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Change in Neighborhood Socioeconomic Status and Weight Gain:

Dallas Heart Study

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Abstract

Introduction—Despite a proposed connection between neighborhood environment and obesity, few longitudinal studies have examined the relationship between change in neighborhood socioeconomic deprivation, as defined by moving between neighborhoods, and change in body weight. The purpose of this study is to examine the longitudinal relationship between moving to more socioeconomically deprived neighborhoods and weight gain as a cardiovascular risk factor.

Methods—Weight (kg) was measured in the Dallas Heart Study (DHS), a multiethnic cohort aged 18–65 years, at baseline (2000–2002) and 7-year follow-up (2007–2009, N=1,835). Data were analyzed in 2013–2014. Geocoded addresses were linked to Dallas County, TX census block groups. A block group-level neighborhood deprivation index (NDI) was created. Multilevel difference-in-difference models with random effects and a Heckman correction factor (HCF) determined weight change relative to NDI change.

Results—Forty-nine percent of the DHS population moved (263 to higher NDI, 586 to lower NDI, 47 within same NDI), with blacks more likely to move than whites or Hispanics ($p<0.01$), but similar baseline BMI and waist circumference were observed in movers vs. non-movers

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(*p*>0.05). Adjusting for HCF, sex, race, and time-varying covariates, those who moved to areas of higher NDI gained more weight compared to those remaining in the same or moving to a lower NDI (0.64 kg per 1-unit NDI increase, 95% CI=0.09, 1.19). Impact of NDI change on weight gain increased with time (*p*=0.03).

Conclusions—Moving to more–socioeconomically deprived neighborhoods was associated with weight gain among DHS participants.

Introduction

Regional variation in obesity prevalence within the U.S. suggests a person's socioeconomic, physical, and social environments likely affect opportunities for healthy behaviors that prevent excess weight gain.[1] Neighborhood-level socioeconomic environment, as measured by U.S. Census–derived socioeconomic indices, may contribute to regional variation in obesity. Prior work has demonstrated a relationship among neighborhood SES, obesity prevalence, and cardiometabolic risk factor prevalence.[2–6] However, longitudinal studies specifically examining the relationship between neighborhood SES change and obesity as a cardiovascular risk factor are rare and have had methodologic limitations, including use of self-reported weight measures,[7] use of intermediate surrogates of weight gain or cardiovascular health,[8] small sample sizes, and limited numbers of movers.[9,10] The Moving to Opportunity (MTO) study, which randomized individuals to areas of varying neighborhood SES, suggested that moving from a high-poverty to low-poverty census tract was associated with a lower likelihood of Class II/III obesity for women.[11] The study was limited to households from census tracts with ≥40% poverty rates, with children in public housing, and that chose participation in a rent subsidy voucher lottery. That study was not designed to collect detailed, baseline health information, presenting a challenge for longitudinal analysis and investigation of causal factors. Previous research has also associated exposure to neighborhood disadvantage with alterations in inflammation- and stress-related biomarkers, including distinct cortisol profiles.[12–14] These findings plausibly support the hypothesis that living in more–socioeconomically deprived neighborhoods may be associated with greater adiposity and poor cardiometabolic health.

Therefore, longitudinal data from the Dallas Heart Study (DHS), a multiethnic, population-based cohort in Dallas County, TX, was used to evaluate the relationship between moving across areas of varying neighborhood socioeconomic deprivation and subsequent weight gain over an approximately 7-year period. We hypothesized that those moving to areas of greater deprivation (lower neighborhood SES) would have greater weight gain over time as compared to a combined group of people who either remained in the same neighborhood or moved to an area of lower neighborhood deprivation. We also hypothesized that weight change would vary for movers based on time in their new neighborhood. The present study further incorporates several recommendations from the literature on built environment and obesity, including: using both objective and perceived neighborhood environment measures, adjusting for self-selection, and using multilevel analysis.[15]

Methods

The DHS cohort is a probability-based sample of Dallas County residents aged 18–65 years at entry. Original data collection occurred in 2000–2002, and 7-year follow-up data were collected in 2007–2009. Detailed data collection methods from study entry and follow-up have been previously reported.[16,17] At study entry and follow-up, 3,072 participants completed a detailed survey, anthropometric measures, and laboratory testing. The DHS protocol was approved by University of Texas Southwestern Medical Center's IRB, and written informed consent was obtained from participants at study entry and follow-up. A protocol to analyze DHS neighborhood data (13-H-N041) was approved by NHLBI's IRB.

Study Definitions

Participants self-reported medical histories and demographic data, including age, sex, race/ethnicity, achieved education level, household income, marital status, home ownership status, and number of children at study entry and follow-up. Length of neighborhood residence in years was recorded for baseline and follow-up addresses. Participants were asked 18 survey questions on neighborhood environment perception abstracted from the 1994 Project on Human Development in Chicago Neighborhoods.[18] An overall neighborhood perception score was computed, as previously described,[19] with a higher score representing more unfavorable perceptions of the overall neighborhood environment (i.e., perceived neighborhood violence, poor physical environment, and low social cohesion). Three separate scores were created evaluating physical environment (Cronbach's α-coefficient=0.82), neighborhood violence (Cronbach's α-coefficient=0.84), and social cohesion (Cronbach's α-coefficient=0.76). A higher physical environment perception score represents more unfavorable perceptions of available neighborhood resources and aesthetics.[19] A higher neighborhood violence perception score and social cohesion perception score represent more unfavorable perceptions of levels of community violence and interconnection, respectively. Physical activity was determined by converting self-reported leisure-time physical activity into MET minutes/week using a validated conversion scale.[20] BMI was calculated in kg/m^2 using measured weight/height data. Waist circumference (WC) was defined as the circumferential distance at the level of the superior iliac crest. Hip circumference (HC) was defined as the largest area around the hips while standing.

Neighborhood Deprivation Index

Geocoding of DHS addresses was based on updated and verified residential mailing address data obtained during participant interviews. Geocoding was performed using ArcGIS-10 software as previously described.[17] As detailed previously, 21 variables from the 2000 U.S. Census were used to develop a Dallas County block group-level neighborhood deprivation index (NDI).[17,21,22] Principal components factor analysis with varimax rotation identified common factors and key variables for the common factor representing neighborhood-level deprivation from the 21 block group variables for the Dallas County NDI. The variables included: % unemployment, % female-headed households, % households on public assistance, % households with a car, % population below the poverty line, and % non-Hispanic blacks. NDI was analyzed as a continuous variable, as described elsewhere.[17]

Using residential address–derived block group, DHS participants were linked to an NDI value, with higher scores indicating more socioeconomic deprivation.

Study Population

Movers were defined as participants who reported a change in residential address between study entry and follow-up. The exact date of participants' moves could not be characterized with available data; however, the time in new neighborhood was estimated by residence length reported at follow-up. Non-movers were defined as those who reported the same residential address at both time points. Of the 2,485 participants with follow-up data, those who moved out of Dallas County (*n*=461); those with missing/inadequate address data (*n*=1); those reporting race/ethnicity other than black, white, or Hispanic (*n*=33); those missing height or weight data (*n*=11); and participants with a cancer history (*n*=114), bariatric surgery history (*n*=22), and who were pregnant at baseline or follow-up (*n*=8) were excluded, leaving a population of 1,835 participants.

Statistical Analysis

Continuous and categorical variables were compared: (1) between movers to higher NDI and those in lower/equal NDI; and (2) between movers and non-movers using a Wilcoxon rank sums or chi-square test. Multilevel linear regression modeling with random effects was used to determine longitudinal weight change relative to a 1-SD NDI increase using a difference-in-difference strategy.[23] The difference-in-difference method compares weight change over time in treated and untreated groups while controlling for unobserved individual differences and common trends. In the analysis, "treated" individuals were movers who moved to a higher NDI neighborhood, whereas "untreated" individuals were those moving to an equal/lower NDI neighborhood or who remained in the same NDI neighborhood. The models were based on the assumption that weight change in treated and untreated groups would be the same if the treated group had not moved to higher-NDI areas. Those who did not move or who moved to an equal/lower NDI neighborhood were included in the untreated group to align with this assumption and to calculate effect estimates specifically for those who moved to higher-NDI neighborhoods. Models were adjusted for age (continuous), sex, race/ethnicity, education, income, smoking, and physical activity. Education, income, smoking, and physical activity were time-varying covariates reflecting baseline and follow-up data. Models were additionally adjusted for neighborhood environment perceptions and neighborhood physical environment perceptions, which were time varying based on survey data from baseline and follow-up. Two-sided *p*-values <0.05 were considered statistically significant. All analyses were performed using SAS, version 9.2 in 2013–2014.

Heckman Correction Factor

Because moving was not randomly assigned, a Heckman's correction factor (HCF), which is used extensively in econometrics to address selection bias, was created to account for self-selection related to moving to a higher-NDI area.[24–26] The HCF was determined using logistic regression modeling of the probability of moving to a higher-NDI area based on age, sex, race, education, income, physical activity, total years in a Dallas County neighborhood at baseline, home ownership, employment status, marital status, number of children, and BMI change as model coefficients (Appendix Table 1).

Results

During the 7-year study period, 49% of DHS participants moved within Dallas County. Median block group deprivation scores were significantly higher for movers as compared to non-movers (median [interquartile range]=0.89 [0.02, 1.85] vs. 0.19 [−0.46, 1.1], $p<0.0001$) (Appendix Table 2). Compared to non-movers, those who moved were younger, more likely to be non-Hispanic black, female, have less than a high school education, report a lower income, and identify as current smokers ($p<0.05$ for all). However, there were no significant differences between movers and non-movers for BMI or WC.

Among the movers, 263 participants moved to a higher-NDI neighborhood, 586 to a lower-NDI neighborhood, 47 participants moved but had no NDI change, and 939 participants remained in the same neighborhood. Movers to higher NDI were composed of 59% non-Hispanic blacks, 24% non-Hispanic whites, and 17% Hispanics (Table 1). Compared to those who did not move or moved to a lower or equal NDI, movers to higher NDI were younger (mean age, 40.7 [10.3] vs 43.8 [10.4] years] and more likely to be current smokers at baseline ($p<0.001$). There were no significant differences at baseline in race, education level, physical activity, BMI, or WC.

In multilevel modeling of changes in NDI and weight (Table 2), adjusted only for HCF, those who moved to higher-NDI areas gained more weight compared to those who remained at the same NDI or moved to lower NDI, although the relationship did not reach statistical significance (0.34 kg per 1-unit NDI increase, 95% CI= −0.21, 0.89). This relationship became significant after adjusting for HCF, sex, race, age, and time-varying covariates (education, income, smoking, and physical activity); those who moved to higher-NDI areas gained more weight compared to those who remained at the same NDI or moved to lower NDI (0.64 kg per 1-unit NDI increase, 95% CI=0.09, 1.19). Further adjustment for overall neighborhood environment perceptions and physical environment perceptions did not attenuate the relationship between NDI change and weight change ($p<0.05$ for all).

Among those who moved to higher-NDI neighborhoods, the impact of NDI change on weight gain increased with duration in the new, more socioeconomically deprived neighborhood. Results were stratified by median residence length in new neighborhood (4 years) (Table 3). For those who lived in a new neighborhood for >4 years, there was a significant relationship between NDI and weight change after covariate adjustment, with a mean additional weight gain per 1-unit NDI increase of 0.85 kg (95% CI=0.08, 1.62). This relationship was not attenuated after adjustment for physical environment perception (0.85 kg per 1-unit NDI increase, 95% CI=0.08, 1.62) and for overall neighborhood environment perception (0.80 kg per 1-unit NDI increase, 95% CI=0.01, 1.60). For those living in the new neighborhood ≤4 years, the relationship between NDI and weight change was not significant (0.57 kg per 1-unit NDI increase, 95% CI= −0.27, 1.41) and remained insignificant after adjustment for all covariates, including perceptions of overall neighborhood environment or of neighborhood physical environment ($p>0.05$ for all). Full models for effect estimates of weight change and covariates are described in Appendix Tables 3 and 4.

Discussion

This study sheds light on the impact changes in neighborhood socioeconomic deprivation by moving can have on weight change and subsequent obesity. After accounting for covariates and the non-random chance of moving to a higher-NDI neighborhood, those who moved to a neighborhood of higher socioeconomic deprivation gained significantly more weight compared to those who moved to a lower-/equal- NDI neighborhood or remained in the same neighborhood. For those who moved to higher-deprivation neighborhoods, the impact of NDI change on weight gain increased with duration of neighborhood residence. This relationship was not significantly attenuated by participants' perceptions of their physical environment or overall neighborhood.

This study is among the first to evaluate the role of moving to higher-NDI areas on weight gain and demonstrate the impact of cumulative exposure to neighborhood deprivation on this relationship. These findings are consistent with longitudinal analyses comparing weight gain among non-movers in the DHS, which linked greater duration of residence in higher-NDI neighborhood to a greater likelihood of weight gain.[17] Changes in biomarkers, including cortisol and c-reactive protein, associated with living in disadvantaged neighborhoods suggest that sympathetic activation or alterations to the typical hypothalamic-pituitary-adrenal axis may contribute to a biological pathway by which exposure to neighborhood deprivation promotes weight gain.[27,28]

Prior to this study, few studies had specifically evaluated the role of residence length on weight change.[29,30] The MTO study described a dose–response effect for time residing in a lower-poverty census tract and decreased risk of Class II/III obesity for women.[11] This was described for a population choosing to participate in a randomized housing intervention, in contrast to our study, which utilized a natural experiment to evaluate the effects of moving to a higher-NDI area. In other selected studies evaluating physical activity and obesity-related health factors other than body weight, duration of residence was not found to play a significant role.[31,32]

Previous work evaluating physical activity as a mediator between neighborhood environment and weight change has yielded variable results.[33,34] This current study and the MTO study suggest that duration of deprivation exposure may have a particular impact on risk of obesity, possibly through mechanisms other than physical activity. Other potential explanatory variables that have been associated with neighborhood deprivation and that may play a mediating role in weight gain include health risk behaviors, such as high dietary fat intake and excessive alcohol consumption, and built environment factors such as neighborhood food retail.[35,36] It was not possible to investigate dietary measures such as dietary fat intake or built environment measures such as food retail given the available data for this study.

Overall, the present longitudinal study did not identify an impact for perceptions of the overall neighborhood or physical environment on the relationship between NDI change and weight change. Numeric differences in neighborhood environment perception scores between movers to higher-NDI neighborhoods and others in the study may not be large enough to be clinically meaningful. Prior DHS data examining the relationship between neighborhood perceptions and prevalent obesity demonstrated that those with prevalent obesity had at least a 10-point greater perception score compared to those without obesity.[19] Previous literature has explored the influence of perceptions of built environment on obesity and health behaviors with mixed results. These include cross-sectional investigations of perceptions of crime and perceived support for physical activity and healthy behaviors, and a longitudinal study of perceived versus objective walkability.[29,37,38] Gustat et al.[38] described a cross-sectional relationship between perceptions of physical activity policies and support towards healthy behaviors in one's neighborhood and reduced BMI. Other work demonstrated a cross-sectional relationship between perceived access to neighborhood amenities such as parks, playgrounds, or open space and decreased odds of obesity.[39] By contrast, perceptions did not attenuate the cross-sectional relationship between walkability and weight change.[29] Nonetheless, more-recent data examining discordance between perceived and objective neighborhood data identified urbanity as a potential modifying factor and supported inclusion of perceptions in addition to objective data in studies of the built environment and health.[40]

The DHS design addresses a major weakness of previous studies by identifying a large, diverse sample with a substantial percentage of movers. Advantages of studying moving within the DHS natural experiment include the longitudinal multiethnic DHS cohort, which allowed for exploration of potential causal mechanisms between NDI change and weight change. The detailed collection of physical and psychosocial data for DHS participants made it feasible to account for potential attenuators of the relationship, including perceptions of both overall and physical neighborhood environment.

By utilizing detailed examination findings including anthropometric measures rather than self-reported measures for main study outcomes, this study was able to avoid information bias due to self-report. DHS also utilized a validated survey tool to investigate neighborhood perceptions, which has been associated with health outcomes, including diabetes.[41] Other studies have evaluated the impact of neighborhood changes on health behaviors, but have not fully accounted for issues of self-selection, which previous research has suggested can lead to underestimation or overestimation of effect strength.[42,43] This study aimed to minimize this source of bias with inclusion of the HCF to account for the non-random chance of moving. Use of the HCF, which is typical to econometric studies, is a novel approach to account for self-selection bias within built environment research.[24–26] Still, this study is not without limitations. The DHS population is limited to one urban county, limiting generalizability compared to studies utilizing more-representative cohorts. The study uses a validated, but self-reported physical activity measure and lacks information on dietary intake, which are important considerations in evaluating differences in weight change. Differences between movers and non-movers that are difficult to account for, including individual and social factors influencing neighborhood selection, may reduce the magnitude of the causal impact of new neighborhood on health, though the HCF was intended to mitigate this difference.[44] Overall, these results are hypothesis generating and suggest the relationship between neighborhood deprivation change with moving and weight change is an area worthy of further study. Alternative approaches, such as studying health outcomes in neighborhoods undergoing rapid growth or decline, gentrification, or poverty increases, could help delineate the impact of changes in deprivation over time on weight gain, independent of moving.

Thus, change in neighborhood environment generated by moving to a neighborhood of higher socioeconomic deprivation was associated with increased weight gain in the DHS cohort. The results suggest a link between neighborhood NDI and weight gain. This relationship appears to be strengthened by increasing residence length in the new neighborhood, further suggesting that cumulative exposure duration to neighborhood deprivation impacts the potential for obesity and obesity-related cardiovascular morbidity. The relationships were not significantly influenced by participants' perceptions of neighborhood environment, and further work is needed to identify psychosocial and built environment factors contributing to the risk of obesity and related cardiovascular outcomes. For the DHS cohort, this study identifies exposure to higher-deprivation neighborhoods with moving as a risk factor for weight gain, and suggests a potential source of disparities that can be addressed through focused community-based public health initiatives. More broadly, addressing neighborhood deprivation as a risk factor for obesity and obesity-related cardiovascular disease requires consideration of public policy that can address sources of deprivation.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Baseline Characteristics-Movers to Higher NDI Neighborhood and Others in DHS, 2000–2009 (N=1,835)

	Movers to higher NDI	Others[a]	*p*-value
Unweighted sample size (N)	263	1,572	
Range of baseline deprivation index[b]	−6.47,0	0, 4.87	
Mean age, mean (SD), years	43.77 (10.41)	40.74 (10.27)	**0.00001**
Female sex, N (%)	911 (58%)	151 (57%)	0.9
Race/Ethnicity			
Non-Hispanic black, N (%)	901 (57%)	155 (59%)	0.6
Non-Hispanic white, N (%)	431 (27%)	64 (24%)	0.3
Hispanic, N (%)	239 (15%)	44 (17%)	0.5
Education			
Less than high school, N (%)	281 (18%)	56 (21%)	0.2
High school, N (%)	505 (32%)	88 (33%)	0.7
Some college, N (%)	444 (28%)	66 (25%)	0.3
College grad or higher, N (%)	340 (22%)	53 (20%)	0.6
Annual income			
<$16,000, N (%)	264 (20%)	56 (24%)	0.2
$16,000 – $29,999, N (%)	301 (23%)	74 (31%)	**0.007**
$ 30,000 – $49,999, N (%)	338 (26%)	47 (20%)	0.05
$ 50,000 or higher, N (%)	400 (31%)	60 (25%)	0.1
Anthropometric measures			
BMI, mean (SD), kg/m^2	29.72 (6.84)	29.57 (7,4)	0.6
Waist-hip ratio, mean (SD)	0.91 (0.12)	0.9 (0.08)	0.6
Waist circumference, mean (SD), cm	99.73 (16.54)	99.41(12.25)	0.3
Health behaviors			
Physical activity ≥150 met/min-wk, N (%)	721 (49%)	114 (47%)	0.5
Current smoker, N (%)	391 (25%)	93 (36%)	**0.0003**
Neighborhood perceptions			
Neighborhood violence score[c], mean (SD)	3.78 (2.36)	4.06 (2.46)	**0.03**
Physical environment score[d], mean (SD)	10.93 (5.51)	10.68 (4.99)	0.9
Social cohesion score[e], mean (SD)	7.43 (3.2)	7.9 (3.3)	**0.03**
Total score[f], mean (SD)	22.13 (8.6)	22.65 (8,2)	0.2

Note: Boldface indicates statistical significance (*p*-value <0.05)

NDI, Neighborhood Deprivation Index; DHS, Dallas Heart Study

[a]Others includes those who moved to neighborhoods with lower NDI or same NDI and those who remained in the same NDI neighborhood.

[b]Median (interquartile Range) of baseline block group deprivation score.

[c]A higher perception of neighborhood violence score is representative of more unfavorable perceptions of the levels and types of neighborhood violence.

[d] A higher perception of neighborhood physical environment score is representative of more unfavorable perceptions of the neighborhood physical environment.

[e] A higher perception of neighborhood social cohesion score is representative of more unfavorable perceptions of the neighborhood social cohesion.

[f] Total perception of neighborhood environment scores were derived from sub-scores for perceived neighborhood violence, perceived neighborhood physical environment, and perceived social cohesion. A higher total score is representative of more unfavorable perceptions of overall neighborhood environment.

Table 2

Weight Change with Neighborhood Deprivation Increase due to Moving in DHS, 2000–2009 (N=1,835)

	Unadjusted[a]	**Adjusted for covariates**[a b]	**Adjusted for covariates**[a b] **+ overall neighborhood perceptions**	**Adjusted for covariates**[a b] **+ perceptions of physical environment**
	Estimate (95% CI)	Estimate (95% CI)	Estimate (95% CI)	Estimate (95% CI)
Change in weight[c]	0.34 (−0.21, 0.89)	**0.64 (0.09, 1.19)**	**0.65 (0.06, 1.24)**	**0.65 (0.09, 1.22)**

Note: Boldface indicates statistical significance (p<0.05)

DHS, Dallas Heart Study

[a]Multilevel models include terms accounting for clustering effects for repeated observations at individual level and clustering effects due to those living within the same block group.

[b]Models adjusted for age (continuous), age^2 (continuous), male sex (female sex as referent group), black race/Hispanic ethnicity (white race as referent group), current smoker (non-smoker as referent group), education (college graduate or higher as referent group), annual income ($50,000 and higher as referent group), physical activity (continuous), change in deprivation (continuous), survey year (survey year=0 for study entry and survey year=1 for follow-up with survey year=0 as the referent).

[c]Effect estimate derived from beta coefficient for unit of deprivation*survey year interaction term in the multilevel model. This effect estimate represents weight change in kilograms for every one unit increase in neighborhood deprivation index due to moving. Survey year represents time period in study (survey year=0 for study entry and survey year=1 for follow-up).

Table 3

Weight Change with NDI Increase for DHS Movers, Stratified by Neighborhood Residence Length, 2000–2009 (N=896)

	Less than or equal to 4 years in neighborhood (N=482)		**Greater than 4 years in neighborhood (N=414)**	
	Unadjusted[a]	**Adjusted for covariates[a,b]**	**Unadjusted[a]**	**Adjusted for covariates[a,b]**
	Estimate (95% CI)	Estimates (95% CI)	Estimates (95% CI)	Estimates (95% CI)
Weight measures				
Change in weight[c]	0.32 (−0.48, 1.12)	0.57 (−0.27, 1.41)	0.69 (−0.11, 1.49)	**0.85 (0.08, 1.62)**
Change in weight Adjusted for[d]:				
Perceptions of overall neighborhood environment[e]		0.64 (−0.29, 1.57)		**0.80 (0.01, 1.60)**
Perceptions of physical environment[f]		0.63 (−0.21, 1.48)		**0.85 (0.08, 1.62)**

Note: Boldface indicates statistical significance (p<0.05)

NDI, Neighborhood Deprivation Index; DHS, Dallas Heart Study

[a]Multilevel models include terms accounting for clustering effects for repeated observations at individual level and clustering effects due to those living within the same block group.

[b]Models adjusted for age (continuous), age^2 (continuous), male sex (female sex as referent group), black race (white race as referent group), Hispanic ethnicity (non-Hispanic white ethnicity as the referent group), current smoker (non-smoker as referent group), education (college graduate or higher as referent group), annual income ($50,000 as referent group), physical activity (continuous), change in deprivation (continuous), time (DHS 1 as referent group).

[c]Effect estimate derived from beta coefficient for unit of deprivation*survey year interaction term in the multilevel model. This effect estimate represents weight change in kilograms for every one unit increase in neighborhood deprivation index due to moving. Survey year represents time period in study (survey year=0 for study entry and survey year=1 for follow-up).

[d]Effect estimate for the additional change of weight models derived from beta coefficient for unit of deprivation*survey year interaction term in model adjusted for age, age^2, male sex, black race/Hispanic ethnicity, education, annual income, current smoker and additional covariates (perceptions of overall neighborhood environment or perceptions of physical environment)

[e]Perceptions of overall neighborhood environment added to model as a continuous variable based on derived score.

[f]Perceptions of physical environment added to model as a continuous variable based on derived score.