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Neighbourhood disadvantage and smoking: Examining the role of neighbourhood-level psychosocial characteristics

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ABSTRACT

Purpose: This study aims to determine if neighbourhood psychosocial characteristics contribute to inequalities in smoking among residents from neighbourhoods of differing socioeconomic disadvantage.
Methods: This cross-sectional study includes 11,035 residents from 200 neighbourhoods in Brisbane, Australia in 2007. Self-reported measures were obtained for smoking and neighbourhood psychosocial characteristics (perceptions of incivilities, crime and safety, and social cohesion). Neighbourhood socioeconomic disadvantage was measured using a census-derived index. Data were analysed using multilevel logistic regression random intercept models.
Results: Smoking was associated with neighbourhood disadvantage; this relationship remained after adjustment for individual-level socioeconomic position. Area-level perceptions of crime and safety and social cohesion were not independently associated with smoking, and did not explain the higher prevalence of smoking in disadvantaged areas; however, perceptions of incivilities showed an independent effect.
Conclusions: Some neighbourhood psychosocial characteristics seem to contribute to the higher rates of smoking in disadvantaged areas.

1. Background

While smoking rates have declined significantly in most developed countries, a strong social gradient remains for individual- and area-level socioeconomic characteristics (Hiscock et al., 2012). Inequalities in smoking between socioeconomically advantaged and disadvantaged neighbourhoods exist, independent of the individual socioeconomic position (SEP) of residents (Chuang et al., 2005; Datta et al., 2006; Giskes et al., 2006; Hanibuchi et al., 2015; Migliorini and Siahpush, 2006; Reijneveld, 2002; Sundquist, Malmström, and Johansson, 1999; Tseng et al., 2001). Not only is smoking prevalence higher among people living in more disadvantaged neighbourhoods, there are also additional disparities among the profile of those who smoke; smokers residing in socioeconomically disadvantaged neighbourhoods are more likely to be heavy smokers (Chaix et al., 2004; Chuang et al., 2005) and less likely to quit successfully (Giskes et al., 2006) compared to their counterparts in more advantaged neighbourhoods. Moreover, mortality due to smoking-related causes is consistent with these trends, and is greatest among residents of disadvantaged neighbourhoods (Chaix et al., 2004; Chaix et al., 2007).

Studies that have sought to understand the mechanisms underlying neighbourhood inequalities in smoking show positive associations with tobacco outlet density (Chuang et al., 2005; Pearce et al., 2009), high crime areas (Tseng et al., 2001), neighbourhood stressors (van Lenthe and Mackenbach, 2006) and neighbourhood smoking norms (Ahern, Galea, Hubbard, and Syme, 2009). One of the explanatory pathways articulated in the literature is that more stressful living environments, characterised by psychosocial factors such as high crime, poor aesthetics, low social cohesion, and perceived relative disadvantage, may increase the likelihood of smoking, and reduce motivation and success of quitting (Miles, 2006; Peretti-Watel et al., 2009; Stead et al., 2001). Stressful neighbourhood environments may pose more immediate concerns that supersede smoking cessation (Businelle et al., 2010; Hiscock et al., 2012).

Studies that have found associations between smoking and neighbourhood-level psychosocial characteristics (the influences

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of social factors on an individual's mental health and behaviour (Vizzotto et al., 2013)) often fail to account for neighbourhood-level socioeconomic disadvantage (Ahern et al., 2009; Ellaway and Macintyre, 2009; Shareck and Ellaway, 2011). Given the known associations between these neighbourhood-level psychosocial characteristics and the level of socioeconomic disadvantage, it is difficult to examine the true relationships between these and smoking, without adjustment for neighbourhood socioeconomic disadvantage.

The purpose of this study was to better understand the independent contribution of neighbourhood psychosocial characteristics to individual-level smoking, and to ascertain how neighbourhood psychosocial characteristics may contribute to the association between smoking and neighbourhood disadvantage. The aims of this study were (1) to examine the association between neighbourhood psychosocial characteristics (perceptions of neighbourhood incivilities, crime and safety, and social cohesion) and smoking, before and after adjustment for neighbourhood disadvantage; and (2) examine the association between neighbourhood disadvantage with smoking before and after adjusting for neighbourhood psychosocial characteristics.

2. Methods

2.1. Scope and sample design

Data were collected in 2007 as part of the HABITAT (How Areas in Brisbane Influence HealTh And AcTivity) study. Details about HABITAT's sampling design have been published elsewhere (Burton et al., 2009). Briefly, HABITAT is a multi-level longitudinal study of the determinants of physical activity, sedentary behaviour and health among mid-aged adults (i. e. aged 40–65 years at baseline). A multi-stage probability sampling design was used to select a stratified random sample (n=200) of Census Collector's Districts (CCDs – hereafter referred to as 'neighbourhoods'), the smallest administrative units used by the Australian Bureau of Statistics (ABS); and from within each neighbourhood, a random sample of people aged 40–65 years (n=17000). A maximum of one in-scope adult was sampled per household. All sampled participants were sent an identical 16-page questionnaire in May 2007. A total of 11035 questionnaires with useable data were returned (response rate of 68.9%). The study was conducted among residents of private dwellings in the Brisbane Local Government Area (Australia). The study sample has been shown to be representative of the Brisbane population (Turrell et al., 2010). The HABITAT study was approved by the institution's Human Research Ethics Committee (Ref. no. 3967H).

2.2. Neighbourhood-level psychosocial measures

To assess perceptions of incivilities (rubbish/graffiti), crime and safety, and social cohesion, participants were provided with a number of statements and were asked to respond on a five-item Likert scale, ranging from 'strongly disagree' to 'strongly agree'. The measures were found to have acceptable test-retest reliability (Turrell et al., 2011).

Incivilities: two items assessed perceptions of neighbourhood incivilities. Participants were asked about the presence of litter or rubbish, and graffiti. Using principal components analysis (PCA) with varimax rotation, disorder and incivilities loaded onto one 'incivilities' factor.

Perceptions of crime and safety: these were ascertained from a six-item scale that asked participants about opinions of the level of crime in their neighbourhood, and perceptions of their personal safety in parks, on the streets, and using public transport in their area. Using PCA with varimax rotation, six of these items were found to load on one 'perceptions of crime and safety' factor, with a Cronbach alpha of 0.80. These measures were adapted for the Australian population from the Neighborhood Environment Walkability Scale (NEWS) questionnaire (Cerin et al., 2006); which has shown acceptable validity and reliability for measuring perceived neighbourhood walkability (Cerin et al., 2009).

Social Cohesion: this was measured by a five-item modified version of the Buckner Social Cohesion Scale (Buckner, 1988). Participants were provided with a range of statements about common values, trust and social relationships between themselves and residents of their area. PCA using varimax rotation showed that all five items loaded onto one 'social cohesion' factor, with a Cronbach alpha of 0.82.

Neighbourhood disadvantage: Neighbourhood socioeconomic disadvantage was derived using a 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 neighbourhoods were then quantised as percentiles, relative to all of Brisbane. The 200 HABITAT neighbourhoods were then grouped into quintiles with Q1 denoting the 20% most disadvantaged areas relative to the whole of Brisbane and Q5 the least disadvantaged 20%.

2.3. Individual-level measures

Smoking status: smoking status was ascertained using a modified question from the Australian National Heart Foundation Risk Factor Prevalence Study (National Heart Foundation of Australia, 1989). Participants were asked, "Which one of the following best describes your cigarette smoking" and the following response categories were provided: I smoke daily, I smoke occasionally, I don't smoke now but used to, and I have never smoked. For analysis, smoking status was re-coded into [1] smoker (I smoke daily), and [0] non-smoker (I smoke occasionally, I don't smoke now but used to, and I have never smoked). The small number of participants (3.2%) who reported being an occasional smoker prevented the use of three smoking categories. A review and meta-analysis of self-reported smoking status has shown that the item has good sensitivity (mean 88%) and specificity (mean 89%) when compared to serum cotinine (Patrick et al., 1994).

Education: participants were asked about their highest level of completed education. 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 post-school qualifications.

Occupation: participants were asked about their current employment situation. If they were currently employed (i. e. full-time, part-time or casual) they were asked to provide the full title of their current occupation. Responses were coded to the Australian and New Zealand Standard Classification of Occupations (Australian Bureau of Statistics, 1997), and were further recoded into professionals (managers, administrators, professionals, and paraprofessionals), white-collar employees (clerks, salespersons, and service workers) and blue-collar employees (tradespersons, machine operators, drivers, labourers, and related workers). A fourth category 'not in employment' was created for respondents who were retired, studying, unemployed, not looking for work, or permanently unable to work.

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').

Demographics: Participants were asked about their age (coded into 5-year categories), sex and country of birth (Australia or 'other').

2.4. Statistical analyses

Of the 11035 participants that returned the questionnaire, a total of n=647 were excluded from analyses for incomplete data for smoking status (n=151), perceptions of incivilities (n=272), crime and safety (n=288) and social cohesion (n=226), education (n=64), and country of birth (n=88), leaving a total analytic sample of n=10,388. To date, studies investigating the relationship between neighbourhood disadvantage and smoking have all used self-report neighbourhood-level psychosocial measures as the exposure for the prediction of smoking practices of the same study participants (Ahern et al., 2009; Andrews et al., 2014; Ellaway and Macintyre, 2009; Peretti-Watel et al., 2009; Poortinga et al., 2007). Such methods have potential to generate a spurious association between the outcome and predictor in analyses due to either correlations between measurement errors, or because the outcome affects the predictor. This phenomenon is otherwise known as same-source bias (Diez Roux, 2007). One approach to control for the effects of same-source bias is to use aggregated responses (i.e. perceptions of neighbourhood psychosocial characteristics) from residents of the same neighbourhoods, whose responses (i.e. their smoking behaviours) are not used in subsequent analyses. This can be achieved via randomly splitting a clustered sample ensuring that responses from some participants are used to generate a more objective measure of area-level psychosocial factors that is used to assess associations with smoking behaviour. In this study, a sub-sample of participants ('informants') was used to generate measures on the psychosocial characteristics of each area, and a separate sub-sample of participants ('cases') was used to examine whether area-level factors were associated with smoking. For each of the 200 neighbourhoods, approximately half the respondents were randomly assigned to the 'informant' group by using the random number generator function of Stata (n=5194, 50.0%), and the remaining participants formed the 'cases' group (n=5194, 50.0%). No significant differences were found between the cases and informant group for any of the variables included in the modelling. Participant demographics of the analytic sample are presented in Table 1.

Table 1
Neighbourhood Disadvantage, Socio-Demographic Characteristics and Smoking: Persons Aged 40–65 Years in the HABITAT Analytic Sample. (n=10,388 Individuals; n=200 Neighbourhoods).

	Cases		Informants		Total	
	n (%)	% who smoked daily (95% CI)	n (%)	% who smoked daily (95% CI)	n (%)	% who smoked daily (95% CI)
Total sample	5194	13.4 (12.5, 14.3)	5194	12.3 (11.4, 13.2)	10,388	12.8 (12.2, 13.5)
Neighbourhood disadvantage						
Q5 (most disadvantaged)	675 (13.0)	22.8 (19.6, 26.0)	678 (13.1)	21.8 (18.7, 25.0)	1353 (13.0)	22.3 (20.1, 24.5)
Q4	1075 (20.7)	16.7 (14.5, 19.0)	1027 (19.8)	17.4 (15.1, 19.8)	2102 (20.2)	17.1 (15.5, 18.7)
Q3	868 (16.7)	15.3 (12.9, 17.7)	906 (17.4)	11.4 (9.3, 13.4)	1774 (17.1)	13.3 (11.7, 14.9)
Q2	1013 (19.5)	10.3 (8.4, 12.1)	1025 (19.7)	9.5 (7.7, 11.3)	2038 (19.6)	9.9 (8.6, 11.2)
Q1 (least disadvantaged)	1563 (30.1)	7.9 (6.5, 9.2)	1558 (30.0)	7.2 (5.9, 8.5)	3121 (30.0)	7.5 (6.6, 8.5)
Sex						
Female	2889 (55.6)	11.5 (10.3, 12.6)	2800 (53.9)	10.1 (9.0, 11.1)	5689 (54.8)	10.8 (10.0, 11.6)
Male	2305 (44.4)	15.8 (14.3, 17.3)	2374 (46.1)	14.9 (13.5, 16.3)	4699 (45.2)	15.3 (14.3, 16.4)
Age						
60–65 years	930 (17.9)	10.1 (8.2, 12.0)	907 (17.5)	9.3 (7.4, 11.2)	1837 (17.7)	9.7 (8.3, 11.0)
55–59 years	998 (19.2)	11.8 (9.8, 13.8)	988 (19.0)	9.0 (7.2, 10.8)	1986 (19.1)	10.4 (9.1, 11.8)
50–54 years	1104 (21.3)	14.5 (12.4, 16.6)	1071 (20.6)	13.2 (11.1, 15.2)	2175 (20.9)	13.8 (12.4, 15.3)
45–49 years	1129 (21.7)	15.4 (13.3, 17.5)	1145 (22.0)	14.5 (12.5, 16.5)	2274 (21.9)	15.0 (13.5, 16.4)
40–44 years	1033 (19.9)	14.3 (12.2, 16.5)	1083 (20.9)	14.7 (12.6, 16.8)	2116 (20.4)	14.5 (13.0, 16.0)
Country of birth						
Other	1271 (24.5)	12.2 (10.4, 14.0)	1279 (24.6)	9.8 (8.1, 11.4)	2550 (24.6)	11.0 (9.8, 12.2)
Australia	3923 (75.5)	13.7 (12.7, 14.8)	3915 (75.4)	13.1 (12.1, 14.2)	7838 (75.5)	13.4 (12.8, 14.2)
Education						
No post-school qualification	2041 (39.3)	18.4 (16.7, 20.1)	2019 (38.9)	17.5 (15.9, 19.2)	4060 (39.1)	18.0 (16.8, 19.1)
Certificate	929 (17.9)	17.6 (15.1, 20.0)	937 (18.0)	13.7 (11.5, 15.9)	1866 (18.0)	15.6 (14.0, 17.2)
Diploma/associate degree	583 (11.2)	8.7 (6.5, 11.1)	616 (11.9)	8.6 (6.4, 10.8)	1199 (11.5)	8.7 (7.1, 10.3)
Bachelor degree or higher	1641 (31.6)	6.4 (5.2, 7.6)	1622 (31.2)	6.4 (5.2, 7.6)	3263 (31.4)	6.4 (5.6, 7.2)
Occupation						
Not in employment	1481 (28.5)	13.8 (12.0, 15.5)	1578 (30.4)	13.2 (11.5, 14.9)	3059 (29.5)	13.5 (12.3, 14.7)
Blue collar	740 (14.3)	20.8 (17.9, 23.7)	757 (14.6)	19.3 (16.5, 22.1)	1497 (14.4)	20.0 (18.0, 22.1)
White collar	1174 (22.6)	14.4 (12.4, 16.4)	1133 (21.8)	12.0 (10.1, 13.9)	2307 (22.2)	13.2 (11.8, 14.6)
Professional	1799 (34.6)	9.3 (7.9, 10.6)	1726 (33.2)	8.6 (7.3, 10.0)	3525 (33.9)	9.0 (8.0, 10.0)
Household income						
Less than $25999	474 (9.13)	20.3 (16.6, 23.9)	475 (9.15)	21.3 (17.6, 25.0)	949 (9.14)	20.8 (18.2, 23.3)
$26000–51599	943 (18.2)	19.4 (16.9, 21.9)	937 (18.0)	15.9 (13.6, 18.2)	1880 (18.1)	17.7 (15.9, 19.4)
$52000–72799	802 (15.4)	13.8 (11.5, 16.2)	753 (14.5)	12.5 (10.1, 14.9)	1555 (15.0)	13.2 (11.5, 14.9)
$72800–129999	1386 (26.7)	11.0 (9.3, 12.6)	1320 (25.4)	10.8 (9.2, 12.5)	2706 (26.1)	10.9 (9.7, 12.1)
$130000+	882 (17.0)	6.8 (5.1, 8.5)	940 (18.1)	6.0 (4.4, 7.5)	1822 (17.5)	6.4 (5.3, 7.5)
Missing	707 (13.6)	13.0 (10.5, 15.5)	769 (14.8)	12.5 (10.1, 14.8)	1476 (14.2)	12.7 (11.0, 14.4)

An empirical Bayes exchangeable (EBE) estimate was used for the neighbourhood psychosocial environment exposure in this analysis. The benefit of this estimation procedure is that it takes into account the number of 'informants' used per neighbourhood, and the variability of the exposure within and between the neighbourhoods (Savitz and Raudenbush, 2009); rather than solely using a mean aggregated score, as has been done in previous studies of the social environment (Ball et al., 2010; Lindström et al., 2001; Lindstrom et al., 2003; Mummery et al., 2008). Spatial dependence was not considered due to the sparsity of neighbourhoods included in the study throughout the Brisbane area. The EBE estimate was obtained via the following four steps: (1) creating a mean score of the exposure for each neighbourhood ($\bar{Y}_{.j}$); (2) using an ANOVA model of the exposure, fitted using maximum likelihood to obtain estimates of the between- and within- neighbourhood variance. This was then used to obtain an estimate of the reliability of the exposure estimate $\hat{\lambda}_{Ej}$ for each neighbourhood, using Eq. (1) (Savitz and Raudenbush, 2009), where $\hat{\tau}_E$ is the between neighbourhood variance, $\hat{\sigma}_e^2$ the within neighbourhood variance, and n_j the number of informants within the neighbourhood; (3) estimating the exposure intercept $\hat{\gamma}_E$; and (4) calculating the EBE estimate using Eq. (2) (Savitz and Raudenbush, 2009).

$$\hat{\lambda}_{Ej}=\frac{\hat{\tau}_E}{(\hat{\tau}_E+\frac{\hat{\sigma}_e^2}{n_j})} \quad (1)$$

$$\hat{\beta}_{EBEj}=\hat{\gamma}_E+\hat{\lambda}_{Ej}(\bar{Y}_{.j}-\hat{\gamma}_E) \quad (2)$$

The 200 HABITAT neighbourhoods were then grouped into quintiles for each psychosocial characteristic with Q1 denoting the 20% (n=40) highest scores, and Q5 the 20% lowest scores (n=40) for incivilities and crime; and Q1 the 20% lowest scores and Q5 the 20% highest scores for social cohesion. Descriptives of neighbourhood psychosocial characteristics and their socioeconomic disadvantage are presented in Table 2.

The modelling approach was informed by postulated relationships between the socioeconomic indicators, neighbourhood disadvantage, the neighbourhood psychosocial environment, and other potential confounders (age, sex, country of birth) and is represented in the form of a directed acyclic graph (DAG – Fig. 1). Briefly, DAGs are an epidemiologic research tool that depicts a causal diagram which graphically encodes relationships between variables. DAGs allow the use of relatively simple and systematic graphical criteria to identify variables that need to be controlled for in order to identify the causal effects of interest (Fleischer and Roux, 2008). Further details on the use of DAGs in epidemiologic research have been published elsewhere (Fleischer and Roux, 2008; Glymour, 2006).

First, to ascertain if daily smoking was associated with neighbourhood disadvantage, a multilevel logistic regression random intercept model was undertaken with daily smoking as the dependent variable, and with each of the individual-level socioeconomic measures, age, sex, and country of birth as covariates. Second, three multilevel logistic regression random intercept models were undertaken, each with daily smoking as the dependent variable, and one of the three neighbourhood-level psychosocial characteristics (level 2) as independent variables. The models were run both unadjusted and then adjusted for neighbourhood disadvantage, and the proportional difference (reduction) in the odds ratios were calculated (Droomers et al., 1999). All models adjusted for age, sex, country of birth, education, occupation and household income. Third, multilevel logistic regression random intercept models were undertaken to ascertain the contributions of neighbourhood-level psychosocial characteristics to neighbourhood inequalities in daily smoking. All models were adjusted for age, sex, country of birth, education, occupation and household income. The base model used daily smoking as the dependent variable, and neighbourhood disadvantage as the independent variable. The factors of interest in the base model were the direction and magnitude of the fixed effects for neighbourhood disadvantage. In the three subsequent models, each neighbourhood-level psychosocial characteristic was added to the model separately, and differences of the neighbourhood disadvantage fixed effects were examined (relative to the base model). In the final model, all neighbourhood psychosocial characteristics were added simultaneously, and their combined contributions to the differences of the neighbourhood disadvantage fixed effects assessed.

Multilevel logistic regression random intercept models used marginal quasi-likelihood iterative generalized least squares (IGLS) as the base estimates for penalised quasi-likelihood IGLS, and these were used as the starting values for Markov chain Monte

Table 2
Neighbourhood Disadvantage and Neighbourhood Psychosocial Characteristics (n=200 Neighbourhoods).

	Q5 (most disadvantaged) N (%)	Q4 N (%)	Q3 N (%)	Q2 N (%)	Q1 (least disadvantaged) N (%)
Incivilities					
Q1 (most)	21 (52.5)	11 (27.5)	4 (10.0)	2 (5.0)	2 (5.0)
Q2	9 (22.5)	16 (40.0)	7 (17.5)	4 (10.0)	4 (10.0)
Q3	2 (5.0)	11 (27.5)	17 (42.5)	7 (17.5)	3 (7.5)
Q4	3 (7.5)	6 (15.0)	7 (17.5)	11 (27.5)	13 (32.5)
Q5 (least)	1 (2.5)	3 (7.5)	1 (2.5)	9 (22.5)	26 (65.0)
Crime					
Q1 (most)	21.5 (52.5)	11 (27.5)	6 (15.0)	0 (0.0)	2 (5.0)
Q2	10 (25.0)	14 (35.0)	7 (17.5)	5 (12.5)	4 (10.0)
Q3	4 (10.0)	13 (32.5)	10 (25.0)	9 (22.5)	4 (10.0)
Q4	1 (2.5)	6 (15.0)	8 (20.0)	12 (30.0)	13 (32.5)
Q5 (least)	0 (0.0)	3 (7.5)	5 (12.5)	7 (17.5)	25 (62.5)
Social cohesion					
Q1 (least)	11 (27.5)	9 (22.5)	9 (22.5)	8 (20.0)	3 (7.5)
Q2	8 (20.0)	10 (25.0)	10 (25.0)	4 (10.0)	8 (20.0)
Q3	10 (25.0)	7 (17.5)	8 (20.0)	5 (12.5)	10 (25.0)
Q4	4 (10.0)	11 (27.5)	6 (15.0)	10 (25.0)	9 (22.5)
Q5 (most)	3 (7.5)	10 (25.0)	3 (7.5)	6 (15.0)	18 (45.0)

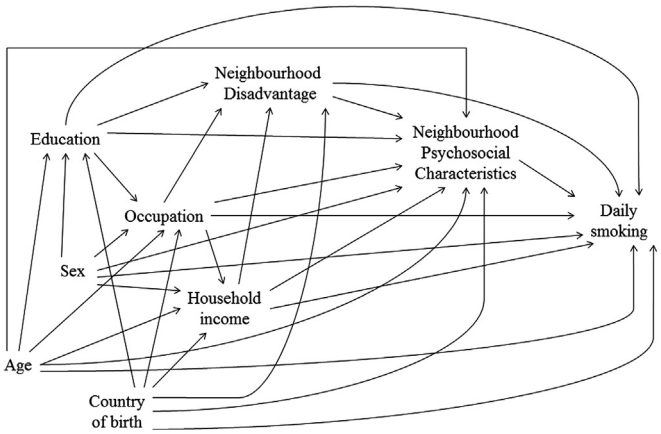

Fig. 1. Directed acyclic graph conceptualising the relationships between individual-level socioeconomic characteristics, neighbourhood disadvantage, neighbourhood psychosocial characteristics, and daily smoking.

Carlo (burn in=500, chain=50000). All results are reported as odds ratios (OR) and their 95% credible intervals (CrI). All data were prepared in StataSE version 13 (StataCorp, 2013), and models were completed in MLwIN version 2.32 (Rasbash et al., 2014).

3. Results

Descriptive statistics for the sample are presented in Table 1. Females were slightly over-represented in the sample (54.8%), and approximately three quarters of the sample were born in Australia (75.5%). The prevalence of daily smoking was 12.8%. Rates of daily smoking were highest among those living in the most disadvantaged neighbourhoods, and lowest among those with a bachelor degree or higher, and with a household income greater than $130000 per year.

The odds of being a daily smoker increased with greater neighbourhood disadvantage (Fig. 2). Participants in the most disadvantaged neighbourhoods were 2.35 times more likely to smoke daily than those in the least disadvantaged neighbourhoods (95% CrI 1.90, 2.92).

Multilevel logistic regressions between neighbourhood-level psychosocial characteristics and smoking revealed several significant associations (Table 3). Prior to adjusting for neighbourhood disadvantage, smoking was shown to be significantly

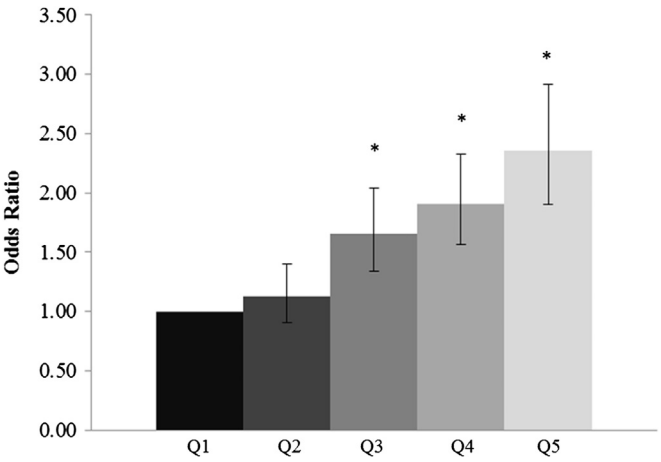

Fig. 2. Prevalence of daily smoking by neighbourhood disadvantage, adjusted for age, sex, country of birth, education, occupation, and household income. *: p ≤.001.

associated with incivilities, crime and safety, and social cohesion. However, these reduced when adjusted for neighbourhood disadvantage, to non-significance for crime and safety and social cohesion, with the proportional differences in odds ratios ranging from 17.0 to 118.4%.

Regression analyses between daily smoking and neighbourhood disadvantage revealed that the differences between the most advantaged and disadvantaged neighbourhoods slightly attenuated after adding the neighbourhood psychosocial characteristics into the model (Table 4).

4. Discussion

This study examined associations between neighbourhood disadvantage, psychosocial characteristics and smoking. As has been shown in many previous studies (Chuang et al., 2005; Datta et al., 2006; Giskes et al., 2006; Hanibuchi et al., 2015; Migliorini and Siahpush, 2006; Reijneveld, 2002; Sundquist et al., 1999; Tseng et al., 2001), the odds of being a current daily smoker increased with neighbourhood socioeconomic disadvantage, independent of individual-level SEP. In the current study, disadvantaged neighbourhoods were characterised by greater perceptions of incivilities, more crime and less social cohesion. The odds of being a daily smoker were associated with each of these neighbourhood-level psychosocial characteristics. However, these associations were attenuated to (to non-significance for some exposures) after adjustment for neighbourhood disadvantage. Neighbourhood psychosocial characteristics only slightly explained the associations between neighbourhood socioeconomic disadvantage and smoking.

The finding that area disadvantage was independently associated with an increased likelihood of smoking is consistent with research conducted in the United States (Chuang et al., 2005; Datta et al., 2006; Tseng et al., 2001), the United Kingdom (Ellaway and Macintyre, 2009), Europe (Reijneveld, 2002; Sundquist et al., 1999; van Lenthe and Mackenbach, 2006), Australia (Migliorini and Siahpush, 2006; Turrell, Hewitt, and Miller, 2012) and New Zealand (Pearce et al., 2009). Several studies have also shown associations between smoking and neighbourhood-level psychosocial perceptions, such as absence of goods, incivilities, physical environmental problems (Ellaway and Macintyre, 2009), collective efficacy (Ahern et al., 2009) and crime (Shareck and Ellaway, 2011). However, each of these aforementioned studies failed to account for neighbourhood-level socioeconomic disadvantage; and the results of this study therefore suggest that their findings may have been confounded by this factor. Patterson et al. (2004) also found that their associations between smoking and perceptions of neighbourhood safety and safety in the home dis-attenuated after adjustment for area-level concentrations of poverty and lower levels of educational attainment; while Echeverría et al. (2008) found similar results for smoking and perceived neighbourhood social cohesion after adjusting for neighbourhood-level socioeconomic condition.

The findings of this study suggest that there may be other neighbourhood-level factors not considered in the current study that play an important role in contributing to the higher prevalence of smoking seen in disadvantaged neighbourhoods. Previous studies examining the association between area disadvantage and smoking have predominantly focussed on the presence and location of outlets selling tobacco products (Chuang et al., 2005; Pearce et al., 2009) or the quality of the area's physical environment (Peretti-Watel et al., 2009; van Lenthe and Mackenbach, 2006), and these studies have found mixed results. A number of qualitative studies suggest that cultural factors and social networks may play an important role. Residents of

Table 3
Daily Smoking by Neighbourhood Psychosocial Characteristics, Before and After Adjustment for Neighbourhood Disadvantage (Estimated Odds Ratios and 95% Credible Intervals, CrI).

	Unadjusted* OR (95% CrI)	Adjusted OR (95% CrI)	% Reduction in OR[a]
Incivilities			
Q1 (least incivilities)	1.00	1.00	
Q2	**1.42 (1.05, 1.94)**	1.29 (0.95, 1.76)	30.1
Q3	**1.79 (1.33, 2.43)**	**1.42 (1.01, 1.98)**	47.0
Q4	**2.00 (1.48, 2.72)**	**1.42 (1.00, 2.01)**	57.7
Q5 (most incivilities)	**2.29 (1.68, 3.13)**	**1.47 (1.01, 2.14)**	69.9
Crime and safety			
Q1 (least crime)	1.00	1.00	
Q2	1.11 (0.82, 1.50)	1.00 (0.75, 1.35)	97.3
Q3	1.28 (0.94, 1.74)	0.96 (0.70, 1.30)	114.9
Q4	**1.40 (1.02, 1.89)**	0.97 (0.70, 1.32)	108.6
Q5 (most crime)	**1.72 (1.26, 2.36)**	1.03 (0.72, 1.46)	95.6
Social cohesion			
Q1 (most social cohesion)	1.00	1.00	
Q2	1.08 (0.80, 1.48)	1.07 (0.80, 1.42)	17.0
Q3	1.25 (0.91, 1.71)	1.14 (0.85, 1.52)	44.8
Q4	1.16 (0.84, 1.59)	0.97 (0.72, 1.31)	118.4
Q5 (least social cohesion)	**1.41 (1.02, 1.92)**	1.18 (0.87, 1.59)	55.9

* All models adjusted for individual age, sex, country of birth, education, occupation and household income.
[a] Reduction in odds ratio (((OR unadjusted – OR adjusted)/ OR unadjusted −1) x 100) (Droomers et al., 1999). Bold indicates significance.

Table 4
Daily Smoking by Neighbourhood Disadvantage, Before and After Adjustment for Neighbourhood Psychosocial Characteristics (Estimated Odds Ratios and 95% Credible Intervals, CrI).

	Base model* OR (95% CrI)	Base model + incivilities OR (95% CrI)	Base model + perceived crime OR (95% CrI)	Base model + social cohesion OR (95% CrI)	Full model OR (95% CrI)
Q1 (least disadvantaged)	1.00	1.00	1.00	1.00	1.00
Q2	1.02 (0.75, 1.38)	0.96 (0.71, 1.31)	1.03 (0.75, 1.42)	1.00 (0.73, 1.36)	0.94 (0.67, 1.30)
Q3	**1.53 (1.14, 2.05)**	1.29 (0.93, 1.79)	**1.54 (1.13, 2.10)**	**1.51 (1.12, 2.04)**	1.29 (0.91, 1.81)
Q4	**2.02 (1.54, 2.64)**	**1.70 (1.24, 2.31)**	**2.05 (1.52, 2.74)**	**2.00 (1.53, 2.63)**	**1.73 (1.25, 2.40)**
Q5 (most disadvantaged)	**2.24 (1.67, 3.00)**	**1.84 (1.28, 2.65)**	**2.23 (1.55, 3.18)**	**2.18 (1.62, 2.95)**	**1.89 (1.28, 2.81)**

* All models adjusted for individual age, sex, country of birth, education, occupation and household income. Bold indicates significance.

disadvantaged areas report that smoking is a major part of (and mechanism for) social interaction (Stead et al., 2001), forms a common bond between residents (Peretti-Watel et al., 2009) and helps residents to cope with their disadvantaged circumstances (Graham and Britain, 1993). With the higher prevalence of smoking in disadvantaged areas, smoking is more normalised in social networks, which can reinforce smoking behaviour and make it more difficult to quit (Miles, 2006). Furthermore, residents' decreased ability to afford cessation aids (such as nicotine replacement therapies (Bauld et al., 2007), lower access to (or awareness of) healthcare or services to assist quitting (Stead et al., 2001) may also contribute to the higher prevalence of smoking in socioeconomically disadvantaged areas. There have also been increasing calls for a broader social determinants of health approach to reducing disparities in tobacco use and its consequences (Garrett et al., 2014), and the findings of the current study add weight to the compelling need to consider other ways in which the neighbourhood context can influence smoking uptake, cessation and social norms. For example, past qualitative work has suggested that limited opportunities for recreation or respite from the immediate environment of disadvantaged neighbourhoods, such as lack of access to leisure facilities, combined with a stressful environment, strong community smoking norms, and isolation from wider social norms, appear not only to foster smoking but to also discourage or undermine cessation (Stead et al., 2001).

The findings of the current study also have pertinent implications for public health and tobacco control policy and the targeting of interventions. It supports recent calls for more increased efforts to ensure access to evidence-based cessation support in disadvantaged areas, with interventions that are able to take into account the additional barriers to quitting and successful cessation that can exist for people living in areas of greater deprivation (Brose and McEwen, 2016). Walkable proximity to tobacco outlets is also an impediment to cessation (Halonen et al., 2013), and given the growing weight of studies reporting higher per capita density of tobacco outlets in disadvantaged areas (Wood et al., 2013), the innovative approach being taken in San Francisco to cap the number of tobacco outlets in residential areas merits wider consideration (Counter Tobacco, 2014). More broadly, the independent association observed in our study between smoking and perceptions of neighbourhood incivilities underscores the importance of considering the wider contextual environment in which smoking and other preventable risk factor behaviours occur. As reflected in ecological models of health, health-related behaviours and choices do not occur in a vacuum, and the built environment is now recognised as a critical element for healthier cities and chronic disease prevention (Giles-Corti et al., 2014).

This present study has several important limitations that need to be considered when interpreting the results. First, residents of advantaged and disadvantaged areas may have different norms for

the psychosocial factors measured in the current study; their perceptions of concepts such as incivilities, crime and safety and social cohesion, and the acceptable levels of these may differ. This study would have been strengthened from the inclusion of objective measures of the neighbourhood psychosocial environment, such as crime rates, or neighbourhood audits of litter and graffiti. Second, survey non-response in the HABITAT baseline study was 31.5% overall and slightly higher among low socioeconomic respondents and residents of more disadvantaged neighbourhoods, allowing the possibility of non-response bias. Along these lines, participants had the option of responding either 'Don't know' or 'Don't want to answer this', or leaving the question blank for the covariate household income. We chose not to apply missing data techniques such as multiple imputation or inverse probability weighting, and instead amalgamated these responses into a 'missing' category. Third, the cross-sectional study design did not permit us to ascertain whether the associations were due to contextual factors (i. e. the features of neighbourhoods influence smoking) or due to selection mechanisms (i. e. people choose to live in neighbourhoods differing in their smoking rates). The latter argument would appear to be the less likely mechanism, given that individuals are unlikely to know the health behaviours of residents before they move to an area. Fourth, the study only considered a limited number of area-level psychosocial characteristics, and only examined these in participants' residential environments. The features of other environments that participants interact with that have been shown to be influential for initiating and maintaining smoking (e.g. work environment (van Jaarsveld et al., 2007)) was not considered in this study. Fifth, the study was based on a sample of persons aged 40–65 years, thus it is possible that the association between neighbourhood psychosocial characteristics and smoking may not have been the same for individuals outside of this age range. The study may have also been limited by the geographical area of the study (urban-only), the use of country of birth rather than ethnicity, and the small number of participants who reported only occasionally smoking.

This study has investigated associations between neighbourhood-level psychosocial characteristics and self-reported daily smoking. Future research should continue to be directed at acquiring more in-depth information on the social and cultural neighbourhood environments; with study designs that reduce the bias associated with obtaining subjective neighbourhood-level psychosocial data (Diez Roux, 2007). Such studies would strengthen the qualitative evidence (Stead et al., 2001), and further inform neighbourhood-level interventions directed at reducing the prevalence of smoking in disadvantaged neighbourhoods.

This study found no associations between daily smoking and neighbourhood-level perceptions of crime and safety and social cohesion independent of neighbourhood socioeconomic disadvantage. Perceptions of neighbourhood incivilities did show an independent effect, though further work may be needed to confirm this association independent of neighbourhood-level disadvantage. Future research should continue to examine differences between the features of these areas, as well as using alternative ways of conceptualising and measuring psychosocial factors, including objective and observational measures, that contribute to inequalities in smoking and smoking-related disease between socioeconomically disadvantaged and advantaged areas.

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