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Personal and Neighborhood Socioeconomic Status and Indices of Neighborhood Walk-ability Predict Body Mass Index in New York City

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Abstract

Past research has observed inverse associations between neighborhood and personal level measures of socioeconomic status and body mass index (BMI), but has not assessed how personal and neighborhood level measures might interact together to predict BMI. Using a sample of 13,102 adult residents of New York City who participated in a health survey, cross-sectional multi-level analyses assessed whether personal income, education and Zip code level poverty rates were associated with BMI. Demographic, income, education and objectively measured height and weight data were collected in the survey and poverty rates and the proportion of Black and Hispanic residents in the subject's Zip code were retrieved from the 2000 Census. Zip code level population density and land use mix, indices of neighborhood walk-ability which are often higher in lower income neighborhoods and are associated with lower BMI, were also measured. After controlling for individual and Zip code level demographic characteristics, increasing income was associated with lower BMI in women but not in men, and college and graduate level education was associated with lower BMI in both men and women. After control for income and individual and Zip code level demographic characteristics, higher Zip code poverty rate was unassociated with BMI. However, as expected, indices of neighborhood walk-ability acted as substantial inverse confounders in the relationship between Zip code poverty rate and BMI. After further adjustment for indices of neighborhood walk-ability, Zip code poverty rate became significantly, and positively associated with BMI in women. Among women, the inverse association between income and BMI was significantly stronger in richer compared to poorer Zip codes. In men and women, the association between college and graduate

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education and lower BMI was significantly stronger in richer versus poorer Zip codes. These analyses suggest that neighborhood socioeconomic context influences how personal socioeconomic status is measured to influence body size.

Keywords

income; education; environmental factors; body mass index (BMI); socioeconomic status (SES); neighborhood; USA; walking; exercise

Introduction

The United States faces an epidemic of overweight and obesity (Ogden, Carroll, Curtin, McDowell, Tabak, & Flegal, 2006). Analyses of NHANES data for 1999 to 2004 show that 32% of Americans over the age of 20 are obese (Ogden et al., 2006). The prevalence of overweight and obesity in the United States has been increasing since at least the mid-1970s (Briefel & Johnson, 2004; Ogden, Flegal, Carroll, & Johnson, 2002; Ogden, Troiano, Briefel, Kuczmarski, Flegal, & Johnson, 1997). Department of Health statistics show that New York City, our study site, likewise faces high rates of overweight/obesity (Thorpe, Mackenzie, Perl, Young, Hajat, Mostashari et al., 2003). While imbalances in calorie intake and expenditure are the most proximal causes of weight gain, there is a growing interest in identifying larger scale social and environmental forces that prompt dietary and physical activity behavior patterns.

A substantial literature finds an association between socioeconomic status and BMI. Analyses of the 2004 NHIS show that the prevalence of a healthy body weight increases with family income and education, with a particularly strong gradient across levels of education (Lethbridge-Cejku, Rose, & Vickerie, 2006). These associations may reflect a variety of factors including social norms, knowledge about the health effects of physical activity, diet, and weight, or access to recreational facilities and health foods. A 1989 review of 144 papers investigating associations between personal socioeconomic status and obesity found consistent and strong negative associations among women in developed countries, while associations among men were weaker (Sobal & Stunkard, 1989). A 2005 paper reviewed 34 longitudinal studies examining the relationship between socioeconomic status and weight change over time in developed countries. The reviews included studies using a wide variety of indices of socioeconomic status, and their results provide consistent evidence of a negative socioeconomic status-obesity relationship in developed countries, particularly among women (Ball & Crawford, 2005). A recent review following-up the work by Sobal and Stunkard assessed 333 reports and again found that higher socio-economic status was generally associated with lower BMI among women in developed countries (McLaren, 2007). The common interpretation of these findings is that the social stigma for being overweight is higher for women than men and that higher-income women use their resources to eat healthier and get more exercise.

Because individuals with higher socio-economic status tend to live in more affluent neighborhoods, it remains unclear whether the influence of socioeconomic status on weight is a matter of individual or neighborhood characteristics. More affluent neighborhoods might, for instance, provide healthier food choices or more resources for recreational exercise. However, urban design characteristics that promote walking, such as increased population density, mixed land use and access to public transit, are more prominent in lower income neighborhoods (Rundle et al., 2007). Prior studies in other locales and our past work with this data set, have shown that BMI is inversely related to these features (Frank, Andressen, & Schmid, 2004; Frank, Schmid, Sallis, Chapman, & Saelens, 2005; Lopez, 2004; Rundle et al., 2007). That indicators of increased neighborhood walk-ability are inversely associated with body size and are more prominent in lower income neighborhoods, suggests the potential for inverse confounding and that past work has under estimated associations between neighborhood socio-economic status and obesity. A study in the United States found that community level disadvantage significantly predicted BMI in women but not men, independent of personal income and education (Robert & Reither, 2004). Similarly among Australian women, area level socioeconomic status disadvantage was found to be at least as important as individual socioeconomic status in explaining individual BMI (King, Kavanagh, Jolley, Turrell, & Crawford, 2006). A Swedish, study found that after control for individual's education level, there was a relationship between area-level socioeconomic status and obesity; comparing the lowest to the highest socioeconomic status group, the odds ratio for obesity was 1.18 (Sundquist, Malmstrom, & Johansson, 1999). Some past studies present results adjusting for measures of neighborhood racial/ethnic composition, which may be another important neighborhood level confounder (Mobley, Root, Finkelstein, Khavjou, Farris, & Will, 2006; Robert & Reither, 2004), while others did not (Inagami, Cohen, Finch, & Asch, 2006; Mujahid, Diez Roux, Borrell, & Nieto, 2005).

There are theoretical reasons to hypothesize an interaction between individual and group-level socioeconomic status. As noted above, the availability of recreational facilities and nutritious food varies by community-level socioeconomic status, thus opportunities to convert personal income into healthy physical activity or dietary patterns may vary by neighborhood socioeconomic conditions (Block, Scribner, & DeSalvo, 2004; Moore & Diez Roux, 2006). Beyond the physical resources of neighborhoods, social norms regarding body image may vary by neighborhood socioeconomic status and racial composition such that associations between personal income and BMI may vary across neighborhoods (Becker, Yanek, Koffman, & Bronner, 1999; McLaren & Gauvin, 2002). Few studies, however, have considered joint, interactive associations of individual and community-level socioeconomic status and obesity outcomes and none have assessed the role of urban design features as a potential confounder. In this paper we consider the associations between BMI and individual-level and neighborhood-level socioeconomic status using data from New York City. We also assess associations between indices of neighborhood walk-ability and neighborhood socioeconomic status and control for these associations in analyses of neighborhood economic status and BMI. New York City presents an interesting locale in which to investigate associations among personal income, neighborhood income, and body size. Within the city there is a wide range in personal income, providing sufficient variation for analyses; and because of the extremely high population density, rich and poor often live in close proximity to one another, reducing the variation in environmental factors across strata of income.

Materials and Methods

Between January 2000 and December 2002 the New York City government, through the Academic Medicine Development Company (AMDeC) conducted a survey of adult volunteers 30 years or older in New York City, including all five boroughs (Bronx, Brooklyn, Manhattan, Queens, and Staten Island) (Mitchell, Gregersen, Johnson, Parsons, & Vlahov, 2004; Rundle et al., 2007). Venue-based sampling with quotas was used to enroll an ethnically and socio-economically diverse population (Mitchell et al., 2004). Data collection took place at six community-based health centers, two community hospitals, and six medical centers, and through the New York Blood Center. Research staff conducted extensive recruitment efforts in community settings such as health and neighborhood fairs, and the study was extensively publicized in the city to encourage participation (Mitchell et al., 2004). Volunteers who presented themselves at these sites were enrolled. The study population and its demographic characteristics has been described extensively elsewhere and it is has been shown to be generally representative of the population of New York City as ascertained by the Census and city wide surveys conducted by the Department of Health (Mitchell et al., 2004; Park, Neckerman, Quinn, Weiss & Rundle, 2008; Rundle et al., 2007). At the Census tract and Zip code level the geographic distribution of the sample is also representative of the geographic distribution of the entire population of New York City (Rundle et al., 2007). Height and weight were measured using clinical scales and rigid stadiometers available at the clinical locations where study subjects were enrolled. Cross site reliability studies of height and weight measurement were not performed. Our analysis includes 13,102 study subjects whose addresses could be geocoded to one of 176 Zip codes in New York City and who had complete data for age, gender, race/ethnicity and education.

Data on age, race and ethnicity, gender, weight, height, pre-tax income, and educational attainment were available for this analysis. Six racial and ethnic categories were distinguished: Asian American, Black - African American, Black - Caribbean American, Caucasian, Hispanic, and Other race. Household income was categorized as less than $15,000, $15,000 to $29,000, $30,000 to $49,000, $50,000 to $99,000, and $100,000. A portion of the study subjects either refused to provide income data or indicated “Don’t Know”. Educational attainment was coded as eighth grade or less, some high school, high school graduate, vocational school, some college, college graduate, and graduate school. The analysis also includes Zip code-level data on poverty rates, measured here as the proportion of households below the poverty line, and racial and ethnic composition, measured as the proportion of residents who were Black or Hispanic. Zip code level measures of population density and land use mix were used as indices of neighborhood walk-ability and these measures were generated from 2000 Census and PLUTO data as previously described (Frank et al., 2004; Frank et al., 2005; Rundle et al., 2007). Land use mix is a measure of the relative proportion of built environment space dedicated to commercial and residential uses, with the scale approaching one as a perfect 50:50 mix of residential and commercial uses is approached (Frank et al., 2004; Frank et al., 2005; Rundle et al., 2007). These two indices of neighborhood walk-ability have been associated with increased walking, more hours of moderate physical activity and lower BMI in prior studies (Frank et al., 2004; Frank et al., 2005; Lopez, 2004; Rundle et al., 2007). Of the walk-ability indices assessed in our prior study of BMI in New York City, population density and land use mix were the most strongly, inversely associated with BMI (Rundle et al., 2007).

The Columbia University IRB approved the analyses of demographic and neighborhood variables.

Statistical Analyses

Multilevel analysis was employed because it allows for the simultaneous estimation of the effects of group-level and individual-level factors, and because it accounts for non-independence of observations within Zip codes (Singer, 1998). Statistical analyses of the cross-sectional data were performed using SAS Proc Mixed (Singer, 1998). Indicator variables for individual-level income were entered into the model, using less than $15,000 income as the referent group. One model excluded individuals who refused to answer the income question or who responded “Don’t Know,” while another model employed indicator variables representing these two categories. Results from the two models were similar, so for purposes of clarity, results from the model excluding these subjects are represented. All models controlled for age, race/ethnicity (Asian, Black – African American, Black – Caribbean, Caucasian, Hispanic, and other).

Analyses were also conducted with and without control for Zip code proportion Black, proportion Hispanic and the indices of neighborhood walk-ability, an exercise which suggested that these variables were substantial confounders of the association between Zip code poverty rate and BMI. The literature suggests that associations between socioeconomic status and BMI depend on gender, so the data from men and women were initially analyzed separately. Interactions between income and gender were formally tested by including a five-level

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categorical variable for individual level income, an indicator variable for gender and an interaction term for the two variables; p-values for the interaction terms are presented in the results tables.

The hypothesis that Zip code-level socioeconomic status would modify the association between individual income and BMI was tested with separate analyses for different levels of neighborhood income. Each Zip code was classified as "poorer" or "richer" based on whether its poverty rate was above or below the median for all New York City Zip code areas. Separate analyses of BMI and personal income were conducted for individuals living in richer versus poorer Zip codes. To formally test whether the association between income and BMI differed significantly in richer and poorer Zip codes, an interaction model was estimated. This model included a five-level categorical variable for income, an indicator variable for richer or poorer Zip code, and an interaction term for the two variables. All analyses were conducted separately in men and women, and controlled for age and race/ethnicity. All models included a random intercept for each Zip code.

A second set of models replaced income with education. A series of dichotomous variables indicated the levels of education, with 8^{th} grade or less as the referent group. Again, multi-level models simultaneously considered associations between BMI and education and Zip code-level poverty rate. Analyses were conducted separately for men and women and controlled for age, race/ethnicity, and Zip code-level proportion Black, proportion Hispanic and indices of neighborhood walk-ability. Interaction terms were used to test whether the association between BMI and each level of education significantly varied by gender. As with the income data, interactions between education and Zip code-level high or low poverty rate were assessed. Because the hypothesis tests revealed that the association between education and BMI did not vary significantly by gender, analyses of education and BMI stratified by Zip code level socioeconomic status were performed with the pooled sample of men and women. All models included a random intercept for each Zip code.

Results

Table 1 documents the demographic composition of the study population by gender. Before and after control for Zip code poverty rate, higher personal income was significantly associated with a lower BMI in women but not men (see Table 2). The mean BMI for women, regardless of income, was in the overweight range. Zip code poverty rate was correlated with population density ($r=0.30$, $p<0.001$) and increased commercial/residential land use mix ($r=0.15$, $p=0.05$). These Zip code characteristics had substantial confounding effects on the association between poverty rate and BMI in women. Table 2 also shows the association between poverty rate and BMI in men and women before and after control for Zip code level racial and ethnic composition (proportion black and proportion Hispanic) and further control for indices of walk-ability (land use mix and population density). As expected Zip code level indices of walk-ability appear to act as inverse confounders and control for these indices increases the strength of association between poverty rate and BMI in women. Table 2 also shows that adding variables for poverty rate, racial and ethnic composition and indices of walk-ability to the model had little impact on the associations between individual income and BMI. Similar to prior reports on indices of neighborhood walk-ability, increasing population density and land use mix at the Zip code level were associated with lower BMI (see Table 2) (Frank et al., 2004;Frank et al., 2005;Rundle et al., 2007). In an unconditional means model the between-Zip code variance was statistically significant in the overall population and for men and women separately ($p<0.001$), indicating that Zip codes differ significantly in average BMI. However, Zip code level differences accounted for only a modest portion of total variance in BMI, 5.7 percent for the overall population, 4.3 percent for men and 7.8 percent for women. Table 2 also shows the percentage of the between-Zip code variation in mean BMI explained by the individual and Zip code level predictor variables.

Table 3 provides descriptive data on men and women in the lowest and highest categories of personal income living in poorer and richer Zip codes. Among men mean BMI does not appear to vary across the strata of personal and Zip code level socioeconomic status, however it does appear to vary for women. After control for age, race/ethnicity, Zip code level racial and ethnic composition and indices of walk-ability, increasing personal income was significantly associated with lower BMI among women in both richer and poorer Zip codes (see Table 4). However, the association between personal income and BMI was significantly weaker in poorer versus richer Zip codes (P for interaction =0.02). Personal income remained unassociated with BMI among men regardless of neighborhood income (results not shown).

As shown in Table 5, for both men and women education was inversely associated with BMI, particularly at the college and graduate school level, and the strength of the association between education and BMI did not differ significantly by gender. As in the analyses of income, before and after controlling for Zip code racial/ethnic composition and indices of walk-ability, Zip code poverty rate was not associated with BMI in men. However, in women Zip code poverty rate was associated with BMI when entered into the model as the only Zip code level variable and after control for Zip code level racial/ethnic composition and indices of walk-ability. In the analyses of education, associations between Zip code poverty rate and BMI and the percentage of explained variance were similar to that observed in the analyses of income. Thus, Table 5 only presents results for analyses of poverty rate fully adjusted for Zip code composition variables and indices of walk-ability. Table 5 shows the estimated beta coefficients for individual-level education and for poverty rate in men and women separately and in men and women combined.

Overall, increasing education, particularly at the college and graduate level, was inversely associated with BMI, but there was also evidence that this association varied between richer and poorer Zip codes. The association between education and BMI was stronger for men and women living in the richer Zip codes. Table 6 shows the association between education and BMI for individuals living in richer versus poorer Zip codes. In this table, men and women are combined because the interactive effect of Zip code socio-economic status and education is similar in men and women, the analyses control for gender, age and race/ethnicity and Zip code level racial and ethnic composition and indices of walk-ability.

Discussion

Consistent with earlier studies, the analyses presented here show that personal socioeconomic status is inversely associated with BMI among residents of New York City. However, the association depends on gender, the measure of socioeconomic status used, and the relative income of the Zip code in which the individual lives. This work is distinctive in considering the simultaneous joint effects of personal and neighborhood socio-economic status and for controlling for indices of neighborhood walk-ability that are themselves associated with neighborhood socioeconomic status.

The results of analyses of income and BMI by gender are similar to much of the published literature in showing an inverse association with income among women but not men. The common interpretation of these findings is that the social stigma for being overweight is higher for women than men and that higher-income women use their resources to eat healthier and get more exercise. However, since much of the published data, as is the case here, are cross-sectional in nature, the causal direction of the association cannot be determined. An alternative explanation for the association is that heavier women face increased discrimination in the work place and therefore receive a lower salary. A recent review of the literature found that there is a wage and promotion penalty for being overweight that is more pronounced in women than men (Puhl & Brownell, 2001).

The observed association between socioeconomic status and BMI depends on whether income or education are used as measures of socioeconomic status. For women there is a significant association with BMI for both measures of socioeconomic status, while for men education but not income is associated with BMI. Our results suggest that these two commonly used measures of socioeconomic status may actually measure different underlying constructs that predict BMI. Education may be associated with awareness of the health risks associated with increased body weight, the ability to turn this awareness into action, the ability to identify low-calorie foods, or with greater flexibility in work hours allowing for more exercise. If men face less stigma than women do for being over-weight, higher-income men may not be motivated to use their economic resources to maintain a lower body weight, but increased education appears to prompt behaviors that lead to a lower BMI for both men and women.

As in past work showing that neighborhood measures of socio-economic status predict body size, in the fully adjusted model Zip code level poverty rate was positively associated with BMI, although the association was significantly stronger in women (Inagami et al., 2006; Mobley et al., 2006; Mujahid et al., 2005; Robert & Reither, 2004). However, our analyses in which racial and ethnic compositional variables and indices of walk-ability were sequentially added to the multi-level model suggest that there are important inter-relationships between Zip code level poverty rate, other Zip code level covariates and BMI. When included in the model as the only Zip code level variable, poverty rate strongly predicted BMI in women, but this association was diminished after control for proportion black and proportion Hispanic. Neighborhood socioeconomic status co-varies with neighborhood racial/ethnic characteristics and there are social norms regarding a healthy body size that vary by race/ethnicity, suggesting that neighborhood racial/ethnic characteristics should be controlled for (Becker et al., 1999; Freedman, Carter, Sbrocco, & Gray, 2004; Kemper, Sargent, Drane, Valois, & Hussey, 1994). Some past studies present results adjusting for measures of neighborhood racial/ethnic composition (Mobley et al., 2006; Robert & Reither, 2004), while others did not (Inagami et al., 2006; Mujahid et al., 2005). As hypothesized, there appeared to be substantial inverse confounding by neighborhood walk-ability measures; when indices of walk-ability were added to the model that included proportion Black and proportion Hispanic, poverty rate became strongly associated with BMI among women. Neighborhood walk-ability indices are higher in poorer than more well off Zip codes and these indices are associated with increased walking, more hours of moderate physical activity and lower BMI (Frank et al., 2004; Frank et al., 2005; Rundle et al., 2007). As would be expected given the positive association between the walk-ability indices and poverty rate and inverse association between the walk-ability indices and BMI, control for population density and land use mix caused the inverse association between poverty rate and BMI to become stronger and significant.

Neighborhood measures in these analyses were constructed at the Zip code level, which in New York City are very small; the median Zip code has an area of 3.58 Km^2 and can be walked across in about 20 minutes. This geo-spatial scale is also similar to that used in prior analyses of neighborhood walk-ability indices and BMI, walking and physical activity (Frank et al., 2004; Frank et al., 2005). In recent, as yet unpublished, analyses we have found that associations between indices of walk-ability and BMI in New York City are robust to changes in the geo-spatial definitions of neighborhood used in the analysis and tend to be stronger for area units approximating the size of New York City Zip codes. The analyses presented here show that the effect of Zip code socioeconomic status was independent of personal income or education and suggests that neighborhood poverty level represents or correlates with characteristics of the neighborhood, other than walk-ability, that promote sedentary lifestyles or poorer diets. Likewise at the Zip Code level we find that indices of neighborhood walk-ability are inversely associated with BMI, independent of measures of neighborhood and personal socioeconomic status.

In addition to predicting BMI, neighborhood socioeconomic status modified the association between personal socioeconomic measures and BMI. Among women, the association between personal income and BMI was significantly stronger in richer versus poorer Zip codes and, in both genders combined, the extent of the association between higher education and BMI depended on neighborhood income. Poverty rate was used to categorize Zip-code as being richer or poorer because past work suggests that area measures of deprivation, such as poverty rate, have stronger associations with health than other socioeconomic status related area measures, such as wealth or education (Krieger, Chen, Waterman, Rehkopf, & Subramanian, 2003; Krieger, Chen, Waterman, Soobader, Subramanian, & Carson, 2002). The observed effect modification may reflect several possible processes, for instance, more affluent neighborhoods may have more resources, such as natural food stores and gyms and health clubs, supporting healthy dietary and exercise patterns (Block et al., 2004; Moore & Diez Roux, 2006). The availability of such purchasable resources may allow higher socioeconomic status to be expressed in a manner than leads to a lower BMI.

These analyses, like many in the literature, are limited due to their cross-sectional nature and the inability to establish the causal order of events. As discussed above, it is not clear whether among women increased income is expressed as a lower BMI, or if a higher body weight causes wage discrimination that results in lower income. For education the temporal order is clearer. Although the questionnaire did not gather information on when the respondents completed their education, given that the respondents were thirty years or older it is likely that their education was completed substantially before the interview was conducted. In regards to the finding that neighborhood income appears to influence how personal education and income are expressed, again the cross-sectional nature of the data prevents absolute causal inference. It is possible that health-conscious individuals are attracted to the better resources often found in higher-income neighborhoods and these same people are likely to spend their income on healthy lifestyles regardless of where they live. Such a selection phenomenon could make it appear that neighborhood income potentiates personal socioeconomic status, when in fact, it just causes a sorting of people who pursue healthy lifestyles into certain neighborhoods.

This work suggests that neighborhood socioeconomic context influences how personal socioeconomic status is expressed to influence body size. Furthermore this effect is independent of urban design features that promote walking and are associated with a lower BMI, which tend to be more prevalent in lower socioeconomic status neighborhoods. While the exact explanations for this finding cannot be derived from this data, it provides further evidence that large scale social forces impact individual’s body size. It is possible that the increasing divide between the rich and poor, expressed as both increased differences in income and increased neighborhood segregation, may be contributing to the obesity epidemic. Further studies that build an understanding of why people have chosen to live where they do would further illuminate the role of neighborhood context in the obesity epidemic.

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Table 1

Demographic Composition of the Study Population

	Men N=4,610	Women N=8,492
Continuous Variables Mean (SD)		
Age	44.9 (10.6)	47.0 (10.5)
BMI	27.0 (4.8)	27.7 (6.3)
Categorical Variables		
Race and Ethnicity		
African American	12.5	14.9
Asian	9.1	13.2
Caribbean Black	3.5	5.7
Caucasian	52.8	44.1
Hispanic	20.2	20.0
Other	2.0	2.1
Income		
<$15,000	12.8	14.4
$15,000-29,000	9.2	14.3
$30,000-49,000	14.5	18.4
$50,000-$100,000	34.2	27.7
>$100,000	18.3	11.2
Refused	11	14.1
Education		
<High School	3.7	6.5
Some High School	6.8	7.4
High School Graduate	20.2	23.1
Vocation School	2.1	2.4
Some College	22.7	20.8
College Graduate	25.4	22.6
Graduate School	19.1	17.2

Table 2

BMI, Personal Income, and Zip-Code Level Measures of Socio-Economic Status, Racial/Ethnic Composition and Indices of Neighborhood Walk-ability in Men and Women[a]

	Men			
	Model 1[b] Beta, P-value	**Model 2 [b] Beta, P-value**	**Model 3 [b] Beta, P-value**	**Model 4 [b] Beta, P-value**
Personal Income				
<15K	Ref	Ref	Ref	Ref
15-29	0.03, 0.93	0.02, 0.95	0.02, .95	-0.02, 0.94
30-49	-0.18, 0.52	-0.20, 0.48	-0.19, 0.48	-0.23, 0.40
50-99	0.43, 0.08	0.41, 0.10	0.41, 0.11	0.32, 0.20
100+	0.21, 0.46	0.19, 0.51	0.18, 0.53	0.19, 0.49
Zip Code Level Variables				
Poverty Rate		-0.39, 0.72	-1.00, 0.52	1.11, 0.44
Proportion Black			1.07, 0.04	0.66, 0.17
Proportion Hispanics			-0.17, 0.83	-0.16, 0.82
Land Use Mix				-0.90, 0.03
Population Density (per 10K people/Km^2)				-0.50, <0.01
% of between Zip code variation explained	21%	20%	22%	54%
	Women			
	Model 1 [b] Beta, P-value	Model 2 [b] Beta, P-value	Model 3 [b] Beta, P-value	Model 4 [b] Beta, P-value
Personal Income				
<15K	Ref	Ref	Ref	Ref
15-29	-0.02, 0.94	0.04, 0.86	0.03, 0.90	0.00, 0.99
30-49	-0.60, 0.01	-0.48, 0.05	-0.49, 0.04	-0.54, 0.03
50-99	-0.90, <0.01	-0.72, <0.01	-0.74, <0.01	-0.79, <0.01
100+	-1.86, <0.01	-1.66, <0.01	-1.67, <0.01	-1.65, <0.01
Zip Code Level Variables				
Poverty Rate		3.62, <0.01	1.77, 0.19	3.53, <0.01
Proportion Black			1.74, <0.01	1.33, <0.01
Proportion Hispanics			0.63, 0.39	0.63, 0.34
Land Use Mix				-1.11, <0.01
Population Density (per 10K people/Km^2)				-0.36, <0.01
% of between Zip code variation explained	80%	83%	84%	92%

[a] Association between income and BMI differs in men and women in all four models (p<0.01) and the association between poverty rate and BMI differs in men and women in all four models (p<0.01).

[b] Controlling for age, and race/ethnicity.

Table 3

Descriptive Data for Men and Women in the Lowest and Highest Income Groups Living in Richer and Poorer Zip Codes [a]

	Lowest Income Group (<$15,000)		Highest Income Group (>=$100,000)	
High Poverty Zip Codes	**Men (n=476)**	**Women (n=965)**	**Men (n=234)**	**Women (n=254)**
Age (mean, SD)	47.21, 11.00	48.26, 11.16	46.00, 10.57	46.72, 9.32
BMI (mean, SD)	27.60, 4.98	28.50, 6.77	27.53, 4.51	26.64, 5.39
Race/Ethnicity n (%)				
African American	128 (27%)	203 (21%)	24 (10%)	28 (11%)
Asian	57 (12%)	213 (22%)	16 (7%)	18 (7%)
Caribbean	11 (2%)	25 (3%)	7 (3%)	9 (4%)
Caucasian	83 (17%)	135 (14%)	160 (68%)	167 (66%)
Hispanic	186 (39%)	378 (39%)	26 (11%)	27 (11%)
Other	11 (2%)	11 (1%)	1 (0.5%)	5 (2%)
Low Poverty Zip Codes	**Men (n=116)**	**Women (n=254)**	**Men (n=608)**	**Women (n=700)**
Age (mean, SD)	48.59, 11.31	49.20, 10.41	44.71, 9.82	46.42, 9.17
BMI (mean, SD)	27.95, 5.49	28.11, 6.53	28.18, 4.65	25.78, 5.50
Race/Ethnicity n(%)				
African American	17 (15%)	26, (10%)	22 (4%)	25 (4%)
Asian	20 (17%)	71 (28%)	38 (6%)	43, 6%)
Caribbean	3 (3%)	14 (6%)	11 (2%)	14, (2%)
Caucasian	54 (47%)	85 (33%)	485 (80%)	551 (79%)
Hispanic	19 (16%)	51 (20%)	42 (7%)	54, (8%)
Other	3 (3%)	7 (3%)	10 (2%)	13 (2%)

[a] Poorer Zip code defined as being a Zip code at or above the median poverty rate of all Zip codes in New York City.

Table 4

Association [a] Between Personal Income and BMI Women Living in Poorer [b] and Richer Zip Codes.

Income	Poorer Zip Codes Beta Coefficient, P-value	Richer Zip Codes Beta Coefficient, P-value
<15K	Ref	Ref
15-29	0.11, 0.72	-0.65, 0.17
30-49	-0.26, 0.40	-1.41, <0.1
50-99	-0.55, 0.08	-1.56, <0.01
100+	-1.56, <0.01	-2.30, <0.01

[a] Adjusted for age, race/ethnicity and Zip code level proportion Black, proportion Hispanic, population density and land use mix.

[b] Poorer Zip code defined as being a Zip code at or above the median poverty rate of all Zip codes in New York City. P for interaction between personal income and socioeconomic status of the Zip code = 0.02.

Table 5

Education and Poverty Rate of the Home Zip-Code and BMI in Men and Women, and Men and Women combined.

	Men		Women		Combined
	Model 1 [a] Beta, P-value	**Model 2 [b] Beta, P-value**	**Model 1 [a] Beta, P-value**	**Model 2 [b] Beta, P-value**	**Model 3 [c] Beta, P-value**
Education					
<=8th Grade	Ref	Ref	Ref	Ref	Ref
Some High School	-0.77, 0.09	-0.88, 0.06	0.07, 0.83	0.05, 0.88	-0.24, 0.39
High School Graduate	-0.67, 0.10	-0.79, 0.05	-0.62, 0.04	-0.62, 0.04	-0.63, <0.01
Vocational School	-1.00, 0.10	-1.11, 0.06	-0.67, 0.17	-0.63, 0.20	-0.79, 0.04
Some College	-0.76, 0.06	-0.89, 0.03	-0.47, 0.13	-0.44, 0.15	-0.58, 0.02
College Graduate	-1.15, <0.01	-1.23, <0.01	-1.53, <0.01	-1.44, <0.01	-1.32, <0.01
Graduate School	-1.69, <0.01	-1.69, <0.01	-1.89,<0.01	-1.72, <0.01	-1.69, <0.01
Poverty rate [d]	-	0.22, 0.87	-	3.45, <0.01	2.39, 0.01
% of between Zip code variation explained	37%	62%	79%	91%	89%

[a] Model 1 controls for age, race/ethnicity

[b] Model 2 controls for all variables in Model 1 and Zip code level proportion Black, proportion Hispanic, population density and land use mix.

[c] Model 3 controls for age, race/ethnicity gender, Zip code level proportion Black, proportion Hispanic, population density and land use mix

[d] Poverty rate is analyzed as a continuous variable and the association between poverty rate and BMI differs for men and women p<0.01

Table 6

Association [a] Between Education and BMI Among Individuals Living in Poorer[b] and Richer Zip Codes.

Education	Poorer Zip Codes Beta Coefficient, P-value	Richer Zip Codes Beta Coefficient, P-value
<=8th Grade	Ref	Ref
Some High School	-0.22, 0.49	-0.47, 0.42
High School Graduate[c]	-0.32, 0.26	-1.71, <0.01
Vocational School	-0.63, 0.22	-1.58, 0.01
Some College	-0.47, 0.11	-1.42, <0.01
College Graduate[c]	-0.88, <0.01	-2.42, <0.01
Graduate School[c]	-1.49, <0.01	-2.62, <0.01

[a]Adjusted for age, gender and race/ethnicity and Zip code level proportion Black, proportion Hispanic, population density and land use mix.

[b]Poorer Zip code defined as being a Zip code at or above the median poverty rate level of all Zip codes in New York City.

[c]Association between education level and BMI differs by socioeconomic status of the Zip code, high school graduate p=0.02, college graduate p=0.01, and graduate school p=0.08 respectively.