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A multilevel study of neighborhood disadvantage, individual socioeconomic position, and body mass index: Exploring cross-level interaction effects

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ABSTRACT

This study examined associations between neighborhood disadvantage and body mass index (BMI), and tested whether this differed by level of individual socioeconomic position (SEP). Data were from 9953 residents living in 200 neighborhoods in Brisbane, Australia in 2007. Multilevel linear regression analyses were undertaken by gender to determine associations between neighborhood disadvantage, individual SEP (education, occupation and household income) and BMI (from self-reported height and weight); with cross-level interactions testing whether the relationship between neighborhood disadvantage and BMI differed by level of individual SEP. Both men (Quintile 4, where Quintile 5 is the most disadvantaged $\beta = 0.66$ 95%CI 0.20, 1.12) and women (Quintile 5 $\beta = 1.32$ 95%CI 0.76, 1.87) from more disadvantaged neighborhoods had a higher BMI. BMI was significantly higher for those with lower educational attainment (men $\beta = 0.71$ 95%CI 0.36, 1.07 and women $\beta = 1.66$ 95%CI 0.78, 1.54), and significantly lower for those in blue collar occupations (men $\beta = -0.67$ 95%CI -1.09, -0.25 and women $\beta = -0.71$ 95%CI -1.40, -0.01). Among men, those with a lower income had a significantly lower BMI, while the opposite was found among women. None of the interaction models had a significantly better fit than the random intercept models. The relationship between neighborhood disadvantage and BMI did not differ by level of education, occupation, or household income. This suggests that individual SEP is unlikely to be an effector modifier of the relationship between neighborhood disadvantage and BMI. Further research is required to assist policy-makers to make more informed decisions about where to intervene to counteract BMI-inequalities.

1. Introduction

In Australia, obese adults (body mass index (BMI) $\geq 30\,kg/m^2$) are seven times more likely to have diabetes than those with a healthy BMI (≥ 18.5 to $< 25\,kg/m^2$), in addition to various other indicators for poor health including cardiovascular and liver disease (Australian Bureau of Statistics, 2013). Worldwide in 2014, approximately 38% of men and 40% of women were classified as overweight (body mass index (BMI) $\geq 25\,kg/m^2$), and 11% of men and 15% of women as obese (BMI $\geq 30\,kg/m^2$) (World Health Organization, 2015). BMI greater than $\geq 25\,kg/m^2$ is associated with many non-communicable diseases, including type 2 diabetes, coronary heart disease and stroke (World Health Organization, 2015). High BMI can also have adverse social impacts including discrimination, social exclusion, reduced earning and unemployment (World Health Organization, 2015).

Many studies have shown that residents of disadvantaged neighborhoods are more likely to be overweight or obese, after adjusting for their individual-level socioeconomic position (SEP) measured on the basis of education attainment, employment status and occupation, and income (Ellaway et al., 1997; King et al., 2006; Sundquist et al., 1999). The reasons for this relationship may reflect the environmental characteristics of more disadvantaged neighborhoods, and their association with overweight and obesity. For example, higher levels of walking are associated with lower BMI (Montgomerie et al., 2014). Neighborhood

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disadvantage is typically negatively associated with walkability (i.e. higher disadvantage and lower walkability) (Badland et al., 2017; Miles et al., 2008). Walkability reflects land use diversity (the mix of land uses such as those used for residential areas, shopping, employment, education and recreation), density (of dwellings, shops, services and jobs within a given area) and street connectivity (street layout and intersection density) (American Planning Association, 2006). In walkable neighborhoods, residents typically undertake more physical activity (Kärmeniemi et al., 2018). In another example, greater neighborhood disadvantage has also been associated a lack of health food availability (Black et al., 2010). The consumption of healthier foods is associated with lower BMI (Newby et al., 2003). The relationship between neighborhood disadvantage and BMI is likely to play out differently for men and women. This is because men and women are likely to have different experiences of neighborhood disadvantage. For example, previous research shows that greater neighborhood disadvantage is associated with high levels of crime (Graif et al., 2014), and that local crime is more likely to affect the physical activity of women than men (Foster and Giles-Corti, 2008).

Previous studies in this field have examined associations between neighborhood disadvantage and BMI (Feng and Wilson, 2015; King et al., 2006; Rachele et al., 2017) in a manner that assumes a uniform effect of neighborhood disadvantage across individual-level SEP. This gap in the literature is problematic and limits our understanding of the relationship between neighborhood disadvantage and BMI. The socioeconomic context of neighborhood environments is likely to affect individuals in different ways, depending on their individual-level socioeconomic characteristics. This is otherwise known in the literature as 'deprivation amplification', a process, applying across the whole range of environmental influences on health, by which disadvantages arising from poorer quality environments amplify individual disadvantages in ways which are detrimental to health (Macintyre and Ellaway, 2003; Macintyre et al., 1993). However, the etiology of overweight and obesity are multifaceted, and the deprivation amplification has since been revisited. It has been suggested that those investigating associations between neighborhoods and health consider that environmental resources are likely to vary, and that the presence or absence of resources is less important than characteristics such as quality, social meaning, or perception of accessibility or relevance (Macintyre, 2007). With these caveats noted, an example of deprivation amplification in this context is that there is a known negative association between neighborhood disadvantage and geographical accessibility of healthy food stores (Ball et al., 2009), and a positive association between level of education and food purchasing behavior through improved health literacy (Turrell and Kavanagh, 2006). It is therefore plausible that the association between lower accessibility of healthy food stores in a disadvantaged neighborhood and BMI may be amplified by the food purchasing behavior of an individual from a lower level of education.

Despite existing evidence demonstrating an association between neighborhood disadvantage and overweight and obesity, the extent to which the strength and direction of this association differs depending on individual socioeconomic characteristics has not been sufficiently explored. The aim of this study was to examine associations between neighborhood disadvantage, individual-level SEP (education, occupation, and household income) and BMI (via self-reported height and weight), and further examine whether the relationship between neighborhood disadvantage and BMI differed by level of individual SEP. Consistent with previous work examining neighborhood disadvantage and BMI, analyses are stratified by gender (Feng and Wilson, 2015; King et al., 2006; Rachele et al., 2017). This investigation is, to the authors' knowledge, the first study to examine gender-specific cross-level interactions between individual-level SEP, neighborhood disadvantage and BMI.

Table 1
Neighborhood disadvantage and socio-demographic characteristics and mean (standard deviation) body mass index for persons aged 40–65 years in the Brisbane, Australia, HABITAT analytic sample (n = 9953), 2007.

	Men (n = 4541)			Women (n = 5412)		
	%	Mean[1]	Std Dev	%	Mean	Std Dev
Overall	100.0	27.42	4.91	100.0	26.32	5.90
Q1 (least disadvantaged)	30.7	27.19	4.52	30.1	25.58	5.13
Q2	19.1	27.06	4.22	20.1	26.00	5.63
Q3	17.9	27.52	4.91	16.2	26.17	5.75
Q4	20.1	27.92	5.81	20.0	27.03	6.46
Q5 (most disadvantaged)	12.3	27.55	5.16	13.6	27.58	6.81
Age						
40–44 years	27.2	27.29	4.64	20.4	25.66	6.17
45–49 years	22.0	27.17	4.53	21.9	26.45	6.32
50–54 years	20.0	27.50	5.16	20.9	26.26	6.05
55–59 years	17.7	27.64	5.15	19.5	26.57	5.48
60–65 years	13.1	27.67	5.31	17.3	26.72	5.16
Education						
Bachelors +	34.3	27.03	4.63	30.0	25.50	5.54
Diploma/Associate degree	12.1	26.93	4.41	11.4	26.00	5.15
Certificate (Trade/Business)	21.7	27.71	4.86	14.5	26.47	6.03
No qualifications beyond school	32.0	27.81	5.35	44.1	26.91	6.20
Occupation						
Managers/professionals	40.3	27.29	4.49	29.6	25.84	5.33
White collar	13.7	27.81	4.80	29.1	26.34	6.04
Blue collar	23.1	27.17	5.04	6.9	25.94	5.36
Not in the labor force	22.9	27.66	5.50	34.4	26.79	6.30
Household income						
$130,000 +	21.2	27.34	4.44	15.3	25.28	4.82
$72,800–129,999	29.2	27.51	4.57	24.2	26.19	5.44
$52,000–72,799	15.5	27.42	4.74	14.4	26.44	5.50
$26,000–51,599	16.2	27.17	5.17	19.9	26.72	6.40
Less than $25,999	6.9	27.80	6.40	10.9	27.66	7.32
Not classified	11.1	27.43	5.39	15.4	25.98	5.91

2. Methods

2.1. Sample design and neighborhood-level unit of analysis

This study used data from the How Areas in Brisbane Influence healTh And acTivity (HABITAT) project. 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. Specific 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 (n = 200) of Census Collector's Districts (CCD) (from a total of n = 1625) from the Australian Bureau of Statistics, and from within each CCD, a random sample of people aged 40–65 years (n = 16,127). 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. 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 aged 40–65 in 2007 (Turrell et al., 2010). The HABITAT study was approved by the Human Research Ethics Committee of the Queensland University of Technology (Ref. no. 3967H).

2.2. Exposure variables

2.2.1. Neighborhood disadvantage

Neighborhood socioeconomic disadvantage was derived using a

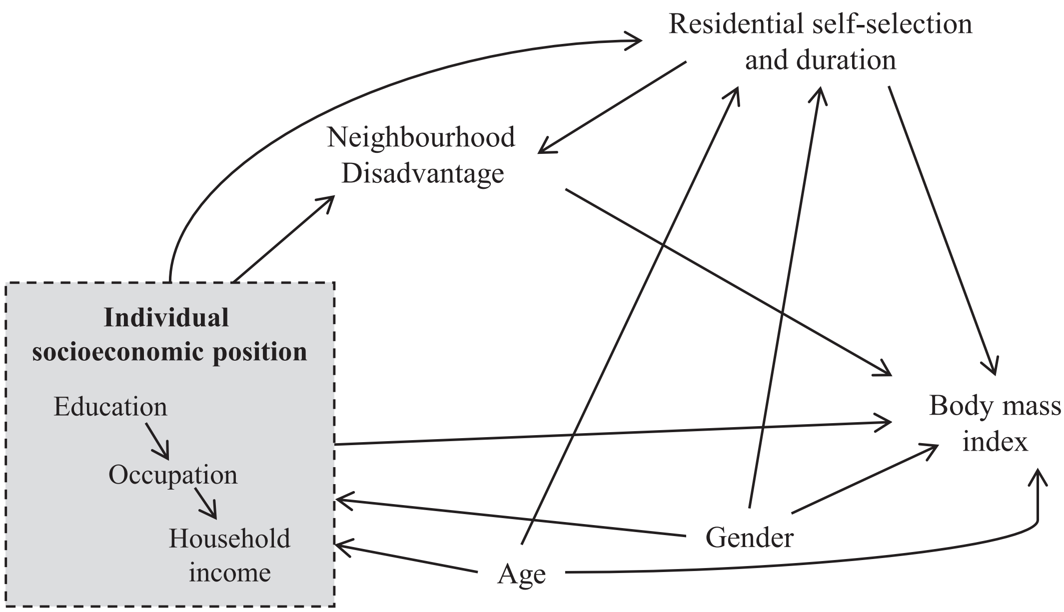

Fig. 1. Cross direct acyclic graph conceptualising the relationships between neighborhood disadvantage, individual-level socioeconomic position and body mass index.

weighted linear regression, using scores from the ABS' Index of Relative Socioeconomic Disadvantage (Australia Bureau of Statistics, 2006) (IRSD) from each of the previous six censuses from 1986 to 2011. The derived socioeconomic scores from each of the HABITAT neighborhoods were then quantized as percentiles, relative to all of Brisbane. The 200 HABITAT neighborhoods were then grouped into quintiles with Q1 denoting the 20% least disadvantaged areas relative to the whole of Brisbane and Q5 the most disadvantaged 20%.

2.2.2. Individual-level socioeconomic measures

2.2.2.1. Education. Participants were asked to provide information about their highest educational qualification attained. Responses were coded as: (1) bachelor degree or higher (including postgraduate diploma, master's degree, or doctorate), (2) diploma (associate or undergraduate), (3) vocational (trade or business certificate or apprenticeship), or (4) no qualifications beyond school.

2.2.2.2. Occupation. Participants who were employed at the time of completing the survey were asked to indicate their job title and then to describe the main tasks or duties they performed. This information was subsequently coded to the Australian Standard Classification of Occupations (ASCO) (Austalian Bureau of Statistics, 1997). The original 9-level ASCO classification was recoded into four categories: (1) managers/professionals (managers and administrators, professionals, and paraprofessionals), (2) white-collar employees (clerks, salespersons, and personal service workers), (3) blue-collar employees (tradespersons, plant and machine operators and drivers, and laborers and related workers), (4) not in the labor force (missing, not employed, home duties, students, retired, permanently unable to work or other).

Household income: participants were asked to estimate the total pre-tax annual household income using a single question with 13 categorical responses. For analysis, these were re-coded into six categories: (1) ≥AU$130,000, (2) AU$129,999–72,800, (3) AU $72,799–52,000, (4) AU$51,999–26,000, (5) ≤AU$25,999, or (6) Not classified (i.e. left the income question blank, ticked ‘Don't know’ or ‘Don't want to answer this’).

2.3. Outcome variable

2.3.1. Body mass index

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.

2.4. Covariates

2.4.1. Duration of residence

Participants were asked how long they had lived at their current address. For analysis, this was re-coded into three categories: (1) < 10 years, (2) between 10 and 20 years, and (3) > 20 years.

2.4.2. Neighborhood self-selection

To assess residential attitudes, participants were asked to respond on a five-item Likert scale, ranging from ‘strongly disagree’ to ‘strongly agree’ on a number of statements regarding “How important were the following reasons for choosing your current address?”. Principal components analysis (PCA) with varimax rotation showed that the items loaded onto three factors, subsequently described as ‘destinations’ (three items, $\alpha = 0.81$) ‘nature’ (three items, $\alpha = 0.78$) and ‘family’ (two items, $\alpha = 0.62$).

2.5. Statistical analysis

Participants who had missing data for height, weight, duration of residence, education, and neighborhood self-selection variables ($n = 720$), and participants who were beyond 65 years of age when they responded to the survey ($n = 2$) were excluded. This reduced the final sample to 9953 (90.2% of the total sample - Table 1). A sensitivity analysis revealed that missingness was associated with demographic variables, but not to values of BMI (the outcome variable). When missingness is related to covariates only, and not to values of the outcome variable, the missingness pattern is called (conditionally on the covariates) missing at random (MAR). Model estimates are unbiased under a MAR pattern provided the covariates related to missingness are included in the models and that there are no further unmeasured

Table 2
Multilevel models to estimate associations between neighborhood disadvantage individual-level socioeconomic position and body mass index, Brisbane, Australia 2007.[a]

	Men (n = 4541)	Women (n = 5412)
	β (95%CI)	β (95%CI)
Neighborhood-level		
Disadvantage	Model 1	Model 1
Q1 (least disadvantaged)	Reference	Reference
Q2	−0.19 (−0.64, 0.26)	0.19 (−0.28, 0.66)
Q3	0.27 (−0.19, 0.73)	0.25 (−0.26, 0.76)
Q4	0.66 (0.20, 1.12)	0.97 (0.48, 1.45)
Q5 (most disadvantaged)	0.21 (−0.33, 0.75)	1.32 (0.76, 1.87)
Individual-level		
Education	Model 2	Model 2
Bachelors+	Reference	Reference
Diploma/Associate degree	−0.15 (−0.63, 0.33)	0.42 (−0.12, 0.97)
Certificate (Trade/Business)	0.63 (0.23, 1.02)	0.83 (0.33, 1.33)
No qualifications beyond school	0.71 (0.36, 1.07)	1.66 (0.78, 1.54)
Occupation[b]	Model 3	Model 3
Managers/professionals	Reference	Reference
White collar	0.15 (−0.31, 0.62)	−0.23 (−0.69, 0.23)
Blue collar	−0.67 (−1.09, −0.25)	−0.71 (−1.40, −0.01)
Not in labor force	−0.01 (−0.41, 0.36)	0.27 (−0.17, 0.70)
Household income[b]	Model 4	Model 4
\$130,000+	Reference	Reference
\$72,800–129,999	0.00 (−0.41, 0.42)	0.75 (0.23, 1.26)
\$41,600–72,799	−0.17 (−0.67, 0.33)	0.92 (0.34, 1.50)
\$26,000–41,599	−0.58 (−1.10, −0.07)	1.02 (0.46, 1.57)
Less than \$25,999	−0.11 (−0.80, 0.58)	1.68 (1.01, 2.34)

Model 1: Neighborhood disadvantage and BMI, adjusted for age, duration of residence, education, occupation and household income.
Model 2: Education adjusted for age.
Model 3: Occupation adjusted for age and education.
Model 4: Household income adjusted for age, education and occupation.
[a] Each multilevel model had the same number of participants for men and women.
[b] The categories for occupation (not easily classifiable) and household income (not classified) were included in the statistical analysis but are not presented in the table.

covariates related to missingness (Fitzmaurice et al., 2012). Although it was anticipated that neighborhood socioeconomic disadvantage would uniquely contribute to BMI, shared variances may arise due to the relationships between individual-level and neighborhood-level socioeconomic indicators (Turrell et al., 2003). In other words, neighborhood disadvantage is likely to be directly associated with BMI, however, it is also likely to operate through other variables (e.g. mediators and moderators) and be confounded by variables which are prior common causes of both neighborhood disadvantage and BMI. These relationships are represented in the form of a directed acyclic graph (Fig. 1). Both neighborhood self-selection and duration of residence were conceptualized as a common prior cause (confounder) of the relationship between neighborhood disadvantage and BMI, education as a confounder of occupation, income and neighborhood disadvantage, occupation as a confounder of income and neighborhood disadvantage, and income as a confounder of neighborhood disadvantage.

The following modelling procedure was undertaken separately for men and women: Model 1) Neighborhood disadvantage and BMI, adjusted for age, duration of residence, neighborhood self-selection, education, occupation and household income, Model 2) Education adjusted for age; Model 3) Occupation adjusted for age and education; and Model 4) Household income adjusted for age, education and occupation. The reference groups for these analyses were the most advantaged neighborhoods (Q1), bachelor degree or higher (education), managers and professionals (occupation) and ≥AU\$130,000 (household income). The analyses were then extended to test for cross-level interactions by including interaction terms for different combinations of individual-level SEP and neighborhood disadvantage on BMI. The substantive focus of the interaction analyses was to ascertain whether associations between education, occupation and household income differed across neighborhoods that varied in their level of socioeconomic disadvantage. The fit of the interaction models was assessed using a joint Wald chi-square test. All coefficients are presented unstandardized and can be interpreted as the average difference in BMI between the category of interest and the reference group. Data were prepared in StataSE version 15 (StataCorp, 2017). All models were completed using MLwIN version 3.00 (Charlton et al., 2017).

3. Results

Descriptive statistics for the study sample are presented in Table 1. Among men, the highest mean BMI was observed among those living in the Q4 (mean (standard deviation) 27.92 (5.81) kg/m^2) of neighborhood disadvantage where Q5 is the most disadvantaged, and the lowest among those with a diploma or associated degree level of education (26.93 (4.41) kg/m^2). Among women, the highest mean BMI was observed among those with a household income less than \$25,999 (27.66 (7.32) kg/m^2), and the lowest among those with an income greater than \$130,000 (mean 25.28 (4.82) kg/m^2).

Table 2 shows that the differences in BMI by level of neighborhood disadvantage were small among men; however, those residing in the more disadvantaged neighborhood (Q4, β 0.66 95% confidence interval (CI) 0.20, 1.12) had a significantly higher BMI than their counterparts living in the most advantaged neighborhoods (Q1). Among women, those residing in the more disadvantaged neighborhoods (Q4 (β 0.97 95%CI 0.48, 1.45) and Q5 (β 1.32 95%CI 0.76, 1.87)) had a significantly higher BMI.

Among both men and women, those with a certificate (men β 0.63 95%CI 0.23, 1.02 and women β 0.83 95%CI 0.33, 1.33), or no qualifications beyond school level of education (men β 0.71 95%CI 0.36, 1.07 and women β 1.66 95%CI 0.78, 1.54) had a significantly higher BMI compared to those with a bachelor degree or higher, while those with a blue collar occupation (men β −0.67 95%CI −1.09, −0.25 and women β -0.71 95%CI -1.40, -0.01) had a significantly lower BMI than managers and professionals. For household income, men in the \$26,000–41,599 category (β −0.58 95%CI −1.10, −0.07) had a significantly lower BMI than those with an income greater than \$130,000, whereas for women, those with a lower level of household income (\$72,800–129,999 β 0.75 95%CI 0.23, 1.26 to less than \$25,999 β 1.68 95%CI 1.01, 2.34) had significantly higher BMI, and this association was graded.

The results of the cross-level analyses are presented in Fig. 2 and Supplement Table 1. Cross-level interactions were not significant for any of education, occupation, or household income, for either gender.

4. Discussion

The findings from this study show a positive graded association between neighborhood disadvantage and BMI among women, and a much less pronounced association among men. The relationship between neighborhood disadvantage and BMI did not differ by level of individual SEP, both in terms of model fit or the individual coefficients, suggesting that the influence of neighborhood disadvantage on BMI is likely to be similar, regardless of individual socioeconomic characteristics.

Our results are consistent with similar Australian studies. Both King

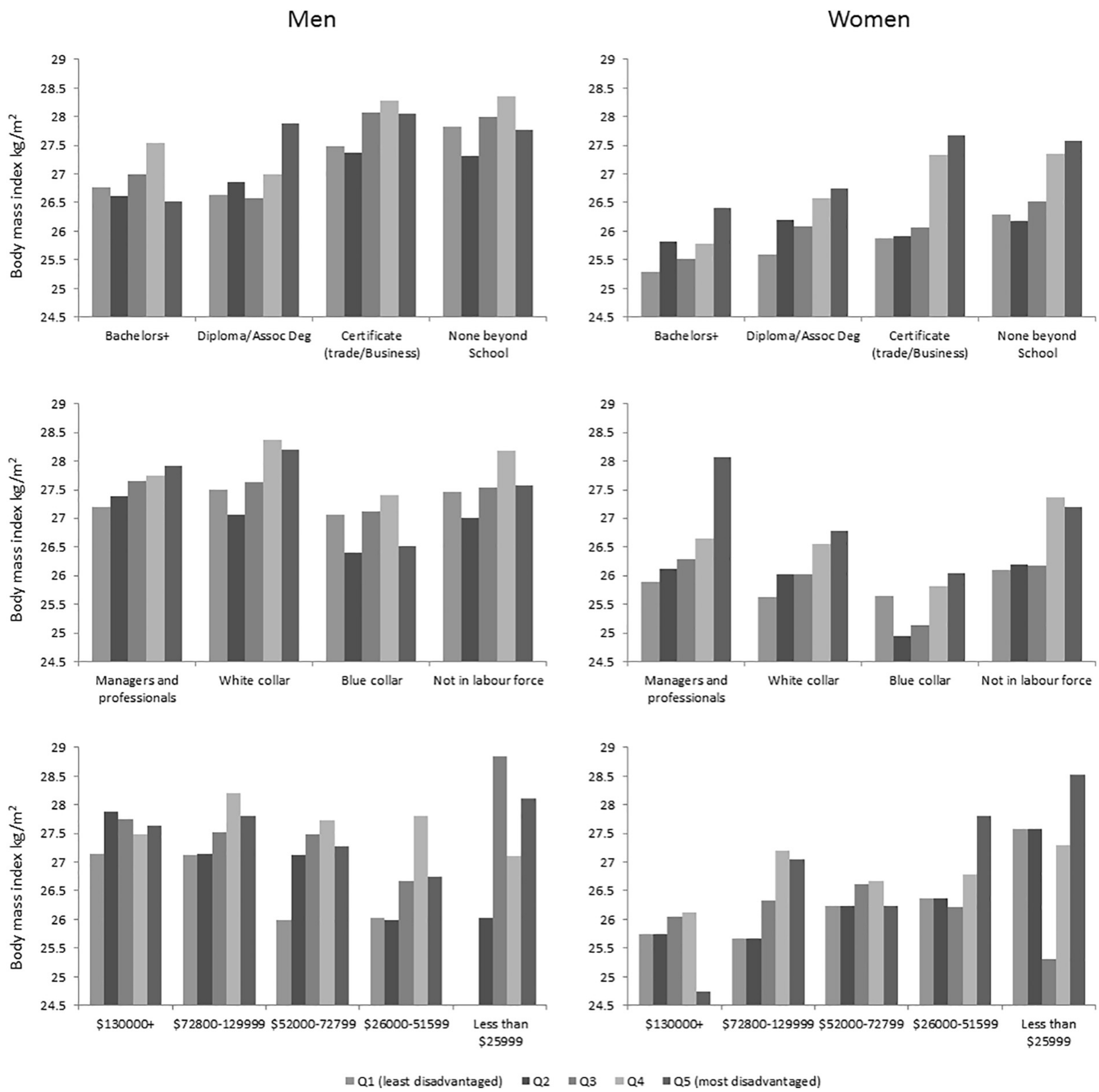

Fig. 2. Mean predicted body mass index for each level of neighborhood disadvantage, by level of individual education, occupation, and household income for men (n = 4541) and women (n = 5412), adjusted for age, residential self-selection and duration of residence in Brisbane, Australia, 2007.

et al. (2006) (aged 18 to > 65 years) and Feng and Wilson (2015) (aged > 15 years) reported that after adjustment for individual SEP (education, occupation and income), women exhibited a stronger and more graded association with area-level disadvantage that was not present among men. The Australian Health Survey 2011–2012 also identified a social gradient for women and overweight and obesity (Australian Bureau of Statistics, 2013): the differences in the proportions of obese women in advantaged and disadvantaged areas (i.e. 47.7% and 63.5% respectively) were much larger than in men (i.e. 68.6% and 69.0%) (Australian Bureau of Statistics, 2013). Our finding of an association between neighborhood disadvantage and BMI among women is consistent with international studies (Hajizadeh et al., 2014; Matheson et al., 2008; Mujahid et al., 2005a; Robert and Reither, 2004a). However, the relationship between BMI and neighborhood disadvantage among men is inconsistent: some studies of men have found either non-linear or null relationships (Mujahid et al., 2005b; Robert and Reither, 2004b), while others have found positive relationships (Hajizadeh et al., 2014; Matheson et al., 2008). There are a number of possible explanations as to why associations between neighborhood disadvantage and BMI were greater in magnitude among women. First, women in our study had lower individual-level socioeconomic characteristics (i.e., more likely to have no further education beyond school, in lower occupational classes, and lower levels of income). Despite individual-level socioeconomic characteristics being adjusted for when examining the association between neighborhood disadvantage and BMI, it is possible that there is some residual confounding (i.e., remaining bias from unmeasured socioeconomic characteristics). And second, it may be because women spend more time in the neighborhood due to greater domestic responsibilities (McGuckin and Murakami, 1999; Raley et al., 2012), although more research is needed to strengthen these assertions.

Although the addition of the cross-level interaction did not significantly improve model fit, they reveal interesting trends on how individuals with similar individual-level socioeconomic characteristics fared in comparison to their counterparts living in neighborhoods of differing levels of disadvantage, particularly among women. For example, women living in the most disadvantaged neighborhoods had on average (and with the exception of women with a household income greater than $130,000) the highest BMI. This “double disadvantage” phenomenon, where lower individual-level socioeconomic characteristics add together with neighborhood-level disadvantage to yield a greater overall disadvantage, is not uncommon in social epidemiology, with Australian studies yielding similar results (Loh et al., 2016; McPhedran, 2010).

Several factors may limit the generalizability of this study's findings. First, survey non-response in the HABITAT baseline study was 31.5%, and slightly higher among residents from lower individual socioeconomic profiles, and those living in more disadvantaged neighborhoods. If the non-responding residents (particularly women) of disadvantaged neighborhoods were more likely to have a higher BMI (as anticipated from the literature), then our findings (Table 2) may underestimate the ‘true’ magnitude of the neighborhood socioeconomic differences in BMI in the Brisbane population. Second, the findings of this study may be confounded by unobserved individual and neighborhood-level socioeconomic factors, or biased from the misclassification of self-reported responses. However, this study employed the three most commonly-used indicators of individual-level SEP (education, occupation and household income (Dutton et al., 2005)), while the neighborhood-level IRSD measure (which forms the basis of our neighborhood disadvantage measure) provides a comprehensive assessment of neighborhood-level disadvantage (Australia Bureau of Statistics, 2006). Third, 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 (Dhaliwal et al., 2010). Last, the cross-sectional nature of this study's design limits claims about causality between neighborhood disadvantage and BMI. Although, these claims can be cautiously made in circumstances in which it is clear that the exposure variable precedes the health behavior or outcome (e.g. participants over 40 years of age are less likely to change their level of education, so education is likely to precede current BMI). Additionally, the inclusion of neighborhood self-selection, seen as a major limitation among studies of neighborhoods and health (McCormack and Shiell, 2011), further reduces the risk of reverse causation. For instance, the inclusion of neighborhood self-selection helps to control for the possibility that an individual with a lower BMI chooses to live in a less disadvantaged neighborhood, with conditions that are favorable to physical activity and with a good quality food environment. Despite this, post-hoc analysis with the removal of neighborhood self-selection from models yielded similar findings to the current study.

The results also have implications for further research. Given the behavioral risk factors for overweight and obesity (e.g. physical inactivity, poor dietary intake), understanding why, after accounting for individual SEP, neighborhood-level disadvantage is associated with higher levels of BMI among women is of particular importance. This would require a more in-depth analysis that includes neighborhood-level features of the built and social environment that characterize neighborhoods that differ by level of socioeconomic disadvantage (Ghani et al., 2016), including studies where exposure measures are couched in policy (Rachele et al., 2018). This analysis could also be extended by observing individuals prospectively, and examining the trends in BMI for residents who live in the same neighborhood over time, or measuring the effect of moving to a new neighborhood with a different level of socioeconomic disadvantage.

5. Conclusion

The relationship between neighborhood disadvantage and BMI did not differ by level of education, occupation, or household income. This suggests that the influence of neighborhood disadvantage on BMI is likely to be similar, regardless of individual socioeconomic characteristics. Further research would assist policy-makers to make more informed decisions about where to intervene in order to counteract the inequities in BMI between advantaged and disadvantaged neighborhoods.

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pmedr.2019.100844.

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Conflict of interest

The authors declare that they have no conflicts of interest.

Ethical approval

The HABITAT study was approved by the Human Research Ethics Committee of the Queensland University of Technology (Ref. no. 3967H).

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