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Brief communication

Neighbourhood disadvantage and self-reported type 2 diabetes, heart disease and comorbidity: a cross-sectional multilevel study

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ABSTRACT

Purpose: This study examines associations between neighborhood socioeconomic disadvantage and self-reported type 2 diabetes and heart disease, occurring separately and concurrently at a single time point (comorbidity).

Methods: This study included 11,035 residents from 200 neighborhoods in Brisbane, Australia. Respondents self-reported type 2 diabetes and heart disease as long-term health conditions. Neighborhood socioeconomic disadvantage was measured using a census-derived composite index. Individual socioeconomic position was measured using education, occupation, and household income. Data were analyzed using multilevel multinomial mixed-effects logistic regression using Markov chain Monte Carlo simulation.

Results: Compared with the most advantaged neighborhoods, residents of the most-disadvantaged neighborhoods were more likely to report type 2 diabetes (odds ratio [OR] = 2.21, 95% credible interval [CrI] = 1.55–3.15), heart disease (OR = 1.72, 95% CrI = 1.25–2.38), and comorbidity (OR = 4.38, 95% CrI = 2.27–8.66). This relationship attenuated after adjustment for individual-level socioeconomic position, but remained statistically significant for type 2 diabetes (OR = 1.81, 95% CrI = 1.15–2.83) and comorbidity (OR = 3.00, 95% CrI = 1.49–6.13).

Conclusions: Studies of neighborhood disadvantage that fail to include individual-level socioeconomic measures may inflate associations. Establishing why residents of disadvantaged neighborhoods are more likely to experience the co-occurrence of heart disease and type 2 diabetes independent of their individual socioeconomic position warrants further investigation.

Background

Type 2 diabetes and cardiovascular disease are two of the most prevalent chronic diseases in Australia [1], and they constitute a significant burden for both individuals [2] and society; in 2008–09, cardiovascular disease cost the Australian economy $7.7 billion [3] and type 2 diabetes $1.5 billion [4], representing 10.4% and 2.3% of total disease expenditure, respectively.

Although living with a single chronic condition presents significant individual and societal burden, living with two or more chronic conditions concurrently, or “comorbidity”, is more challenging. Comorbidity is associated with an increased risk of impaired functional status or quality of life and greater health care utilization, including more hospital admissions, longer stays in hospital [2], and greater frequency of visits to GPs and specialists [5,6]. Comorbidity is compounded by the fact that shared risk factors between these diseases promote co-occurrence and strengthen the association between them;while these risk factors also promote disease progression and increase the risk of complications [3].

A number of studies have found that the prevalence of type 2 diabetes [4,7,8] and heart disease [9] increases with area-level disadvantage. However to date, few studies have examined associations between neighborhood disadvantage and chronic disease comorbidity. Those that have, find positive associations between increasing area-level disadvantage and disease prevalence [4,10,11]. Typically these studies do not consider individual-level socioeconomic position (SEP) [4,10–12]. Those that do, have included measures of occupational class [13] and levels of education and income [14,15]. Neighborhood studies that do not include

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individual-level measures of socioeconomic disadvantage fail to disentangle the relative contribution of socioeconomic factors at the individual and neighborhood levels. Moreover, the inclusion of measures of individual-level socioeconomic indicators that do not adequately cover all dimensions of socioeconomic status (i.e., only occupation or education) may inflate estimates of area-level disadvantage effects on chronic disease [16].

This study attempts to address these limitations by examining associations between neighborhood socioeconomic disadvantage and comorbidity for type 2 diabetes and heart disease, independent of the three most commonly used individual-level measures of SEP in health research [17]; namely education, occupation, and household income. It is hypothesized that those living in more disadvantaged neighborhoods will be more likely to report a single chronic disease and comorbidity, independent of their SEP.

Methods

Sample design and neighborhood-level unit of analysis

This study used data from the How Areas in Brisbane Influence healTh And acTivity (HABITAT) project. Details about HABITAT's sampling design have been published elsewhere [18]. Briefly, a multistage probability sampling design was used to select a stratified random sample ($n = 200$) of Census Collector's Districts (CCD—hereby referred to as neighborhoods) from the Australian Bureau of Statistics. Within each neighborhood, randomly selected adults aged 40–65 years were mailed a self-administered questionnaire between May and July 2007. Of 16,128 surveys mailed to eligible Brisbane residents, 11,035 (68.4% response rate) usable surveys were returned. Residents were representative of the general Brisbane population. The HABITAT study was approved by the Human Research Ethics Committee of the Queensland University of Technology (Ref. no. 3967H).

Neighborhood disadvantage

Neighborhood socioeconomic disadvantage was derived using a weighted linear regression, using scores from the Australian Bureau of Statistics′ Index of Relative Socioeconomic Disadvantage [19] (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% ($n = 40$) least disadvantaged areas relative to the whole of Brisbane and Q5 the most disadvantaged 20% ($n = 40$).

Chronic disease

Self-reported type 2 diabetes and heart disease

Participants responded to the question "Have you ever been told by a doctor or nurse that you have any of the long-term health conditions listed below? (please only include those conditions that have lasted, or are likely to last, for six (6) months or more)." Type 2 diabetes and heart/coronary disease were two of eight conditions listed, and respondents were asked to indicate "yes" (coded 1) or "no" (coded 0) for each condition. Comorbidity in this study is the presence of both type 2 diabetes and heart disease for the same participant. Self-reported measures of chronic conditions have been shown to be valid [20]; whereas this question has been used extensively in previous Australian health research [21].

Covariates

Education

Participants were asked to provide information about their highest educational qualification attained. A participant's education was subsequently 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), and (4) no postschool qualifications.

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 [22]. The original 9-level Australian Standard Classification of Occupations classification was re-coded into five categories: (1) managers/professionals (managers and administrators, professionals, and paraprofessionals), (2) white-collar employees (clerks, salespersons, and personal service workers), and (3) blue-collar employees (tradespersons, plant and machine operators and drivers, and laborers and related workers), (4) home duties, (5) retired, and (6) missing/NEC (not easily classifiable - permanently unable to work, students or other).

Household income

Participants were asked to estimate the total pre-tax annual household income using a single question comprising 13 income categories. 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, and (6) missing (i.e. left the income question blank, ticked "Don't know" or "Don't want to answer this").

Statistical analysis

Participants who had missing data for either type 2 diabetes, heart disease, or education were excluded ($n = 413$), and two participants were dropped who were beyond the scope of the study at the time of the survey. The final analytical data set was $n = 10,620$ (96.2% of the total sample—Table 1).

The analysis was informed by postulated relationships between the socioeconomic indicators. Education, occupation, and household income were conceptualized as common prior causes (confounders) of neighborhood disadvantage and chronic disease; in addition to other potential confounders (age and sex). These relationships are depicted in a directed acyclic graph (Fig. 1). Multilevel multinomial logistic regression was undertaken with self-reported type 2 diabetes, heart disease, and comorbidity as an unordered categorical dependent variable (neither condition-reference group = 0; both conditions = 1; type 2 diabetes only = 2; and heart disease only = 3). The models undertaken for analysis were model 1—neighborhood disadvantage and chronic disease adjusted for age and sex; and model 2—model 1 plus further adjustment for education, occupation, and household income. The highest socioeconomic category was used as the reference group in each model. Each regression analysis used marginal quasi-likelihood iterative generalized least square methods as the base estimates for Markov chain Monte Carlo (MCMC) simulation (burn in = 500, chain = 100,000). The MCMC estimation procedure uses a Bayesian sequential learning approach that combines prior information for a parameter (incorporated via a prior distribution) with the likelihood function produced from the collected data to make inferences about the unknown model parameters. These

Table 1
Number of participants in the analytic sample and the proportion (95% CI) who reported heart disease or type 2 diabetes as a long-term condition

	N	Type 2 diabetes	Heart disease	Both conditions
		% (95% CI)	% (95% CI)	% (95% CI)
Total	10620	5.1 (4.6–5.5)	5.5 (5.1–6.0)	1.2 (1.0–1.4)
Neighborhood disadvantage				
Q1 (least disadvantaged)	3170	3.3 (2.6–3.9)	4.4 (3.7–5.1)	0.5 (2.6–7.5)
Q2	2103	3.8 (2.9–4.6)	5.3 (4.4–6.3)	1.1 (0.7–1.6)
Q3	1809	5.0 (4.0–6.0)	5.2 (4.2–6.2)	1.0 (0.5–1.5)
Q4	2154	7.2 (6.1–8.3)	5.9 (4.9–6.9)	1.6 (1.1–2.3)
Q5 (most disadvantaged)	1384	7.8 (3.4–9.2)	8.4 (6.9–9.8)	2.1 (1.3–2.9)
Sex				
Males	4787	6.0 (5.3–6.7)	6.4 (5.7–7.1)	1.6 (1.3–1.9)
Females	5833	4.3 (3.8–4.8)	4.8 (4.3–5.4)	0.8 (0.5–1.0)
Age (y)				
40–44	2173	2.3 (1.6–2.9)	2.0 (1.4–2.6)	0.4 (0.1–0.6)
45–49	2366	2.7 (2.0–3.3)	3.2 (2.5–3.9)	0.3 (0.1–0.6)
50–54	2231	4.9 (4.0–5.8)	4.4 (3.5–5.2)	0.9 (0.5–1.3)
55–59	2005	6.6 (5.5–7.7)	8.0 (6.8–9.2)	1.6 (1.0–2.1)
60–65	1845	9.9 (8.5–11.2)	11.4 (10.0–12.9)	3.0 (2.2–3.8)
Education				
Bachelors+	3367	3.8 (3.2–4.5)	4.0 (3.3–4.6)	0.7 (0.4–0.9)
Diploma/assoc deg	1237	4.2 (3.1–5.3)	5.0 (3.8–6.2)	1.2 (0.6–1.8)
Certificate (trade/business)	1888	5.5 (4.5–6.5)	5.5 (4.5–6.5)	1.0 (0.6–1.5)
None beyond school	4128	6.1 (5.4–6.8)	7.0 (6.2–7.8)	1.6 (1.2–2.0)
Occupation*				
Mgr/prof	3619	3.2 (2.7–3.8)	4.0 (3.4–4.7)	0.6 (0.3–0.8)
White collar	2367	4.4 (3.6–5.2)	4.1 (3.3–4.9)	0.9 (0.5–1.2)
Blue collar	1524	4.3 (3.3–5.4)	5.0 (3.9–6.1)	0.7 (0.3–1.1)
Home Duties	591	5.6 (3.7–7.4)	5.8 (3.9–7.6)	1.4 (0.4–2.3)
Retired	873	11.0 (8.9–13.1)	11.6 (9.4–13.7)	3.2 (2.0–4.4)
Household income*				
$130000+	1857	2.7 (2.0–3.4)	2.9 (2.1–3.6)	0.3 (0.1–0.6)
$72800–129999	2784	3.8 (3.1–4.6)	4.3 (3.5–5.0)	0.9 (0.6–1.3)
$52000–72799	1577	4.4 (3.4–5.4)	4.8 (3.7–5.8)	0.8 (0.3–1.2)
$26000–51599	1925	6.3 (5.3–7.4)	6.7 (5.6–7.8)	1.3 (0.8–1.8)
Less than $25999	935	11.1 (9.1–13.1)	12.4 (10.3–14.5)	3.2 (2.1–4.3)

* The missing occupation and household income categories were retained in all analyses but the results are not presented.

methods differ from a likelihood-based frequentist approach, in that rather than iterating between deterministic steps until two consecutive estimates for model parameters are sufficiently close together to achieve convergence, MCMC is a simulation-based procedure where estimates from the last iteration are used to produce new estimates. This then generates a sample of values from the posterior distribution from which estimates of the parameter

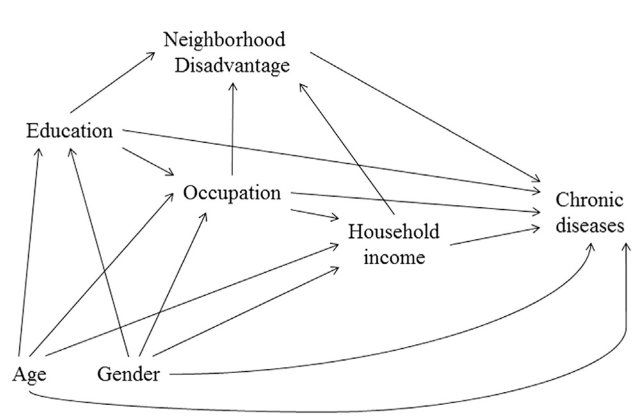

Fig. 1. Directed acyclic graph conceptualizing the relationships between neighborhood disadvantage, individual-level socioeconomic characteristics, and chronic diseases.

can be obtained and that are useful for producing accurate interval estimates [23]. All results are reported as odds ratios (ORs) and their 95% credible intervals (CrIs). Data were prepared in Stata, SE version 13 [24], and all analyses were completed in MLwIN, version 2.30 [25].

Results

Descriptive statistics for the proportion of participants for each neighborhood-level and individual-level category who self-reported type 2 diabetes, heart disease, or comorbidity are listed in Table 1. Residents of the most-disadvantaged neighborhoods (Q5) reported the highest levels of heart disease (8.4%), type 2 diabetes (7.8%), and comorbidity (2.1%).

Associations between neighborhood-level disadvantage and the odds of type 2 diabetes, heart disease, and comorbidity are listed in Table 2. Compared with residents living in the least disadvantaged neighborhoods (Q1), those living in the most-disadvantaged neighborhoods (Q5) were significantly more likely to report type 2 diabetes, heart disease, and comorbidity in the age-adjusted and sex-adjusted models (model 1). The relationship between neighborhood disadvantage and each health outcome attenuated with further adjustment for individual-level education, occupation, and household income (model 2); however, the odds of reporting type 2 diabetes and comorbidity remained significantly higher for residents of the most-disadvantaged neighborhoods.

Discussion

This study found that residents from disadvantaged neighborhoods were more likely to report being diagnosed with type 2 diabetes, heart disease, and comorbidity. Of particular note, the odds of reporting comorbidity were greater among residents of

Table 2
Neighborhood disadvantage and self-reported heart disease and type 2 diabetes*

	Model 1†	Model 2‡
	OR (95% CrI)	OR (95% CrI)
Type 2 diabetes		
Q1 (least disadvantaged)	1.00	1.00
Q2	0.98 (0.66–1.43)	0.94 (0.60–1.48)
Q3	1.47 (1.02–2.10)	1.35 (0.87–2.08)
Q4	2.15 (1.56–2.97)	1.93 (1.30–2.92)
Q5 (most disadvantaged)	2.21 (1.55–3.15)	1.81 (1.15–2.83)
Between-neighborhood variance (SE)	0.117 (0.039)	0.346 (0.068)
Heart Disease		
Q1 (least disadvantaged)	1.00	1.00
Q2	1.10 (0.80–1.51)	1.00 (0.73–1.39)
Q3	1.08 (0.78–1.50)	0.96 (0.69–1.35)
Q4	1.15 (0.85–1.57)	0.97 (0.71–1.34)
Q5 (most disadvantaged)	1.72 (1.25–2.38)	1.26 (0.90–1.78)
Between-neighborhood variance (SE)	0.097 (0.030)	0.091 (0.028)
Comorbidity		
Q1 (least disadvantaged)	1.00	1.00
Q2	2.29 (1.15–4.60)	2.03 (1.01–4.11)
Q3	1.94 (0.93–4.10)	1.73 (0.82–3.59)
Q4	3.46 (1.84–6.68)	2.85 (1.49–5.60)
Q5 (most disadvantaged)	4.38 (2.27–8.66)	3.00 (1.49–6.13)
Between-neighborhood variance (SE)	0.263 (0.133)	0.251 (0.134)

* The missing income and occupation categories were retained in all analyses but the results are not presented.
† Model 1: Neighborhood disadvantage and each health outcome adjusted for age and sex.
‡ Model 2: Model 1 with additional adjustment for education, occupation, and household income.

more disadvantaged neighborhoods, than for either of the single chronic conditions. Our findings are consistent with previous literature, which also show area-level socioeconomic inequalities in type 2 diabetes [26], heart disease [27], and comorbidity for these conditions [4,10–12]. Wild et al. [10] found that type 2 diabetes was significantly more prevalent among those in the most deprived neighborhood compared to their counterparts from the least deprived neighborhoods. Similarly, Larranaga et al. [11] observed that the prevalence of type 2 diabetes was higher among those from the most-disadvantaged neighborhoods (OR = 2.17, 95% confidence interval = 1.77–2.28); whereas Leyland [13] found that those living in the most deprived areas were significantly more likely to report cardiovascular disease (OR = 1.32, 95% confidence interval = 1.15–1.51).

Notably in this study, after adjustment for individual-level SEP, all associations between chronic disease and neighborhood disadvantage attenuated (to the null for heart disease), although significant associations remained for type 2 diabetes and comorbidity. This attenuation has implications for studies examining area-level effects that do not consider individual-level SEP [4,10–12] and suggests that the exclusion of individual-level socioeconomic measures may inflate neighborhood-level effects. Excluding measures of individual-level SEP also prevents the disentanglement of the relative contributions of socioeconomic factors at the individual and neighborhood levels. Previous studies have not considered the same range of individual-level socioeconomic measures as was undertaken in the present study, yet they have also found associations between chronic disease and neighborhood disadvantage attenuated after the inclusion of individual-level socioeconomic indicators [14]; with Wight [15] reporting attenuation to the null after the inclusion of individual-level education and household wealth and income. This highlights the importance of including a range of individual-level socioeconomic measures in studies of area-level deprivation and health, to more accurately identify independent neighborhood-level effects. This is important given that study participants with lower individual-level socioeconomic characteristics are more likely to reside in disadvantaged neighborhoods [28].

There are several factors that may limit the generalizability of this study's findings. First, survey nonresponse in the HABITAT baseline study was 31.5%, and slightly higher among those of lower SEP, and residents of more disadvantaged neighborhoods [29]. If the nonresponding residents of disadvantaged neighborhoods were more likely to present with chronic conditions (as anticipated from the literature), then our findings (Table 2) may underestimate the "true" magnitude of the neighborhood socioeconomic differences in chronic disease in the Brisbane population. The findings of this study may also be confounded by unobserved individual- and neighborhood-level socioeconomic factors or biased from the misclassification of self-reported responses. However, this study used the three most commonly used indicators of individual-level SEP (education, occupation, and income [16]), while the neighborhood-level Index of Relative Socioeconomic Disadvantage measure (which forms of the basis of our neighborhood disadvantage measure) provides a comprehensive assessment of neighborhood-level disadvantage [19]. Furthermore, although the study was sufficiently powered to address the purpose of this investigation, there was insufficient power to further explore the data via cross-level interactions between neighborhood disadvantage and individual-level SEP.

The results also have implications for further research. Understanding why, independent of one's own SEP, neighborhood-level disadvantage is associated with major chronic disease outcomes is important. This has relevance for interventions that seek to change social norms in these areas (such as social contagion [30]), in addition to those targeting individual health behaviors. Although strategies such as these may prove beneficial in the short-to-medium term, addressing the causes of social inequality, rather than its downstream effects, may provide a more sustainable long-term (and equitable) solution [31].

There are many potential explanations for differences in the reporting of type 2 diabetes, heart disease, and comorbidity in more disadvantaged neighborhoods, over and above individual-level SEP. Neighborhood inequalities exist for many health behaviors associated with chronic disease, which share similar behavioral etiology; including physical activity [32], diet [33], smoking [34], and harmful alcohol consumption [35]. For example, there is clear evidence of the relationship between physical activity and chronic disease [32]. Neighborhood-level features that are likely to impact on residents' engagement in physical activities, such as the built environment (e.g., the presence of recreational facilities, sidewalks, shops and services, heavy traffic [36]) and the social environment (e.g., crime and safety and cohesion [37]), may be differentially present in advantaged and disadvantaged neighborhoods; and may in turn increase the likelihood of chronic disease. Our previous work has shown that creating more walkable environments may reduce inequalities [28]. In addition, neighborhood greenness is likely to be socially patterned. We have previously shown that among adults, higher levels and greater variation of neighborhood greenness was associated with lower odds of obesity [38] and neighborhood greenness variation with hospital admissions for heart disease and stroke [39]. Such notions need to be explored further in longitudinal studies of the neighborhood environment, health-related behaviors, and the incidence of chronic diseases in later life.

This study found associations between neighborhood disadvantage and self-reported chronic disease, independent of individual-level SEP. Future studies should endeavor to establish why these inequalities exist, in particular, what aspects of disadvantaged neighborhoods (such as their location, access to employment, transport and services, and built and social environment characteristics) result in residents being more likely to experience one or more chronic conditions.

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