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**The influence of neighbourhood disadvantage on smoking cessation and its contribution to inequalities in smoking status**

Running title: Neighbourhood inequalities in smoking behaviour

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## Abstract

**Introduction and aims:** Individual smokers from disadvantaged backgrounds are less likely to quit, which contributes to widening inequalities in smoking. Residents of disadvantaged neighbourhoods are more likely to smoke, and neighbourhood inequalities in smoking may also be widening because of neighbourhood differences in rates of cessation. This study examined the association between neighbourhood disadvantage and smoking cessation and its relationship with neighbourhood inequalities in smoking.

**Design and methods:** A multilevel longitudinal study of mid-aged (40-67 years) residents (n=6915) of Brisbane, Australia, who lived in the same neighbourhoods (n=200) in 2007 and 2009. Neighbourhood inequalities in cessation and smoking were analysed using multilevel logistic regression and Markov chain Monte Carlo simulation.

**Results:** After adjustment for individual-level socioeconomic factors, the probability of quitting smoking between 2007 and 2009 was lower for residents of disadvantaged neighbourhoods (9.0%-12.8%) than their counterparts in more advantaged neighbourhoods (20.7%-22.5%). These inequalities in cessation manifested in widening inequalities in smoking: in 2007 the between-neighbourhood variance in rates of smoking was 0.242 ( $p \leq 0.001$ ) and in 2009 it was 0.260 ( $p \leq 0.001$ ). In 2007, residents of the most disadvantaged neighbourhoods were 88% (OR 1.88, 95% CrI 1.41-2.49) more likely to smoke than residents in the least disadvantaged neighbourhoods: the corresponding difference in 2009 was 98% (OR 1.98 95% CrI 1.48-2.66).

**Conclusion:** Fundamentally, social and economic inequalities at the neighbourhood and individual-levels cause smoking and cessation inequalities. Reducing these

inequalities will require comprehensive, well-funded, and targeted tobacco control efforts *and* equity based policies that address the social and economic determinants of smoking.

**Key words:** neighbourhood, disadvantaged, tobacco smoking, tobacco cessation, inequalities.

## Introduction

Numerous studies have examined the association between neighbourhood disadvantage and health [1-3]. Some of this work shows that residents of socioeconomically disadvantaged neighbourhoods experience higher rates of morbidity and mortality for smoking-related chronic disease [4-6]. A parallel literature has investigated the relationship between neighbourhood disadvantage and smoking [7-20], and these studies find that residents of disadvantaged neighbourhoods are significantly more likely than their advantaged counterparts to smoke. As smoking contributes substantially to the burden of preventable chronic disease [21], higher smoking rates in disadvantaged neighbourhoods are probably a key reason for the poorer health profile of these areas.

It is well documented that individuals from socioeconomically disadvantaged backgrounds are more likely to smoke [22]: moreover, socioeconomic inequalities in smoking are widening in many countries [23-24] including Australia [25], partly as a result of higher rates of cessation among advantaged groups [26-28].

Neighbourhood inequalities in smoking may also be widening over time because of differences in rates of cessation between those living in advantaged and disadvantaged neighbourhoods; however no known research has examined this phenomenon. The dearth of research on this topic may reflect the lack of appropriate data: smoking cessation is a transitional process that involves moving from one state (smoking) to another (quitting), and accurately assessing the impact of this process on neighbourhood inequalities in smoking requires data that are longitudinal and multilevel. This paper addresses this gap by undertaking a longitudinal multilevel study of neighbourhood differences in smoking cessation and the impact of this

relationship on neighbourhood inequalities in smoking status. Two research questions are examined:

1. Are residents of disadvantaged neighbourhoods less likely to stop smoking over time, and, as a consequence
2. Is the gap in neighbourhood inequalities in smoking widening?

This investigation of neighbourhood cessation and smoking inequalities uses data from the first two waves (2007 & 2009) of the HABITAT study (**H**ow **A**reas in **B**risbane **I**nfluence **H**eal**T**h and **A**c**T**ivity). HABITAT is a multilevel longitudinal (2007–2011) study of health-related behaviours and risk factors among mid-aged (40–65 years) adults living in Brisbane, Australia [29]. The primary aim of HABITAT is to examine patterns of change in behaviours and risk factors, and to assess the relative contributions of environmental, social, psychological and socio-demographic factors, to these changes.

## Methods

### *Sample design*

HABITAT's sampling design has been published elsewhere [29]. Briefly, a multi-stage probability sampling design was used to select a stratified random sample ( $n=200$ ) of Census Collector's Districts (CCD), and from within each CCD, a random sample of people aged 40–65 years ( $n=17,000$ ). A CCD is the smallest administrative unit used by the Australian Bureau of Statistics (ABS) to collect census data. In Brisbane, a CCD contains an average of 200 private dwellings which are relatively homogeneous in terms of their socioeconomic characteristics.

### *Individual-level data collection*

Using a mail-survey methodology developed by Dillman [30], the data were collected via a structured self-administered questionnaire. Respondents were asked about their smoking status and smoking history, and their sociodemographic characteristics. After excluding out-of-scope respondents (e.g. deceased, overseas), at baseline a total of 11,037 surveys were returned, with a response rate of 68.5%. The corresponding number of survey returns and response rate at first follow-up was 7,873 and 73.7% respectively.

### *Measures*

#### Neighbourhood disadvantage:

Each of the 200 CCDs was assigned a socioeconomic score using the Australian Bureau of Statistics' (ABS) Index of Relative Socioeconomic Disadvantage (IRSD) [31]. The IRSD scores were calculated using 2006 census data and derived by the ABS using Principal Components Analysis. A CCDs IRSD score reflects each area's level of disadvantage measured by 17 variables capturing a wide range of socioeconomic attributes, including; education, occupation, income, unemployment, and household structure. For analysis, the 200 CCDs were grouped into quintiles based on their IRSD scores with Q1 denoting the 20% (n=40) most disadvantaged areas in Brisbane and Q5 the least disadvantaged 20% (n=40).

#### Controls:

The IRSD is an ecologic exposure derived by aggregating individual responses to the national census. When testing for an ecologic effect with an aggregated exposure it is necessary to simultaneously model individual-level variables (e.g.

income) and their neighbourhood-level analogues (e.g. % low income households) [32]. Thus, we included three individual-level socioeconomic controls in the multilevel analyses – education, occupation, and household income – each of which has an area-level analogue represented in the IRSD. Sex and age were also included as controls. Table 1 presents descriptive statistics for the IRSD measure and the control variables for the HABITAT sample. Previous research has demonstrated that this sample is broadly representative of the wider Brisbane population, although residents from disadvantaged areas, blue-collar employees, and persons who did not attain a post-school educational qualification are underrepresented [33].

Table 1 about here

Smoking status and cessation:

At each Wave, respondents were asked “Which ONE of the following best describes your cigarette smoking”? The response options were “I smoke daily”, “I smoke occasionally”, “I don’t smoke now, but I used to”, and “I have never smoked”. The first two response options were categorised as “smoker” and the latter two as “non-smoker”. This measure was used to examine neighbourhood inequalities in smoking status. For the longitudinal analysis of smoking cessation we used information on respondents who were smoking at Wave 1 and operationalised a measure that indicated whether they had quit smoking at Wave 2 (coded 1), with a referent of 0 (still smoking).

#### *Data exclusions and analysis*

We restricted our sample to persons who participated in both waves (n=7,873), and excluded those who had missing data on their smoking status and educational qualifications in 2007, or moved neighbourhoods between 2007 and 2009. Our final



analytic sample comprised 6,915 participants. From Table 1 it is evident that the sociodemographic profile of the baseline and analytic samples are similar.

The descriptive analyses were undertaken using Stata version 10.0 [34] and the multilevel analyses were conducted using MLwiN version 2.22 [35]. The first research question, examining neighbourhood inequalities in smoking cessation, was investigated using multilevel logistic regression, and estimated the likelihood that respondents had quit smoking by 2009 based on their sociodemographic characteristics at Wave 1 (2007). The analyses were conducted in two stages. First, we specified a random intercept model (Model 1) that comprised individuals nested in neighbourhoods with sex, age, and neighbourhood disadvantage in the fixed part of the model. Second, we added individual-level fixed effects for education, occupation, and household income (Model 2). For this analysis we present the mean predicted probability of quitting smoking for each quintile of neighbourhood disadvantage, estimated using the 'customised predictions' option in MLwiN [36].

Our second research question was also investigated using multilevel logistic regression, and estimated differences between advantaged and disadvantaged neighbourhoods in smoking rates in 2007 and 2009 after adjustment for individual-level socio-demographic factors. Analyses were conducted separately for each wave and two models were specified: a null model, and a random intercept model that included fixed effects for sex, age, education, occupation, household income and neighbourhood disadvantage. For the null model we report the neighbourhood-level random term, which if significant (indicated using Wald Chi-square), suggests that rates of smoking vary across Brisbane neighbourhoods. The predicted probability of smoking by neighbourhood disadvantage is also presented for each model.

As recommended [37], the multilevel logistic model parameters were estimated using Markov chain Monte Carlo (MCMC) simulation. All multilevel results are reported as odds ratios (OR) and their 95% credible intervals (CrI).

## Results

Of the 6,915 respondents, 891 (12.9%) were smoking in 2007; and 153 (17.2%) quit smoking between 2007 and 2009. Table 2 presents the association between neighbourhood disadvantage and smoking cessation. Model 1 shows that after adjustment for within-neighbourhood variation in sex and age, the probability of quitting smoking was lower in the more disadvantaged neighbourhoods (9.3%-12.5%) and higher in the less disadvantaged (23.1%-25.0%). Compared with residents in the most disadvantaged neighbourhoods (quintile 1), residents of the least disadvantaged neighbourhoods (quintile 5) were 151% (OR 2.51, 95% CrI 1.38-4.57) more likely to have ceased smoking. Additional adjustment for education, occupation, and household income attenuated the association however residents of the less disadvantaged areas were still more likely to have quit smoking. Residents of neighbourhoods in quintile 4 were 103% (OR 2.03, 95% CrI 1.10-3.79) more likely to have quit, and those living in neighbourhoods in quintile 5 were 82% more likely, although this latter association was only marginally significant ( $p=0.076$ ).

Table 2 about here

Table 3 presents the association between neighbourhood disadvantage and smoking status in 2007 and 2009. In 2007, the smoking rate varied significantly across the 200 neighbourhoods: variance 0.242 (se 0.055),  $p \leq 0.001$ . The probability of smoking in 2007 was 88% (OR 1.88 95% CrI 1.41-2.49) higher for residents of the most disadvantaged neighbourhoods than those in the least disadvantaged

neighbourhoods, after adjustment for within-neighbourhood variation in education, occupation, and household income. In 2009, the smoking rate varied significantly across the neighbourhoods: variance 0.260 (se 0.059),  $p \leq 0.001$ , which was greater than that observed in 2007. The probability of smoking in 2009 was 98% (OR 1.98 95% CrI 1.48-2.66) higher for residents of the most disadvantaged neighbourhoods.

Table 3 about here

## Discussion

Smokers from socioeconomically disadvantaged backgrounds are significantly less likely to quit smoking than their higher status counterparts [22]. This differential rate of cessation partly contributes to widening inequalities in smoking between socioeconomic groups over time [26-28]. In this present study we found a similar temporal association at the neighbourhood level. Using longitudinal multilevel data we observed rates of smoking cessation were significantly higher in advantaged neighbourhoods. This finding is consistent with previous research, which finds that the likelihood of quitting is significantly lower among residents of disadvantaged neighbourhoods [38-40]. A larger body of work has investigated the relationship between neighbourhood disadvantage and smoking, and like this present study, these find that residents of disadvantaged neighbourhoods are significantly more likely to smoke after adjustment for individual-level socioeconomic factors [7-20].

Additionally, we observed widening inequalities in smoking as indicated by greater between-neighbourhood variation in smoking rates in 2009 compared with 2007, and increased relative inequalities in smoking between residents of the least and most disadvantaged neighbourhoods. To our knowledge, no previous study has had the requisite data to directly link neighbourhood-level cessation with neighbourhood-level smoking. Disconcertingly, widening inequalities in smoking may

in the future manifest themselves as widening inequalities between advantaged and disadvantaged neighbourhoods in morbidity and mortality rates for smoking-related chronic disease [41-43].

*Possible reasons for neighbourhood inequalities in cessation and smoking*

As our understanding of neighbourhood inequalities in cessation and smoking is at a nascent stage [22] we can only speculate about why the inequalities exist. Prima facie, it seems reasonable to assume that the neighbourhood factors that influence smoking also affect cessation. First, living in a disadvantaged neighbourhood has been linked with higher rates of perceived social and physical problems such as crime, lack of personal safety, pollution, graffiti and litter, and noise and traffic congestion [44-48]. These negative aspects of the neighbourhood environment might produce elevated stress levels [17, 49] which function to sustain and reinforce smoking behaviour. Second, studies [50-52] have found that disadvantaged neighbourhoods are characterised by greater availability of and access to shops selling tobacco products, and this might also be true of Brisbane neighbourhoods. Third, residents of disadvantaged neighbourhoods are more likely to be exposed to others who smoke [47, 53-55] reflecting a pro-smoking environment [56-57] or weaker social capital and cohesion [58] which together may operate synergistically to make quitting difficult. Clearly, these issues need to be further investigated to advance knowledge and address neighbourhood-level inequalities in cessation and smoking.

### *Study limitations*

Several methodological and analytic issues need to be considered when interpreting and understanding this study's findings. First, this study achieved a moderate individual-level response rate (68.5%) that was inversely associated with neighbourhood disadvantage. Previous studies show that low SES groups [59] and residents of more deprived neighbourhoods [60] are least likely to participate in survey research. As a consequence, the socioeconomic variation in the HABITAT baseline sample is likely to be truncated compared with variation in the Brisbane population. Further our investigation of sample attrition between 2007 and 2009 revealed that loss to follow-up was significantly higher among smokers, lower SES, and lower SES smokers. Given that loss to follow-up was related to both the exposure (SES) and outcome (smoking) it is likely that our findings are biased towards the null [61]. Taken together, these suggest that our results underestimate the magnitude of neighbourhood inequalities in cessation and smoking.

Second, as with most multilevel studies [62] our choice of area-unit (i.e. CCD) was made for reasons of sampling and analytic convenience. Hence, associations between neighbourhood disadvantage and smoking behaviour are likely to be underestimated. If we had used an area-unit based on people's perceptions of their local neighbourhood and what was socially and culturally meaningful in terms of their health and behaviour we might have observed stronger neighbourhood effects on cessation and smoking.

Third, our finding of an association between neighbourhood disadvantage, cessation, and smoking might be confounded by individual-level socioeconomic factors not included in the models. However, we used the three most commonly employed individual-level indicators of SES in health research, education,

occupation and income[63], and given the correlation among these measures [64] it is likely that they were capturing the unmeasured influence of other socioeconomic factors not included in the models.

Fourth, this paper focused on the nature and extent of inequalities in cessation and smoking and not on investigating reasons for these associations. Hence we did not include in our analysis potential explanatory factors such as nicotine dependence: such factors are arguably mediators of the association between neighbourhood disadvantage and smoking (not confounders), thus modelling such variables may have resulted in over adjustment, leading to an under-estimation of the relationship between neighbourhood disadvantage and smoking [65].

Fifth, this study examined inequalities in cessation and smoking rates in a mid-aged (40–65 years) sample. Smoking dependence tends to increase with age [66, 67] hence it remains unclear whether similar effects are found among younger smokers.

### *Conclusions*

Several studies [68-69] and recent commentaries [70-71] have suggested that population-level tobacco control efforts such as mass media campaigns and smoke-free policies are equally effective in influencing the smoking behaviours of all socioeconomic groups, and that some interventions such as real-price tax increases are more efficacious among disadvantaged groups [72-73]. Despite this, socioeconomic inequalities in smoking initiation, cessation, and maintenance continue, and for some of these outcomes the inequalities are widening. In concluding, we argue, as do others [44,48,49,74] that comprehensive, well-funded,

and targeted tobacco control efforts are necessary, but not sufficient, to reduce inequalities in cessation and smoking. Fundamentally, social and economic inequalities cause smoking and cessation inequalities, and tobacco control efforts, irrespective of whether they are directed at populations, environments, or individuals do not change unequal socioeconomic conditions. As Hilary Graham has cogently argued, reducing smoking and cessation inequalities will require the simultaneous implementation of tobacco control measures in conjunction with progressive social and economic policies that result in a more equitable distribution of the fundamental determinants of health at both the individual- and neighbourhood-levels [75].

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**Table 1: Sociodemographic profile of the HABITAT sample at baseline (2007), and the samples used for the analysis of smoking cessation and maintenance**

	Baseline sample (n=11,037)		Smoking cessation and maintenance sample (n=6,915) <sup>1</sup>	
	n	%	n	%
<i>Neighbourhood disadvantage</i>				
Quintile 5 (least disadvantaged)	2613	23.7	1686	24.4
Quintile 4	2671	24.2	1697	24.5
Quintile 3	2303	20.9	1438	20.8
Quintile 2	1814	16.4	1125	16.3
Quintile 1 (most disadvantaged)	1636	14.8	969	14.0
<i>Sex</i>				
Male	4867	44.1	2931	42.4
Female	6170	55.9	3984	57.6
<i>Age</i>				
60-65	1996	18.1	1413	20.4
55-59	2097	19.0	1356	19.6
50-54	2274	20.6	1419	20.5
45-49	2430	22.0	1486	21.5
40-44	2240	20.3	1241	18.0
<i>Educational attainment</i>				
Bachelor's degree or higher	3458	31.3	2253	32.6
Diploma/Associate diploma	1269	11.5	780	11.3
Certificate (trade/business)	1952	17.7	1213	17.5
School	4311	39.1	2669	38.6
Missing <sup>2</sup>	47	0.4	--	--
<i>Occupation</i>				
Manager/Professional	3669	33.2	2360	34.1
White collar	2413	21.9	1509	21.8
Blue collar	1554	14.1	927	13.4
Home duties	683	6.2	461	6.7
Retired	977	8.9	697	10.1
Permanently unable to work	332	3.0	187	2.7
Missing <sup>3</sup>	1409	12.8	774	11.2
<i>Household Income</i>				
≥\$130,000	1889	17.1	1189	17.2
\$72,800-129,999	2845	25.8	1819	26.3
\$41,600-72,799	2438	22.1	1556	22.5
\$26,000-41,599	1189	10.8	740	10.7
<\$25,999	1045	9.5	664	9.6
Missing <sup>4</sup>	1631	14.8	947	13.7

1. Excludes baseline respondents who did not participate in 2009 (n=3,164), who were not the same respondent in 2007 and 2009 (n=185), who changed their neighbourhood of residence between 2007 and 2009 (n=651), who did not provide data about their smoking status (n=103), and who provided insufficient information for their educational qualifications to be reliably classified (n=19)

2. Respondents who provided insufficient information for their educational qualifications to be reliably classified
3. Respondents who missed the occupation question, those who provided insufficient information for their occupation to be reliably coded, and respondents who were not in the labour market but were too few in number to be classified into their own category (e.g. unemployed, students).
4. Respondents who missed the income question, those who reported that they did not know the household's income, and those who indicated that they did not want to answer the question.

**Table 2: Neighbourhood disadvantage and smoking cessation between 2007 and 2009**

		Model 1 <sup>1</sup>			Model 2 <sup>2</sup>		
	Number of smokers in 2007	Predicted probability of cessation	Odds Ratio	95% CrI	Predicted probability of cessation	Odds Ratio	95% CrI
<i>Neighbourhood disadvantage</i>							
Quintile 1 (most disadvantaged)	206	12.5	1.00	--	12.8	1.00	--
Quintile 2	159	9.3	0.70	0.32-1.45	9.0	0.67	0.31-1.42
Quintile 3	202	23.1	2.28	1.30-4.07	22.8	2.07	1.14-3.79
Quintile 4	182	23.4	2.31	1.29-4.16	22.5	2.03	1.10-3.79
Quintile 5 (least disadvantaged)	142	25.0	2.51	1.38-4.57	20.7	1.82	0.95-3.56

1. Model 1: adjusted for within-neighbourhood variation in age and sex

2. Model 2: Model 1 plus adjustment for within-neighbourhood variation in education, occupation, and household income

**Table 3: Smoking status in 2007 and 2009 by neighbourhood disadvantage**

	2007			2009		
	Predicted probability of smoking	OR	95% CrI	Predicted probability of smoking	OR	95% CrI
<i>Neighbourhood disadvantage<sup>1</sup></i>						
Quintile 5 (least disadvantaged)	9.3	1.00	--	8.2	1.00	--
Quintile 4	10.2	1.16	0.85-1.47	9.0	1.11	0.84-1.47
Quintile 3	12.5	1.40	1.07-1.86	10.6	1.31	0.99-1.76
Quintile 2	12.1	1.35	1.02-1.80	12.7	1.63	1.22-2.18
Quintile 1 (most disadvantaged)	16.0	1.88	1.41-2.49	15.1	1.98	1.48-2.66

1. Neighbourhood disadvantage adjusted for age, sex, education, occupation, and household income