Preventive Medicine 105 (2017) 271–274

Contents lists available at ScienceDirect

Preventive Medicine

journal homepage: www.elsevier.com/locate/ypmed

Short Communication

Neighborhood socioeconomic disadvantage and body mass index among residentially stable mid-older aged adults: Findings from the HABITAT multilevel longitudinal study

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ARTICLE INFO

Keywords:
Body mass index
Obesity
Multilevel modelling
Longitudinal
Neighborhood disadvantage
Residence characteristics
Social class

ABSTRACT

Despite a body of evidence on the relationship between neighborhood socioeconomic disadvantage and body mass index (BMI), few studies have examined this relationship over time among ageing populations. This study examined associations between level of neighborhood socioeconomic disadvantage and the rate of change in BMI over time. The sample included 11,035 participants aged between 40 and 65 years at baseline from the HABITAT study, residing in 200 neighborhoods in Brisbane, Australia. Data were collected biennially over four waves from 2007 to 2013. Self-reported height and weight were used to calculate BMI, while neighborhood disadvantage was measured using a census-based composite index. All models were adjusted for age, education, occupation, and household income. Analyses were conducted using multilevel linear regression models. BMI increased over time at a rate of 0.08 kg/m^2 (95% CI 0.02, 0.13) and 0.17 kg/m^2 (95% CI 0.11, 0.29) per wave for men and women respectively. Both men and women residing in the most disadvantaged neighborhoods had a higher average BMI than their counterparts living in the least disadvantaged neighborhoods. There were no evident differences in the rate of BMI change over time by level of neighborhood disadvantage. The findings suggest that by mid-older age, the influence of neighborhood socioeconomic conditions over time on BMI may have already played out. Future research should endeavor to identify the genesis of neighborhood socioeconomic inequalities in BMI, the determinants of these inequalities, and then suitable approaches to intervening.

1. Introduction

Neighborhood social and economic environments have been shown to contribute to poor health behaviors and outcomes (Badland et al., 2017; Ghani et al., 2016; Loh et al., 2016; Marmot et al., 2008; Rachele et al., 2016a; Rachele et al., 2016b; Rachele et al., 2015; Rachele and Turrell, 2016), and understanding how this relationship plays out over time has become a research priority (Glass and McAtee, 2006). The effect of exposure to social conditions appears to be cumulative: a dose-response association has been consistently observed between higher levels of exposure to social and economic disadvantage and increased disease risk (Hallqvist et al., 2004). Late life also appears to be a period of increasing vulnerability to the influence of disadvantage (Lantz et al., 2001). In this light, a number of cross-sectional studies have shown that adult residents of disadvantaged neighborhoods were more likely to be overweight or obese, even after adjusting for their individual socioeconomic position (King et al., 2006). The prevalence of obesity worldwide almost doubled between 1980 and 2014 (World Health Organization, 2015), with approximately 38% of men and 40% of women classified as overweight (BMI ≥ 25 kg/m^2), and 11% of men and 15% of women as obese (BMI ≥ 30 kg/m^2) in 2014 (World Health Organization, 2015). In Australia in 2014–15, 63.4% of adults were overweight or obese, up from 56.3% in 1995 (Australia Bureau of Statistics, 2015). Overweight and obesity are strongly linked to poor health and all-cause mortality (Di Angelantonio, 2016). Having a high body mass index (BMI) means that an individual is more likely to present with non-communicable diseases, including type 2 diabetes, coronary heart disease and stroke (World Health Organization, 2015).

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http://dx.doi.org/10.1016/j.ypmed.2017.09.017
Received 6 March 2017; Received in revised form 22 September 2017; Accepted 24 September 2017
Available online 27 September 2017
0091-7435/

High BMI can also have adverse social impacts including discrimination, social exclusion, reduced earning and unemployment (World Health Organization, 2015).

Longitudinal studies examining the rate of change in BMI over time provide mixed findings. For example, among a study of 48,359 African-American women from the United States who participated in the Black Women's Health Study, Coogan et al. (2010) found that lower neighborhood socioeconomic background was significantly associated with weight gain and incidence of obesity at 10 year follow-up. Among participants in the Whitehall II study in the United Kingdom, Stafford et al. (2010) found a significant association between living in a socioeconomically deprived neighborhood and weight gain among women (n = 2501) living in the most deprived neighborhood over 10 years, but no association among men (n = 5650). However, no association was found between weight gain and neighborhood disadvantage after nine year follow-up of 13,167 participants in the Atherosclerosis Risk in Communities Study (Mujahid et al., 2005), or after 16 year follow-up of 1487 women in the United States (Ruel et al., 2010). Feng and Wilson (2015) examined neighborhood disadvantage and BMI between 2006 and 2012 (seven waves) among participants aged 15 to 75 + years using the Household, Income and Labour Dynamics in Australia (HILDA) survey and found that neighborhood-level inequalities in BMI were already evident in the 15–24 year old age group. While neighborhood socioeconomic differences remained constant among men through the age groups, the gap became wider among women over time. From the age of 75 and older, neighborhood socioeconomic differences in BMI narrowed for both genders.

Against a back-drop of weight-gain as people age (Feng and Wilson, 2015), and evidence that demonstrates a relationship over time between exposure to social contexts and health (Glass and McAtee, 2006; Hallqvist et al., 2004), building the evidence base is an important step in understanding the influence of neighborhood socioeconomic disadvantage on rate of weight gain. Specifically, it will provide policymakers and intervention researchers with evidence about what age to intervene, in order to prevent inequalities in BMI widening between socioeconomic groups. Hence, this study examines whether the relationship between time and BMI differs depending on the level of neighborhood socioeconomic disadvantage, using data from the How Areas in Brisbane Influence healTh And acTivity (HABITAT) project. HABITAT is a multilevel longitudinal (2007–2018) study of mid-aged adults (40–65 years in 2007) living in Brisbane, Australia. Brisbane is the capital city of the state of Queensland, and the third largest city in Australia with a population of approximately 2.3 million and a median age of 35 in 2014 (Australian Bureau of Statistics, 2015). Rates of overweight and obesity among adults across greater metropolitan Brisbane vary from 58 to 62% (Australian Institute of Health and Welfare, 2016).

2. Methods

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 socio-demographic factors to these changes. Details about HABITAT's sampling design have been published elsewhere (Burton et al., 2009). Briefly, a multi-stage probability sampling design was used to select a stratified random sample. Overall, 1625 Census Collector's Districts (CCD) existed in Brisbane and had sufficient population to draw a sample. Those CCDs were ranked based on scores from the Australian Bureau of Statistics' Index of Relative Socioeconomic Disadvantage, divided into deciles, and 20 CCDs were randomly selected from each decile, yielding 200 areas for study inclusion. Data from the Australian Electoral Commission were then used to identify all households in each of the selected CCDs that had a least one person aged 40–65 years as at March 2007, and a random sample of n = 16,127 was invited to participate in the study (one participant per household). A total of 11,035 questionnaires with useable data were returned (response rate of 68.4%). This sample was broadly representative of the Brisbane population (Turrell et al., 2010). CCDs at baseline contained an average of 203 (SD 81) occupied private dwellings, and are embedded within a larger suburb; hence the area corresponding to, and immediately surrounding, a CCD is likely to have meaning and significance for their residents. For this reason, we hereafter use the term ‘neighborhood’ to refer to CCDs.

Questionnaires were sent during May–July in 2007, 2009, 2011 and 2013. Based on the original 11,035 respondents, response rates were 7866 (72.6%) for wave 2, 6900 (67.3%) for wave 3, and 6520 (67.1%) for wave 4. The HABITAT study was approved by the Human Research Ethics Committee of the Queensland University of Technology (Ref. no. 3967H).

2.1. Exposure measure

Neighborhood socioeconomic disadvantage was derived using scores from the Australian Bureau of Statistics' Index of Relative Socioeconomic Disadvantage (Australian Bureau of Statistics, 2006). An area's Index of Relative Disadvantage score reflects its 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. The derived socioeconomic scores from each of the HABITAT neighborhoods were then quantized as percentiles, relative to all of Brisbane. For analysis, neighborhoods were grouped into quintiles based on their disadvantage scores at baseline, with Q1 denoting the 20% least disadvantaged areas and Q5 the most disadvantaged 20%. This was done to be consistent and enable comparability with previous longitudinal studies of neighborhood disadvantage and BMI (Coogan et al., 2010; Feng and Wilson, 2015; Mujahid et al., 2005; Stafford et al., 2010).

2.2. 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.

2.3. Adjustment variables

All models were adjusted for age, education, occupation, and household income. With the exception of education (baseline only), all variables are observed at each wave, with two years in between the waves, and are included as time-varying factors in all models.

2.4. Statistical analysis

The analytic sample comprised of participants who lived at the same address until moving, or withdrawing from the study; and participants who returned to the study after a non-response, and remained at the same address.

The association between BMI and neighborhood disadvantage over time was examined using a three-level mixed effects linear regression model with observations (level 1), clustered within individuals (level 2) clustered within neighborhoods (level 3); with a continuous measure for BMI, and nominal categorical measure for neighborhood disadvantage, with Q1 (least disadvantaged neighborhoods) as the reference group. Initially, fixed-effects coefficients for time (fitted as a continuous variable) are presented, then for neighborhood disadvantage adjusted for age, education, occupation, and household income. An interaction term with time was then introduced, which assesses the rate of change in BMI for each neighborhood disadvantage

Table 1
Neighborhood disadvantage and body mass index: 2007 and 2013 for adults aged 40–65 years at baseline in the HABITAT analytic sample, Brisbane, Australia.

	2007		2013	
	%	Mean BMI (95% CI)	%	Mean BMI (95% CI)
Men	(n = 4593)		(n = 2056)	
Neighborhood disadvantage				
Q1 (least disadvantaged)	30.1	27.15 (26.91, 27.34)	21.2	26.97 (26.60, 27.34)
Q2	19.1	27.18 (26.89, 27.47)	27.1	27.37 (27.00, 27.73)
Q3	18.0	27.46 (27.13, 27.80)	20.6	27.90 (27.47, 27.34)
Q4	20.3	27.87 (27.50, 28.24)	18.5	28.17 (27.67, 28.67)
Q5 (most disadvantaged)	15.5	27.61 (27.17, 28.05)	12.6	28.18 (27.54, 28.82)
Women	(n = 5606)		(n = 2703)	
Neighborhood disadvantage				
Q1 (least disadvantaged)	29.5	25.54 (25.30, 25.79)	20.3	26.02 (25.54, 26.50)
Q2	19.9	25.96 (25.63, 26.28)	27.1	26.45 (26.09, 26.82)
Q3	16.3	26.28 (25.90, 26.66)	19.8	26.47 (25.99, 26.94)
Q4	20.5	26.93 (26.57, 27.30)	18.4	27.75 (27.21, 28.28)
Q5 (most disadvantaged)	13.8	27.75 (27.25, 28.26)	14.5	28.08 (27.40, 28.77)

quintile. Models were undertaken separately for men and women. Data were prepared in StataSE version 14 (StataCorp, 2013), and all models were completed using MLwIN version 2.35 (Rasbash et al., 2014).

3. Results

The socio-demographic characteristics and mean (95% confidence interval) BMI for waves 1 and 4 are presented in Table 1. Men living in the least disadvantaged neighborhoods (Q1) had the lowest mean BMI at both baseline and wave 4; while men in Q4 and Q5 had the highest mean BMI at baseline and wave 4 respectively. Women living in the least disadvantaged neighborhoods had the lowest BMI, and those living in the most disadvantaged neighborhoods had the highest BMI at both baseline and wave 4.

The results of the multilevel mixed effects linear regression between neighborhood disadvantage and BMI are presented in Table 2. BMI increased over time at a rate of 0.08 kg/m^2 (95% CI 0.02, 0.13) and 0.17 kg/m^2 (95% CI 0.11, 0.29) per wave for men and women respectively. Compared to their counterparts in Q1 (least disadvantaged neighborhoods), men residing in Q3 and Q4, and women living in Q3, Q4 and Q5 had a higher average BMI. There were no evident differences in the rate of change in BMI over time by level of neighborhood disadvantage for men or women.

Table 2
Body mass index differences by level of neighborhood socioeconomic disadvantage, 2007–2013 in the HABITAT analytic sample, Brisbane, Australia.

	Men (n = 12,004 observations)	Women (n = 15,307 observations)
	β (95% CI)	β (95% CI)
Fixed effects		
Time (0 = 2007)	0.08 (0.02, 0.13)**	0.17 (0.12, 0.23)***
Neighborhood disadvantage[a]		
Q1 (least disadvantaged)		
Q2	0.04 (−0.17, 0.24)	0.07 (−0.14, 0.28)
Q3	0.32 (0.04, 0.59)**	0.27 (−0.01, 0.55)
Q4	0.50 (0.19, 0.81)**	0.62 (0.30, 0.94)***
Q5 (most disadvantaged)	0.09 (−0.31, 0.48)	1.27 (0.86, 1.67)***
Neighborhood disadvantage * time[a]		
Q1 (least disadvantaged)		
Q2	0.07 (−0.06, 0.19)	−0.02 (−0.15, 0.10)
Q3	0.08 (−0.05, 0.21)	0.00 (−0.13, 0.12)
Q4	0.01 (−0.12, 0.13)	−0.03 (−0.15, 0.10)
Q5 (most disadvantaged)	0.19 (−0.01, 0.27)	−0.09 (−0.23, 0.04)

[a] Adjusted for age, education, occupation and household income
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

4. Discussion

This study examined the rate of change in BMI over time, and whether the relationship between time and BMI differed by level of neighborhood disadvantage. Although BMI increased over time for both men and women, there were no differences in the rate of BMI change by level of neighborhood disadvantage for either gender. Feng and Wilson (2015) found that neighborhood socioeconomic inequalities in BMI already existed among participants in the youngest age category (15–24 years), suggesting that the influence of exposure to neighborhood socioeconomic disadvantage may be more likely to occur in the younger years. However, Feng and Wilson (2015) did find that, while the rates of BMI change were relatively constant by neighborhood disadvantage among men, neighborhood inequalities among women widened until the age of 54 years. Post-hoc analysis in the current study among women who were 40–49 years of age at baseline (subsequently observed until the ages of 47–56 years) did not reveal any significant differences in the rates of BMI change by level of neighborhood disadvantage.

Several factors may limit the generalizability of this study's findings. Survey non-response in the HABITAT baseline study was 31.5%, and slightly higher among residents with lower individual socioeconomic profiles, and living in more disadvantaged neighborhoods. Another source of potential bias is the drop-out of participants. An analysis of factors related to participant drop-out revealed that drop-out was associated with some demographic variables (education, occupation, household income) but was not related 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 (Knuiman et al., 2014). 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 it is also possible that error in the reporting of height and weight varies by gender, and socioeconomic groups (Gorber et al., 2007). There is therefore some risk of bias in the current study's findings. Last, the neighborhood disadvantage measure was obtained via census data, and provided as a rank variable, rather than an absolute score. We were therefore unable to explore the functional form of the association between neighborhood disadvantage and BMI. However, post-hoc analysis of this association fitting neighborhood as a linear variable yielded similar findings.

The current study may have implications for those trying to break the link between exposure to neighborhood socioeconomic disadvantage and BMI. Specifically, it suggests that strategies designed to prevent inequalities widening between socioeconomic advantaged and disadvantaged neighborhoods should not target mid-older aged adults. While we did find that BMI increased significantly over time, and that those living in more disadvantaged neighborhoods had a higher BMI, BMI increased at the same rate for everyone regardless of the level of neighborhood disadvantage. While the rate of BMI increase needs to be addressed, the finding that the rate of BMI change did not appear to be differentially affected by neighborhood socioeconomic conditions should be taken as a positive. The findings from the current study suggest that by mid-older age, the influence of neighborhood socioeconomic conditions on BMI may have already played out. Future research should explore the associations between levels of neighborhood socioeconomic disadvantage and BMI among different age cohorts in an effort to identify the genesis of neighborhood socioeconomic inequalities in BMI, and the determinants of these inequalities, to inform intervention approaches.

Acknowledgments

The HABITAT study is funded by the National Health and Medical Research Council (NHMRC) (ID 497236, 339718, 1047453). JNR is supported by the NHMRC Centre for Research Excellence in Healthy Livable Communities (ID 1061404).

Conflicts of interest

None declared.

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