	0.491**	0.000	0.337	0.646	0.258**	0.001	0.100	0.416
Age^2 (Continuous)		−0.003**	0.000	−0.005	−0.001	−0.005**	0.000	−0.006	−0.003	−0.003**	0.000	−0.004	−0.001
Education (5-categories coded 1–5; treated as continuous)		−0.340	0.059	−0.693	0.014	−0.634**	0.001	−1.000	−0.268	0.185	0.376	−0.225	0.595
Income (9-categories coded 1–9; treated as continuous)		−0.464**	0.000	−0.687	−0.240	0.015	0.897	−0.219	0.250	−0.384**	0.002	−0.624	−0.144
Screen time (hours/week)		0.043**	0.005	0.013	0.072	0.016	0.225	−0.010	0.043	0.026	0.125	−0.007	0.059
Meals Out (meals/week)	0		(Reference group)				(Reference group)				(Reference group)		
	1	0.525	0.357	−0.593	1.642	−0.756	0.263	−2.081	0.569	−0.209	0.729	−1.390	0.973
	2 – 3	1.948**	0.001	0.848	3.048	0.277	0.655	−0.938	1.492	−0.214	0.717	−1.374	0.946
	4+	1.514*	0.011	0.342	2.685	0.832	0.191	−0.416	2.080	0.389	0.561	−0.924	1.702
Difficulty walking (Somewhat difficult, very difficult, do not do this activity vs. Not at all or a little difficult, ref.)		3.349**	0.000	1.851	4.848	2.781**	0.000	1.288	4.273	3.290**	0.000	1.795	4.784
Physical Activity (Excluding walking, how many days in a typical week do you get at least 30 minutes of physical activity? Days/week)		−0.350**	0.000	−0.523	−0.177	−0.221*	0.012	−0.393	−0.049	−0.217*	0.024	−0.406	−0.028
Recreational walking (min/week)	0		(Reference group)				(Reference group)				(Reference group)		
	1 – 149	1.460*	0.013	0.307	2.612	−0.495	0.316	−1.464	0.474	0.537	0.374	−0.650	1.724

Northeast region Obs.: 623 | F (15, 607): 10.50 | Adj-R^2: 0.1863 | AIC: 3710.700 | BIC: 3781.653

Texas region Obs.: 606 | F (15, 590): 9.41 | Adj-R^2: 0.1725 | AIC: 3606.610 | BIC: 3677.120

Washington region Obs.: 581 | F (15, 565): 4.30 | Adj-R^2: 0.0786 | AIC: 3568.307 | BIC: 3638.143

Variables		Northeast Region				Texas Region				Washington Region			
		Coef.	P-value	95% Conf. Interval		Coef.	P-value	95% Conf. Interval		Coef.	P-value	95% Conf. Interval	
				Lower	Upper			Lower	Upper			Lower	Upper
	150+	0.673	0.311	−0.630	1.976	−1.297*	0.032	−2.480	−0.113	1.552*	0.031	0.138	2.966
Utilitarian walking (min/week)	0	(Reference group)				(Reference group)				(Reference group)			
	1 – 149	−1.449**	0.003	−2.419	−0.480	−0.204	0.640	−1.059	0.652	−0.721	0.241	−1.927	0.485
	150+	−1.822**	0.002	−2.979	−0.666	−1.274	0.070	−2.654	0.106	−1.891**	0.011	−3.344	−0.437

*: $p<0.05$/

**: $p<0.01$

Table 3

Final models for each region. Data collected in 2011 and 2012.

Northeast region Obs.: 606 | F (18, 587): 10.36 | Adj-R^2: 0.2179 | AIC: 3595.717 | BIC: 3679.448

Texas region Obs.: 599 | F (20, 578): 9.70 | Adj-R^2: 0.2255 | AIC: 3533.998 | BIC: 3626.299

Washington region Obs.: 569 | F (19, 549): 5.05 | Adj-R^2: 0.1192 | AIC: 3472.133 | BIC: 3559.010

Variables		Northeast Region				Texas Region				Washington Region			
		Coef.	P-value	95% Conf. Interval		Coef.	P-value	95% Conf. Interval		Coef.	P-value	95% Conf. Interval	
				Lower	Upper			Lower	Upper			Lower	Upper
Gender (Female vs. Male, ref.)		−1.403**	0.000	−2.189	−0.618	−1.251**	0.002	−2.031	−0.470	−0.995*	0.027	−1.875	−0.114
Age (Continuous)		0.324**	0.000	0.145	0.503	0.454**	0.000	0.302	0.606	0.297**	0.000	0.141	0.453
Age^2 (Continuous)		−0.003**	0.000	−0.005	−0.001	−0.004**	0.000	−0.006	−0.003	−0.003**	0.000	−0.005	−0.002
Education (5-categories coded 1–5; treated as continuous)		−0.288	0.116	−0.646	0.071	−0.417*	0.028	−0.789	−0.045	0.198	0.341	−0.209	0.605
Income (9-categories coded 1–9; treated as continuous)		−0.354**	0.003	−0.584	−0.123	0.115	0.333	−0.118	0.348	−0.380**	0.002	−0.619	−0.141
Screen time (hours/week)		0.046**	0.002	0.016	0.075	0.020	0.125	−0.006	0.046	0.027	0.108	−0.006	0.060
Meals Out (meals/week)	0		(Reference group)				(Reference group)				(Reference group)		
	1	0.617	0.282	−0.508	1.742	−0.673	0.308	−1.968	0.623	0.001	0.998	−1.175	1.177
	2 – 3	2.032**	0.000	0.926	3.138	0.312	0.607	−0.879	1.504	0.084	0.886	−1.064	1.232
	4+	1.634**	0.006	0.462	2.806	0.903	0.147	−0.317	2.123	0.920	0.170	−0.394	2.235
Difficulty walking (Somewhat difficult, very difficult, do not do this activity vs. Not at all or a little difficult, ref.)		3.208**	0.000	1.718	4.699	2.705**	0.000	1.226	4.185	3.138**	0.000	1.631	4.645
Physical Activity (Excluding walking, how many days in a typical week do you get at least 30 minutes of physical activity? Days/week)		−0.354**	0.000	−0.528	−0.180	−0.205*	0.017	−0.372	−0.037	−0.223*	0.020	−0.411	−0.035
Recreational walking (min/week)	0		(Reference group)				(Reference group)				(Reference group)		
	1 – 149	1.801**	0.003	0.628	2.975	−0.449	0.353	−1.398	0.500	0.931	0.124	−0.257	2.119

Northeast region Obs.: 606 | F (18, 587): 10.36 | Adj-R^2: 0.2179 | AIC: 3595.717 | BIC: 3679.448

Texas region Obs.: 599 | F (20, 578): 9.70 | Adj-R^2: 0.2255 | AIC: 3533.998 | BIC: 3626.299

Washington region Obs.: 569 | F (19, 549): 5.05 | Adj-R^2: 0.1192 | AIC: 3472.133 | BIC: 3559.010

Variables		Northeast Region				Texas Region				Washington Region			
		Coef.	P-value	95% Conf. Interval		Coef.	P-value	95% Conf. Interval		Coef.	P-value	95% Conf. Interval	
				Lower	Upper			Lower	Upper			Lower	Upper
	150+	0.831	0.216	−0.486	2.148	−1.204 *	0.043	−2.369	−0.038	2.324 **	0.001	0.898	3.751
Utilitarian walking (min/week)	0	(Reference group)				(Reference group)				(Reference group)			
	1 – 149	−1.618 **	0.001	−2.605	−0.631	−0.301	0.482	−1.141	0.539	−0.995	0.113	−2.226	0.236
	150+	−2.006 **	0.001	−3.186	−0.826	−1.579 *	0.022	−2.932	−0.227	−2.105 **	0.006	−3.590	−0.621
Subjective Environment variables													
Why to choose where to live	Attractiveness of the neighborhood	−2.315 **	0.000	−3.465	−1.165								
Neighborhood Perception	There are trees along the streets in my neighborhood.									−1.824 *	0.015	−3.295	−0.354
	Unattended dogs are a problem in my neighborhood.	1.919 **	0.008	0.505	3.332								
Presence of Destination	A grocery store or supermarket									−1.423 **	0.003	−2.351	−0.494
	A fast food restaurant					−1.692 **	0.000	−2.511	−0.873				
	A trail, path, or running track									−1.291 **	0.008	−2.240	−0.343
	A park or natural recreation area	1.094 *	0.011	0.249	1.938								
	A religious institution					0.978 *	0.025	0.124	1.832				
Objective Environment variables													

Northeast region Obs.: 606 | F (18, 587): 10.36 | Adj-R^2: 0.2179 | AIC: 3595.717 | BIC: 3679.448

Texas region Obs.: 599 | F (20, 578): 9.70 | Adj-R^2: 0.2255 | AIC: 3533.998 | BIC: 3626.299

Washington region Obs.: 569 | F (19, 549): 5.05 | Adj-R^2: 0.1192 | AIC: 3472.133 | BIC: 3559.010

Variables		Northeast Region				Texas Region				Washington Region			
		Coef.	P-value	95% Conf. Interval		Coef.	P-value	95% Conf. Interval		Coef.	P-value	95% Conf. Interval	
				Lower	Upper			Lower	Upper			Lower	Upper
Percentage of Single Family Residential Land Use	(Total area of residential, single family within buffer/Buffer area) *100					−0.041 *	0.010	−0.072	−0.010				
Destination (individual)	Presence of dessert destinations within buffer (1+ vs. 0, ref.)					1.318 *	0.012	0.292	2.343				
Economic Environment	Median appraised value of single family residential parcels within buffer (log-transformation)					−1.091 **	0.003	−1.796	−0.385				
Natural Environment	Mean slope within buffer (5.1+ vs. 0 – 5.0, ref.)									−1.557 *	0.012	−2.772	−0.343

* p<0.05

** p<0.01