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Body Mass Index, Safety Hazards, and Neighborhood Attractiveness

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Abstract

Background—Neighborhood attractiveness and safety may encourage physical activity and help individuals maintain a healthy weight. However, these neighborhood characteristics may not be equally relevant to health across all settings and population subgroups.

Purpose—To evaluate whether potentially attractive neighborhood features are associated with lower BMI, whether safety hazards are associated with higher BMI, and whether environment–environment interactions are present such that associations for a particular characteristic are stronger in an otherwise supportive environment.

Methods—Survey data and measured height and weight were collected from a convenience sample of 13,102 adult New York City (NYC) residents in 2000–2002; data analyses were completed 2008–2012. Built-environment measures based on municipal GIS data sources were constructed within 1-km network buffers to assess walkable urban form (density, land-use mix, transit access); attractiveness (sidewalk cafés, landmark buildings, street trees, street cleanliness); and safety (homicide rate, pedestrian–auto collision and fatality prevalence). Generalized linear models with cluster-robust SEs controlled for individual and area-based sociodemographic characteristics.

Results—The presence of sidewalk cafés, density of landmark buildings, and density of street trees were associated with lower BMI, whereas the proportion of streets rated as clean was associated with higher BMI. Interactions were observed for sidewalk cafés with neighborhood poverty and walkability, for street-tree density with walkability, and for street cleanliness with safety. Safety hazard indicators were not independently associated with BMI.

Conclusions—Potentially attractive community and natural features were associated with lower BMI among adults in NYC, and there was some evidence of effect modification.

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Introduction

The current high prevalence of obesity[1–3] represents a dramatic increase during recent decades that cannot be explained by genetics or other stable characteristics. One promising strategy is to promote physical activity and prevent obesity through modifications to the built environment.[5–7] Most built-environment and health studies focus on walkable urban form,[5,8,9] including features such as residential density, land-use mix, and street design. Safety and attractiveness may also encourage walking and promote healthy weight outcomes,[10,11] yet point-level objective (audit-based or GIS) measures of safety or attractiveness are not widely investigated as predictors of obesity.[8,12,13]

Neighborhood characteristics are often viewed simply as independent influences but may instead exhibit meaningful environment–environment interactions. Such interactions could take the form of an ordered hierarchy,[20] such that the presence of barriers at the most basic level would eliminate other associations. Once walkable urban form makes pedestrian transportation feasible, safety concerns may become salient for those residents who have a viable alternative to walking. Finally, attractiveness may become salient among people living in safe, walkable environments.

Alternatively, socially disadvantaged populations may experience multiple barriers to maintaining a healthy weight,[21] such that removing any one barrier has little effect; that is, an investment focused on any one built-environment characteristic may be ineffective if other barriers remain. This could make residents' lifestyles and ensuing obesity resistant to environmental intervention strategies until some threshold of cumulative opportunity has been reached. Both the hierarchy and the cumulative opportunity threshold models would suggest that an attractive built environment will be more influential in the absence of other barriers.

The current paper has two main objectives. The first is to examine the associations between neighborhood attractiveness and safety based on municipal GIS data sources and BMI using data from 13,102 adults in NYC. Potentially attractive features (landmark buildings, sidewalk cafés, street trees, and clean sidewalks) are hypothesized to predict lower BMI, and safety hazards (homicide or pedestrian–auto fatality prevalence) are hypothesized to predict higher BMI. The second objective is to examine interactions among neighborhood characteristics.

Methods

Subjects and Setting

The current analyses use an extensive geographic database and individual-level data from a previously described study.[15,22] Briefly, data were collected during baseline enrollment of subjects for the New York Cancer Project (NYCP) between January 2000 and December 2002. Research staff carried out extensive publicity and recruitment efforts throughout the five boroughs of NYC to recruit an ethnically and socioeconomically diverse convenience sample of 18,187 volunteers. Qualifications for enrollment included a minimum age of 30 years and a literacy level high enough to complete a follow-up questionnaire.

Anthropometric and Questionnaire Data

Data collection took place at six community-based health centers, two community hospitals, and six medical centers, and through the New York Blood Center. Weight and height were measured using clinical scales and rigid stadiometers available at the medical centers and hospitals. The analytic sample was restricted to individuals who had geocoded addresses falling within NYC boundaries (n=14,147), of whom 13,102 had complete data for objectively measured height and weight, a BMI less than 70, and questionnaire measures of key covariates: age, race and ethnicity, gender, and educational attainment. All study participants provided written informed consent in person. The Columbia University Medical Center IRB approved analyses of BMI, individual demographic variables, and appended neighborhood characteristics.

Neighborhood Composition and Built Environment

Participants' home addresses were geocoded using Geosupport, a software package developed by the NYC Department of City Planning. A network buffer was drawn around each address, tracing the areas that could be accessed within 1 kilometer in any direction along pedestrian-accessible streets. This size of network buffer was selected because of the relatively small territory typically covered on foot,[7,23] and the lack of correlation between perceived and objective measures of the built environment beyond 1 kilometer.[24,25] Previous work in this population[26] and others[27] supports the robustness of health associations to the range of common neighborhood definitions. These buffers were then intersected with GIS layers from the federal, state, and city governments to create each of the neighborhood characteristics described below, with efforts to maximize the temporal correspondence with BMI measurement in 2000–2002.

Potentially attractive built-environment features were selected from those previously found to distinguish high-poverty areas from low-poverty areas in NYC.[18] Locations of legally operating sidewalk cafés were obtained from the NYC Department of Consumer Affairs in 2006. Landmark buildings were included based on a designation before 2003 by the NYC Landmarks Preservation Commission. The density of street trees (based on a 2005–2006 street tree census) per square kilometer were estimated based on data from the NYC Department of Parks & Recreation. The proportion of streets and sidewalks rated as acceptably clean was available from Project Scorecard, conducted by the Mayor's Office of Operations, estimated within the 234 sanitation sections across NYC. The threshold used to define "acceptable" cleanliness was informed by Sanitation Department standards and public surveys; trained evaluation teams compared the observed litter to photographic standards.

Safety-hazard indicators included the prevalence of homicide and pedestrian–auto collision-related fatalities. Homicide locations for the year 2003 were collected from the NY Times website (projects.nytimes.com/crime/homicides/map/). Homicide prevalence was selected as the primary indicator of crime safety because of its spatial precision (in contrast to less-severe violent crimes, which are tracked at the precinct level), and because of expectations that homicide would be both correlated with less-severe criminal infractions and potentially salient in shaping safety perceptions. Locations of pedestrian–auto collisions resulting in injuries or fatalities in 2000–2002 were based on the nearest intersection as provided by Transportation Alternatives. The prevalence of pedestrian–auto fatalities was used as the primary indicator of traffic hazards to limit the potential bias from selective under-reporting of less-serious injuries.

Neighborhood composition (percentage poverty, black race, and Hispanic ethnicity) and population density (residents per square kilometer) variables were constructed using U.S. Census data for the year 2000, Summary File 3 at the block group level. Block groups were intersected with network buffers to create areal-weighted averages. Land-use mix was constructed using a parcel-level data set, the 2004–2005 Primary Land Use Tax Lot Output data, available from the Department of City Planning.

The numbers of bus and subway stops per square kilometer were from 2004 and 2007 NYC Metropolitan Transit Authority data, respectively (more-recent data were used for subway stops because of improved spatial alignment and because stop locations are relatively stable over time). A walkability index was constructed by summing *z*-scores for intersection density (unique street intersections per km^2, a measure of street connectivity); residential density (residential units per km^2); land-use mix (an entropy-based measure constructed from residential, educational, entertainment, retail, and office land uses); retail floor-area ratio (retail floor area per km^2); and subway-stop density (subway stations per km^2).[18,28,29] ArcGIS 9.3 was used for all geospatial analysis.

Statistical Analysis

Generalized linear models with cluster-robust SEs were used to evaluate associations with BMI. Robust SEs were used to account for clustering within United Hospital Fund (UHF) areas (health-reporting districts in NYC). The 42 UHF areas range in size from 3 to 67 km^2 and each area comprises four to ten ZIP codes. All models controlled for individual and area-based demographic and socioeconomic characteristics.

In an effort to facilitate comparisons across measures with very different units and distributions, predictor variables were dichotomized or rescaled. Both sidewalk cafés and landmark buildings were coded as present (1) or absent (0) for the primary analyses. The log-transformed densities (count of street trees or landmark buildings per square kilometer) were also evaluated as predictors of BMI among the subset with any locations present. All other predictors were rescaled to have a minimum value of 0 and an interquartile range of 1 for ease of comparison; the model coefficients for these variables may thus be interpreted as the expected BMI increase associated with moving from the 25^{th} percentile to the 75^{th} percentile of exposure.

Interactions were evaluated using Wald tests of an interaction term for a given built-environment characteristic across quartiles of the stratifying variable. A combined safety variable, created by adding the rescaled homicide and pedestrian fatality rates, was used for stratification and tests of interaction. All analyses were conducted in Stata 12.1 during the period from 2008 to 2012.

Results

The current study population included 13,102 adults, with a mean age of 46 years, of whom 65% were women, 37% were overweight, and 28% were obese. High poverty or high walkability neighborhood buffers (categorized based on a median split) were estimated to have more sidewalk cafés, landmark buildings, homicides, and pedestrian–auto fatalities (Table 1). Each potentially attractive built-environment feature was associated with BMI when added to a model with potential individual and neighborhood confounders (Table 2, first column).

Sidewalk cafés, landmark buildings, and street trees were each associated with lower BMI as hypothesized. In contrast, the proportion of streets rated as having an acceptable level of litter was associated with higher BMI. Secondary analyses using cleanliness ratings of sidewalks instead of streets were similar and significant (p=0.03). Most of these associations were attenuated when the attractiveness and safety characteristics were simultaneously entered into a single model (Table 2, last column). Sidewalk cafés and street trees remained significant in this mutually adjusted model.

Secondary analyses examined the density of sidewalk cafés or landmark buildings. Among 4,334 participants with a sidewalk café present, the log-transformed density of sidewalk cafés was associated with lower BMI, but this association was not significant when including all neighborhood characteristics as covariates. The log-transformed density of landmark buildings was associated with lower BMI among 7,234 participants with at least one landmark building in the 1-km network buffer, and the association remained significant in fully adjusted models (p=0.001). Neither safety-hazard indicator was associated with BMI (Table 2). Secondary analyses using a more inclusive indicator of traffic safety hazards, based on pedestrian–auto collisions resulting in injury or fatality, likewise showed no association with BMI (p=0.55).

Effect modification was examined for the observed associations between potentially attractive features or safety hazards and BMI (Figure 1). Sidewalk cafés had weaker associations with BMI in high poverty areas. The association between trees and BMI was stronger in areas with higher walkability. There was also an interaction between clean streets and safety, such that the BMI was lowest for areas that had few acceptably clean streets and low safety as indicated by high prevalence of homicides and pedestrian–auto fatalities. Homicide prevalence had a stronger association with BMI in the high- and low-poverty quartiles.

Discussion

After adjustment for individual and neighborhood sociodemographic characteristics, potentially attractive community and natural features were associated with lower BMI in this population of adult NYC residents. Contrary to expectation, street cleanliness ratings were associated with higher BMI, perhaps reflecting the role of pedestrians in generating litter. Safety-hazard indicators were not associated with BMI. Environment–environment interactions were observed.

Although no evidence was found to support the hypothesized link between safety hazards and BMI, this echoes the null findings of several previous studies of crime rate with BMI or obesity.[30,31] A previous study found an association between perceived safety and physical activity, despite the absence of a link between independently observed crime rates and physical activity.[10] Measures of perceived safety may incorporate aspects of the local environment that are not reflected in crime rates themselves, but they may also allow for information bias or social desirability bias. The interaction observed for safety with street cleanliness suggests another possible explanation for the discrepancy: reverse causation. Pedestrian traffic in areas with a more-active, lean population may contribute to both litter on the streets and the number of potential targets for pedestrian–auto fatalities.

The potentially attractive features measured in the current study incorporated aspects of social and commercial activity, architecture, natural landscape, and cleanliness. However, any one of these neighborhood characteristics may be serving as a proxy for an underlying cause, such as commercial investment or social and political power that is more directly linked to neighborhood selection or health behaviors.

Caution and attention to the perspective of local residents is warranted before using these associations to design a structural intervention.[41] Particularly when considering attractiveness, there may be important disagreement over what constitutes neighborhood improvement.[42,43] It was observed that the presence of sidewalk cafés was associated only with lower BMI within more-advantaged (low-poverty) neighborhoods, a trend which may reflect differences in the perceptions of and behavioral response to sidewalk cafés, if the association is indeed causal. Empirical analyses of effect modification, along with qualitative investigations[45–48] and participatory approaches,[49–51] can inform tailored and targeted approaches to addressing obesity and obesity-related health disparities.

Ecologic models informing research on the built environment and health have drawn attention to multiple built-environment characteristics with potential relevance to health.[52]

An important complement to this approach is to evaluate the potential for interactions.[5,6,8,21] Although several interactions were observed in this study, there was no clear hierarchy across the set of neighborhood built-environment characteristics. The interaction of street trees with walkability, however, parallels findings from a previous study that found an objectively measured vegetation index to be associated with lower BMI, but only within highly walkable neighborhoods (assessed by high accessibility to destinations).[53]

Key limitations include the absence of behavioral measures such as diet or physical activity and the observational and cross-sectional design with limited ability to control for neighborhood self-selection other than by incorporating sociodemographic characteristics. The study population consisted of adult residents of NYC, and results may not be generalizable to other settings. The analyses relied on residential address to define the neighborhood context, and were unable to incorporate other frequently visited locations or travel patterns that might be helpful in defining a more personalized neighborhood.[55]

Finally, residents’ perceptions of neighborhood attractiveness and safety were not examined, but may be shaped by unmeasured aspects of the environment and play an important role in determining behavior and health. In particular, less-serious crimes or injuries were not considered in the current characterization of neighborhood safety because of investigator concerns about limited spatial precision and potential bias from selective under-reporting in the available data on less-severe safety problems. Likewise, the indicators of attractiveness used in this analysis reflect data availability, and although they cover multiple potential domains of attractiveness, there may be unmeasured neighborhood characteristics such as commercial investment or social capital driving the observed associations rather than attractiveness itself.

Conclusion

Attractive community and natural features were associated with a lower BMI in this population of adult NYC residents. Street cleanliness and safety-hazard indicators were not robustly linked to BMI. Several neighborhood characteristics were observed to interact with each other. While investments in the built environment have the potential to reduce obesity and related health disparities, well-intentioned efforts may not have the anticipated health benefits if interactions across population subgroups and settings are not well understood.

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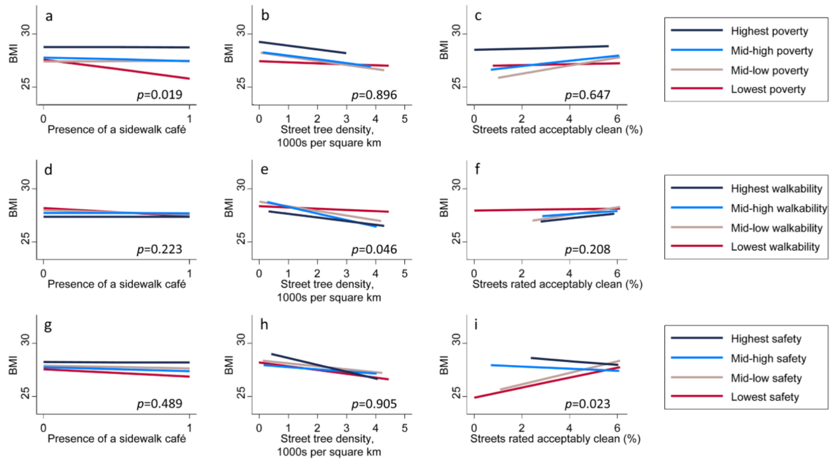

Figure 1.

Effect modification for the associations with BMI

Note: These fitted regression lines from stratified models are adjusted for individual race/ethnicity, gender, age, education as well as percentage poverty, percentage black, percentage Latino, and built-environment characteristics of the 1-kilometer network buffer (walkability index, potentially attractive features, and safety-hazard indicators); interaction *p*-values are from a joint significance test of interaction terms in an unstratified model.

Table 1

Characteristics of 1-kilometer network buffers for 13,102 participants

	Overall Median (p25, p75) or %	High poverty areas Median (p25, p75) or %	High walkability areas Median (p25, p75) or %	High safety areas Median (p25, p75) or %
Proportion of residents < poverty line	0.17 (0.09, 0.27)	0.27 (0.20, 0.35)	0.24 (0.16, 0.33)	0.10 (0.07, 0.17)
Walkability index	−0.1 (−1.8, 1.3)	0.6 (−0.5, 2.0)	1.1 (0.0, 2.8)	−1.3 (−2.9, 0.1)
Aesthetic characteristics				
Presence of a sidewalk café	33	3%	56	23
Presence of a landmark building	55	66	80	38
Street tree density, thousands per km^2	1.9 (1.4, 2.4)	1.6 (1.2, 2.0)	1.8 (1.4, 2.4)	2.0 (1.5, 2.5)
Percentage of streets rated acceptably clean	4.9 (4.5, 5.5)	4.6 (4.3, 4.9)	4.6 (4.3, 4.9)	5.4 (4.9, 5.8)
Safety-hazard indicators				
Homicides per 100,000 residents	3.4 (0.0, 9.9)	7.7 (3.0, 13.6)	5.9 (2.3, 11.6)	0.0 (0.0, 0.0)
Pedestrian–auto fatalities per 100,000 residents	1.5 (0.0, 3.0)	1.7 (0.7, 2.9)	1.9 (1.0, 3.0)	0.0 (0.0, 2.4)

Note: p25 and p75 indicate the 25^{th} and 75^{th} percentiles, respectively; areas with high poverty, walkability, or safety (based on low combined prevalence of homicide and pedestrian–auto fatality) were identified based on median split for characteristics of 1-kilometer network buffers

Table 2

Adjusted associations of aesthetic and safety characteristics with BMI

	Each aesthetic and safety variable in a separate model	All aesthetic characteristics in a single model	Both safety hazard indicators in a single model	All aesthetic and safety variables in a single mutually adjusted model
Aesthetic characteristics:				
Presence of a sidewalk café	−0.58 (−0.90 to −0.27)[a]	−0.34 (−0.59, −0.10) [a]		−0.35 (−0.58, −0.12) [a]
Presence of a landmark building	−0.36 (−0.67, −0.06) [a]	−0.20 (−0.46, 0.07)		−0.20 (−0.46, 0.06)
Street tree density, thousands per km^2	−0.39 (−0.60, −0.17) [a]	−0.32 (−0.46, −0.13) [a]		−0.33 (−0.52, −0.14) [a]
Percentage of streets rated acceptably clean	0.35 (0.13, 0.57)[a]	0.25 (0.05, 0.45)[a]		0.25 (0.04, 0.45)[a]
Safety-hazard indicators:				
Homicide prevalence (log- transformed)	−0.24 (−0.62, 0.13)		−0.24 (−0.62, 0.14)	−0.06 (−0.37, 0.25)
Pedestrian–auto fatality prevalence (log-transformed	−0.05 (−0.35, 0.25)		−0.03 (−0.32, 0.27)	0.10 (−0.13, 0.34)

[a] 95% CI excludes 0.00

Note: Values shown are regression coefficients and 95% CIs adjusted for individual race/ethnicity, gender, age, education as well as percentage poverty, percentage black, percentage Latino, and walkability of the 1-kilometer buffer; continuous variables have been rescaled so that 1 unit is equal to the interquartile range and regression coefficients can be interpreted as the difference in BMI for a contrast between neighborhoods at the 75^{th} and 25^{th} percentiles of the characteristic.