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Original Contribution

Neighborhood Disadvantage and Body Mass Index: A Study of Residential Relocation

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Natural experiments, such as longitudinal observational studies that follow-up residents as they relocate, provide a strong basis to infer causation between the neighborhood environment and health. In this study, we examined whether changes in the level of neighborhood disadvantage were associated with changes in body mass index (BMI) after residential relocation. This analysis included data from 928 residents who relocated between 2007 and 2013, across 4 waves of the How Areas in Brisbane Influence Health and Activity (HABITAT) study in Brisbane, Australia. Neighborhood disadvantage was measured using a census-derived composite index. For individual-level data, participants self-reported their height, weight, education, occupation, and household income. Data were analyzed using multilevel, hybrid linear models. Women residing in less disadvantaged neighborhoods had a lower BMI, but there was no association among men. Neighborhood disadvantage was not associated with within-individual changes in BMI among men or women when moving to a new neighborhood. Despite a growing body of literature suggesting an association between neighborhood disadvantage and BMI, we found this association may not be causal among middle-aged and older adults. Observing associations between neighborhood socioeconomic disadvantage and BMI over the life course, including the impact of residential relocation at younger ages, remains a priority for future research.

deprivation; inequality; inequity; mobility; natural experiment; obesity

Abbreviations: BMI, body mass index; IRSD, Index of Relative Socioeconomic Disadvantage; HABITAT, How Areas in Brisbane Influence Health and Activity.

Poorer health behaviors and outcomes among residents of socioeconomically disadvantaged neighborhoods have been observed in several studies, even after adjusting for individual-level socioeconomic position (1–6). Researchers have called for an increased understanding of the social context (i.e., the circumstances within which people live) that poor health manifests (7), and the need to focus on risk factors for chronic disease, like overweight and obesity (8). Positive associations have been found between body mass index (BMI) and several noncommunicable diseases, including type 2 diabetes, coronary heart disease, and stroke (8), and, in some studies, all-cause mortality (9). Higher BMI has also been associated with higher rates of discrimination, social exclusion, and lower income and unemployment (8, 10). The prevalence of obesity worldwide almost doubled between 1980 and 2014 (8). In 2014, approximately 38% of men and 40% of women were classified as overweight (BMI ≥25, calculated by dividing weight in kilograms by squared height in meters), and 11% of men and 15% of women as obese (BMI ≥30) (8).

Establishing strong evidence of the relationship between neighborhood disadvantage and BMI is an important step in understanding how the neighborhood environment might be related to the likelihood of being overweight or obese. Progress has been made in understanding the potential mechanisms that might explain this relationship. For example, a systematic review of built environments and obesity among disadvantaged populations revealed that residents of disadvantaged neighborhoods were disproportionately exposed to environments that lacked food stores and places to exercise, had aesthetic problems, and had worse traffic- or crime-related safety and that BMI was being adversely affected by a number of these environmental characteristics (11). However, gaps in our understanding of the relationship between neighborhood disadvantage and BMI remain.

In several cross-sectional studies (12–14), it has been demonstrated that residents of more-disadvantaged neighborhoods were more likely to be overweight or obese, after data were adjusted for individual socioeconomic position. However, cross-sectional studies, by their design, provide weak evidence for causal inference because they do not provide explicit information about temporal precedence. Causal relationships are most validly established through experimental designs such as randomized controlled trials in which individuals are randomly assigned to intervention or control groups, and exposure and outcomes are measured before and after the intervention. However, when conducting community-based research, randomized experiments are often not feasible, practical, or ethical (15).

Natural experiments, such as those in which participants move residences and, therefore, are exposed to different environmental conditions over time, provide a more appropriate design for examining causal effects of neighborhoods on health (16, 17). In such studies, researchers are able to observe changes in the level of neighborhood disadvantage exposure, along with changes in BMI, and therefore can provide a strong basis to infer causation (18). Furthermore, longitudinal studies of neighborhood disadvantage and BMI that examine trends over time and make between-individual comparisons (19–21) are often limited by their inability to control for unmeasured time-invariant confounding. In contrast, in natural experiment studies in which changes in the level of neighborhood disadvantage exposure are observed, researchers are able to make within-individual comparisons. Such comparisons, by their design, automatically control for unobserved confounding by individual-level covariates that do not change over time. Among previous studies using this approach, Powell-Wiley et al. (22) found that moving to more socioeconomically deprived neighborhoods was associated with weight gain among participants in the Dallas Heart Study. Hirsch et al. (23) and Wasfi et al. (24) found that moving to a neighborhood with a higher Walk Score (a composite measure of walkability) was associated with a reduction in BMI; and Halonen et al. (25) found that moving away from green space increased the odds of obesity.

In this investigation, we used a multilevel longitudinal (2007–2013) cohort study of neighborhoods and health to examine whether changes in the level of neighborhood disadvantage were associated with changes in BMI during residential relocation. In line with previous investigations of the relationship between neighborhood disadvantage and BMI, which observed a stronger socioeconomic gradient among women (13, 26, 27), our analysis was stratified by sex.

METHODS

Data from the How Areas in Brisbane Influence Health and Activity (HABITAT) project were used. HABITAT is a multilevel longitudinal (2007–2018) study of middle-aged adults (40–65 years old in 2007) living in Brisbane, Australia. The primary aim of HABITAT is to examine patterns of change in physical activity, sedentary behavior, and health over the period 2007–2018 and to assess the relative contributions of environmental, social, psychological, and sociodemographic factors to these changes. Details about HABITAT's sampling design have been published elsewhere (28). Briefly, a multistage probability sampling design was used to select a stratified random sample (n = 200) of census collector districts (from a total of 1,625) from the Australian Bureau of Statistics; from within each census collector district, a random sample of people aged 40–65 years (n = 16,127) was selected.

Census collector districts at baseline contained an average of 203 (standard deviation, 81) occupied private dwellings and are embedded within a larger suburb, hence the area corresponding to, and immediately surrounding, a census collector district is likely to have meaning and significance for their residents. For this reason, we hereafter use the term "neighborhood" to refer to census collector districts. During the course of the study, several participants moved residences such that the derived number of HABITAT neighborhoods for each of the waves was 200 in 2007, 415 in 2009, 576 in 2011, and 724 in 2013 (neighborhoods outside of Brisbane were not included).

A questionnaire was sent during May–July in 2007, 2009, 2011, and 2013, using the mail survey method developed by Dillman (29). After excluding out-of-scope respondents (i.e., deceased, no longer at the address, unable to participate for health-related reasons), the total number of usable surveys returned at baseline was 11,035 (68.3% response). This sample was broadly representative of the Brisbane population (4). Response rates were 7,866 (72.6%) for wave 2, 6,900 (67.3%) for wave 3, and 6,520 (67.1%) for wave 4. The HABITAT study was approved by the Human Research Ethics Committee of the Queensland University of Technology (reference no. 3967H).

Exposure measure

Neighborhood disadvantage. Each neighborhood was assigned a socioeconomic score, using the Australian Bureau of Statistics' Index of Relative Socioeconomic Disadvantage (IRSD) (30). IRSD scores are calculated using census data and derived using principal component analysis. A neighborhood's IRSD score reflects each area's overall level of disadvantage measured on the basis of 17 variables that capture a wide range of socioeconomic attributes, including education, occupation, income, unemployment, household structure, and household tenure (among others). For this study, the IRSD scores for each of the HABITAT neighborhoods were quantized as percentiles, relative to all of Brisbane. Neighborhoods were grouped into quintiles on the basis of their disadvantage scores, with 1 denoting the 20% least disadvantaged areas relative to the whole of Brisbane and 5 the most disadvantaged 20%.

Outcome measure

Body mass index. For each survey, participants were asked "how tall are you without shoes on?" and were able to respond in either centimeters or feet and inches; and "how much do you weigh without your clothes or shoes on?" and were able to respond in either kilograms or stones and pounds. BMI was calculated as weight in kilograms, divided by height in meters squared.

Confounders

Education. Participants were asked to provide information about their highest educational qualification attained in the baseline survey. Responses were coded as 1) undergraduate degree or higher (including postgraduate diploma, master's degree, or doctorate), 2) community or junior college (associate degree), 3) vocational (trade or business certificate or apprenticeship), or 4) no postschool qualifications.

Occupation. Participants who were employed at the time of completing each survey were asked to indicate their job title, which was subsequently coded to the Australian Standard Classification of Occupations (31). The original 9-level Australian Standard Classification of Occupations classification was recoded into the following 6 categories: 1) managers/professionals (i.e., managers and administrators, professionals, and paraprofessionals), 2) white-collar employees (i.e., clerks, salespersons, and personal service workers), 3) blue-collar employees (i.e., tradespersons, plant and machine operators and drivers, laborers and related workers), 4) home duties, 5) retired, or 6) not easily classifiable (i.e., not employed, students, permanently unable to work, or other). Because of the small number of men whose occupation was classified as home duties ($n = 11$ observations), these participants were absorbed into the "not easily classifiable" category.

Household income. Participants were asked to estimate their total pretax annual household income using a single question with 13 categorical responses at each survey. For analysis, these were recoded into the following 7 categories: 1) more than A$130,000, 2) A$129,999–72,800, 3) A$72,799–52,000, 4) A$51,999–26,000, 5) <A$25,999, 6) "Don't know," or 7) "Don't want to answer this."

Neighborhood self-selection. To assess residential attitudes, participants were asked to respond on a 5-item Likert scale, ranging from "strongly disagree" to "strongly agree," to 14 statements regarding "How important were the following reasons for choosing your current address?" Examples of items included "Ease of walking to places," "Closeness to schools," "Closeness to open spaces (e.g., parks)," and "Closeness to public transport." According to principal components analysis with varimax rotation, 8 of the 14 items loaded onto 3 factors, subsequently described as "destinations" (3 items, $\alpha = 0.81$), "nature" (3 items, $\alpha = 0.78$), and "family" (2 items, $\alpha = 0.62$).

Statistical analysis

The analytic sample included participants who changed address at some point during the study. Participants who returned to the study after a nonresponse and had moved were included in the sample. Details of how the sample was derived are presented in Web Figure 1 (available at https://academic.oup.com/aje). A total of 898 participants (97%) were included in the analytic sample after exclusion of those who were not the same participants at follow-up ($n = 30$; e.g., the survey was completed by another member of the household). There were, therefore, a total of 3,226 observations over the 4 data collections, out of a possible 3,592 (90%).

An analysis of factors related to attrition revealed that participant drop out was associated with demographic variables but not to prior values of BMI (the outcome variable). When drop out is related to covariates only and not to prior or missing values of the outcome variable, the drop-out pattern is called (conditionally on the covariates) missing at random. Model estimates are unbiased under this pattern provided the covariates related to drop out are included in the models and that there are no additional unmeasured covariates related to drop out (32).

All models were adjusted for the following potential confounders: age, education, occupation, household income, and neighborhood self-selection. The reference groups for analysis were the least disadvantaged neighborhoods (quintile 1), undergraduate degree or higher (education), managers and professionals (occupation), and income greater than A$130,000 (household income). With the exception of education (only measured at wave 1) and neighborhood self-selection (only measured at wave 1 and after moving), all variables were observed at each wave, with 2 years in between the waves (data were collected in 2007, 2009, 2011, and 2013) such that time was measured from 0 (baseline) to 3. Changes in neighborhood disadvantage during the study are shown in a transition table (Table 1), in which the rows reflect the baseline quintile of neighborhood disadvantage, and the columns reflect the final quintile.

The association between changes in neighborhood disadvantage and changes in BMI was examined using 3-level mixed-effects linear regression models. Observations varied over time

Table 1. Transitions Between Quintiles of Neighborhood Disadvantage[a] During Residential Relocation, How Areas in Brisbane Influence Health and Activity Study, 2007–2013[b]

Sex and Quintile of Baseline Distribution	Final Distribution by Quintile, %				
	1	2	3	4	5
Men[c]					
1	73.7	19.1	4.4	1.4	1.4
2	17.0	56.9	13.3	6.4	6.4
3	9.1	18.3	46.9	21.1	4.6
4	3.8	9.7	19.5	56.2	10.8
5	2.3	6.8	6.8	11.4	72.7
Women[d]					
1	65.7	22.0	5.9	2.4	4.0
2	23.4	52.4	12.6	5.2	6.5
3	5.3	14.5	56.5	19.8	3.9
4	4.5	9.4	17.8	56.4	11.9
5	2.9	3.5	9.8	19.7	64.2

[a] Neighborhoods were grouped into quintiles on the basis of their disadvantage scores, with 1 denoting the 20% least disadvantaged areas relative to the whole of Brisbane and 5 the most disadvantaged 20% for each wave.

[b] This table reports the change in categories of neighborhood disadvantage over time. For example, 73.7% of men located in quintile 1 at baseline moved to a neighborhood with the same level of disadvantage, 19.1% moved to quintile 2, and 4.4% moved to quintile 3.

[c] $n = 1,417$ observations.

[d] $n = 1,690$ observations.

within individuals and were specified at level 1. These observations, therefore, were clustered within individuals who were specified at level 2, and these individuals were clustered within neighborhoods, which were specified at level 3. As individuals moved residences, they belonged to more than 1 neighborhood during the study, representing a multiple-membership data structure (33). The model had continuous measures for neighborhood disadvantage and BMI, with the former entered as a fixed effect decomposed into within- and between-individual differences, otherwise referred to as a hybrid model (18), and was adjusted for age (entered as a continuous variable), education, neighborhood self-selection, and changes in occupation and household income (entered into the model as decomposed fixed effects). Because occupation and household income are categorical variables, several 0–1 dummy indicator variables were created; then variables were created for the mean and deviation from the mean for each category and entered into the model separately. The coefficients represent the change in BMI associated with a 1-quintile increase in neighborhood disadvantage (i.e., moving 1 quintile from a more advantaged neighborhood to a more disadvantaged neighborhood). Models were undertaken separately for men and women. Data were prepared in Stata SE, version 15 (StataCorp LP, College Station, Texas) (34), and models were completed using MLwIN, version 3.01 (35).

RESULTS

Overall, 857 participants (92.4%) moved once during the study, with an additional 68 participants (7.3%) moving twice, and 3 participants (0.3%) moving a third time. The sociodemographic characteristics and mean (95% confidence interval) BMI for waves 1 and 4 are presented in Table 2. Men living in quintile 2 had the lowest mean BMI at baseline, and those living in least disadvantaged neighborhoods (quintile 1) had the lowest mean BMI at wave 4; men living in the most disadvantaged neighborhoods had the highest mean BMI at both baseline and wave 4. Women living in the least disadvantaged neighborhoods had the lowest mean BMI, and those living in the most disadvantaged neighborhoods had the highest mean BMI at both baseline and wave 4.

Changes in neighborhood disadvantage over the duration of the study are presented as a transition table (Table 1). Most participants moved to a neighborhood within the same quintile of neighborhood disadvantage. For example, among men who were located in quintile 1 (least disadvantaged) at baseline, 73.7% moved to a neighborhood of the same level of neighborhood disadvantage. Among men who changed their quintile of neighborhood disadvantage, the largest change was from quintiles 3 to 4, and the smallest changes were between quintiles 1 and 4 and between quintiles 1 and 5. Among women, the largest change was between quintiles 2 and 1, and the smallest was between quintiles 1 and 4.

Associations between neighborhood disadvantage and BMI are presented in Table 3. The between-individual coefficients show that women living in more disadvantaged neighborhoods had, on average, a higher BMI score, but this was not true for men. The within-individual coefficients show that moving to a new neighborhood with a 1-quintile increase in disadvantage (i.e., moving to a more disadvantaged neighborhood) was not associated with a within-individual increase in BMI among men or women.

DISCUSSION

In the present study, we examined whether changes in neighborhood disadvantage were associated with changes in BMI. Although, on average, women living in the most disadvantaged neighborhoods had a higher BMI, the findings did not reveal any associations between changes in the level of neighborhood disadvantage and BMI for either sex. This finding is inconsistent with that of Powell-Wiley et al. (22), who found that among participants in the Dallas Heart Study, moving to more socioeconomically deprived neighborhoods was associated with weight gain. Both studies had similar sample sizes ($n = 896$ vs. $n = 928$ in the present study), follow-up periods (7 years vs. 6 years), and measures of neighborhood deprivation (both census derived); however, the studies differed by measurement of BMI (objective vs. self-report in the present study), setting (United States vs. Australia), and sample age (18–65 years vs. 40–65 years at baseline).

Despite the finding of an association between neighborhood disadvantage and BMI in several cross-sectional studies (12–14), we found that changes in the level of neighborhood disadvantage were not associated with changes in BMI among residents who moved neighborhoods. There are several possible reasons why an association was not found. First, it is important to note that, among women in our study, there was a between-individual association between neighborhood disadvantage and BMI, which was not evident when examined within individuals; it is possible, therefore, that prior studies may have been biased from unaccounted time-invariant confounding. Second, we observed greater variation in BMI between individuals than within individuals over time. A lack of power to detect a small effect size may have explained the null association within individuals in the present study. Specifically, within-individual changes in BMI are biologically constrained because an individual's weight can only change so much within a given time. Therefore, limited variability in BMI over a relatively short time (such as in our study) may result in low power to detect change. The differences in time-invariant confounding by sex in this study highlight the importance in future studies that explore the relationship between neighborhood disadvantage and BMI of examining the relationship by sex and ensuring that there is sufficient variation in the exposure to allow for within-individual comparisons that account for this type of confounding.

Researchers have posited that the influence of the social context plays out over time (7), and that the effect of exposure to social conditions is likely to appear over time (36–39). It is possible that the impact of neighborhood disadvantage on BMI may have already played out during earlier years, and that by mid to late adulthood, a change in the level of neighborhood disadvantage is ineffectual. Differences in the relationship between neighborhood disadvantage and BMI between age groups might also explain why our findings differ from those of by Powel-Wiley et al. (22) and would also be consistent with the World Health Organization report "Closing the Gap in a Generation," by the Commission on

Table 2. Sociodemographic Characteristics and Body Mass Index in Participants in the Analytic Sample Aged 40–65 Years at Baseline, How Areas in Brisbane Influence Health and Activity, 2007–2013

Sociodemographic Characteristic	BMI[a] in Men						BMI[a] in Women					
	2007 (n = 394)			2013 (n = 345)			2007 (n = 462)			2013 (n = 426)		
	%	Mean	95% CI	%	Mean	95% CI	%	Mean	95% CI	%	Mean	95% CI
Neighborhood disadvantage												
Quintile 1 (least disadvantaged)	30.5	26.85	26.20, 27.50	25.2	26.93	26.23, 27.64	35.1	25.06	24.16, 25.96	24.4	24.57	27.72, 25.41
Quintile 2	17.5	26.17	25.39, 26.95	23.5	27.54	26.70, 28.38	17.1	26.24	24.78, 27.70	23.0	25.73	24.81, 26.65
Quintile 3	18.3	27.80	26.73, 28.88	16.2	27.64	26.42, 28.85	15.2	25.21	23.80, 26.62	18.1	26.70	25.03, 28.37
Quintile 4	21.1	27.88	26.65, 29.12	19.4	27.61	26.63, 28.59	18.2	26.88	25.53, 28.23	20.2	27.38	26.26, 28.51
Quintile 5 (most disadvantaged)	12.7	27.95	26.27, 29.62	15.7	28.75	26.49, 31.00	14.5	27.46	26.06, 28.86	14.3	28.51	26.75, 30.26
Age, years												
40–44	34.5	27.26	26.45, 28.08				25.5	25.07	23.85, 26.28			
45–49	21.1	28.16	27.10, 29.22	30.7	27.38	26.54, 28.22	22.3	25.98	24.64, 27.32	20.0	25.67	24.70, 26.64
50–54	20.6	26.51	25.69, 27.33	22.0	27.75	26.82, 28.69	21.7	26.38	25.21, 27.55	23.9	25.83	24.61, 27.06
55–59	16.0	26.92	25.91, 27.92	20.9	27.42	25.89, 28.96	17.1	26.36	25.29, 27.44	21.6	27.33	25.93, 28.74
60–65	7.9	27.51	25.38, 29.64	18.0	28.18	29.99, 29.36	13.4	26.47	25.20, 27.73	21.6	26.35	25.18, 27.52
66–70				8.4	27.27	25.79, 28.74				12.9	26.75	25.44, 28.02
Education												
Undergraduate degree or higher	38.8	27.19	26.54, 27.85	39.4	27.54	26.67, 28.41	32.3	25.05	24.14, 25.96	32.9	25.46	24.56, 26.35
Community or junior college	13.2	26.06	25.36, 26.77	11.9	26.08	25.05, 27.10	11.5	26.03	24.45, 27.62	12.7	26.27	24.88, 27.66
Vocational	18.0	26.76	25.94, 27.59	19.1	27.70	26.69, 28.71	17.1	25.44	24.38, 26.51	14.8	26.34	24.86, 27.82
No postschool qualification	30.0	28.18	27.06, 29.30	29.6	28.24	27.18, 29.31	39.2	26.92	25.91, 27.93	39.7	27.13	26.19, 28.06
Occupation												
Professional	47.2	27.57	26.94, 28.20	43.2	27.52	26.76, 28.27	40.0	25.51	24.65, 26.37	38.7	25.49	24.75, 26.23
White collar[b]	15.5	26.15	25.23, 27.06	16.5	27.47	26.19, 28.75	28.1	25.84	24.78, 26.89	24.9	26.33	25.33, 27.33
Blue collar[c]	19.5	27.57	26.43, 28.72	18.6	28.30	27.18, 29.41	6.1	25.45	23.78, 27.12	4.9	26.83	24.86, 27.79
Home duties							7.8	25.60	23.89, 27.30	7.0	26.12	23.79, 28.45
Retired	3.3	26.10	24.39, 27.81	12.8	26.60	25.54, 27.67	6.1	26.69	24.92, 28.47	15.3	26.96	25.49, 28.44
Not easily classifiable	14.5	27.30	25.78, 28.81	9.0	28.28	25.57, 30.99	11.9	27.93	25.79, 30.06	9.2	28.95	26.05, 31.85
Income, A$												
≥130,000	26.9	27.38	26.57, 28.20	37.4	27.56	26.89, 28.23	20.4	25.21	23.86, 26.55	22.3	24.78	24.02, 25.54
72,800–129,999	33.0	27.04	26.28, 27.81	26.1	27.02	26.20, 27.83	24.5	24.99	24.19, 25.78	28.9	26.06	25.05, 27.08
52,000–72,799	16.5	27.15	26.27, 28.03	13.3	27.83	26.53, 29.13	18.0	25.91	24.84, 26.98	11.3	26.11	24.52, 27.72
26,000–51,599	9.9	28.16	26.16, 30.16	10.4	28.31	25.88, 30.74	19.3	26.19	24.75, 27.64	18.3	27.52	26.18, 28.85
<25,999	5.3	27.69	25.25, 30.13	6.1	29.73	25.66, 33.81	9.3	29.96	27.37, 32.55	8.7	28.02	25.83, 30.21
Respondent did not know	1.5	22.88	20.20, 25.56	1.7	26.94	24.62, 29.26	1.5	27.73	24.28, 31.18	3.1	27.29	24.62, 29.97
Respondent did not want to answer	6.9	27.44	25.34, 29.55	4.9	25.67	25.01, 28.13	7.1	25.42	23.83, 27.00	7.5	27.35	24.34, 30.36

Abbreviations: BMI, body mass index; CI, confidence interval.
[a] Weight (kg)/height (m)^2.
[b] Clerks, salespersons, and personal service workers.
[c] Tradespersons, plant and machine operators and drivers, laborers and related workers.

Table 3. Neighborhood Disadvantage and Body Mass Index: Hybrid Effects Models[a], HABITAT Study, 2007–2013

Model	Men[b]			Women[c]		
	β	95% CI	SE	β	95% CI	SE
Fixed effects						
Between-individual	0.22	−0.14, 0.55		0.82	0.48, 1.16	
Within-individual	0.15	−0.15, 0.44		−0.08	−0.38, 0.22	
Random effects						
Between-neighborhood variation	2.44		0.97	0.00		0.00
Between-individual variation	14.91		1.19	26.61		1.39
Within-individual variation	3.84		0.22	5.10		0.27

Abbreviations: CI, confidence interval; SE, standard error.
[a] Adjusted for age, education, neighborhood self-selection, and changes in occupation and household income.
[b] $n = 1{,}417$ observations.
[c] $n = 1{,}690$ observations.

the Social Determinants of Health (40). The report includes a chapter titled "Equity From the Start" (41), in which it is suggested that targeted investment in mitigating the influence of exposure to poor neighborhood social conditions in early life is likely to yield greater benefits for reducing levels of overweight and obesity than those targeted at middle-aged and older adults. According to the findings from our study, for policy makers and public health advocates, breaking the link between neighborhood disadvantage and BMI may not be as simple as relocating individuals to neighborhoods of a lower level of disadvantage. Future research should endeavor to observe associations between levels of neighborhood socioeconomic disadvantage and BMI over the life course, examining the impact of residential relocation on this relationship in the younger years, and observing how this might affect BMI and other health risk factors in mid to late adulthood. Furthermore, the characteristics of disadvantaged neighborhoods that are likely to affect BMI through etiological, behavioral pathways, including neighborhood walkability, healthy food availability, and social cohesion (13, 42–44), remain priorities for future research.

There are several strengths and limitations that should be considered when generalizing this study's findings. A major strength of this study was that we conducted within-individual analysis. This accounts for all time-invariant confounding, while we also accounted for additional time-variant confounding, such as changes in individual-level occupation and household income, both of which have been shown to be consistently associated with BMI (45). We also adjusted for self-selection into the neighborhood, which has been identified as a major confounder of epidemiologic studies of neighborhoods and health (17). Among the limitations, survey nonresponse in the HABITAT baseline study was 31.5%; it was slightly higher among residents from lower individual socioeconomic backgrounds and those living in more disadvantaged neighborhoods. The findings of this study may also be confounded by unobserved time-varying individual and neighborhood-level socioeconomic factors or by bias from the misclassification of self-reported responses. However, we included the 3 most commonly used indicators of individual-level socioeconomic position (i.e., education, occupation, and household income (46)), and the neighborhood-level IRSD measure, which forms the basis of our neighborhood disadvantage measure, provides a comprehensive assessment of neighborhood-level disadvantage (30). The use of self-reported height and weight to calculate BMI is subject to measurement error that may result in the underestimation of BMI. This underestimation appears to be higher as measured BMI increases and may differ in women and men (47). However, the within-individual comparisons mean that if this measurement error is constant over time within individuals, then bias from measurement error is negated. It should also be noted that self-reported BMI is often used in large population studies, due to its ease of recording (48, 49), and that strong correlations have been found between self-reported and objectively measured height and weight (50). Another limitation of the study is the relatively small exposure gradient. Most people who moved remained in the same quintile or adjacent quintiles of neighborhood disadvantage, which limited the power of the study. Furthermore, people move neighborhoods for various reasons, such as changes in life circumstances (51). It is possible that these reasons for moving may have been prior common causes for the relationship between neighborhood disadvantage and BMI. Last, longer follow-up periods after moving would have strengthened the study findings. A number of participants ($n = 228$) moved to a new address between the final 2 waves of the study, leaving a small amount of time to observe changes in BMI after the move. Furthermore, we only observed that participants were at a new address at the next data-collection wave; we did not know when participants moved between waves.

This study adds to the limited literature examining whether changes in the level of neighborhood disadvantage are associated with changes in BMI during residential relocation. Despite a growing body of literature suggesting an association between neighborhood disadvantage and BMI, we suggest, on the basis of our study findings, that neighborhood disadvantage may not be causally related to BMI among middle-aged and older adults.

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