Is neighbourhood access to tobacco outlets related to smoking behaviour and tobacco-related health outcomes and hospital admissions?

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ABSTRACT

Objectives: Although the harms of tobacco use are widely accepted, few studies have examined the relationship between access to tobacco outlets and hospital admissions. This study aimed to examine the relationship between neighbourhood access to tobacco outlets, smoking and hospital admissions and self-reported morbidity.

Methods: Responses as to smoking behaviour were obtained from 12,270 adult participants in Western Australia (2003-2009) and individually record-linked to hospital admissions and geographically linked to tobacco outlets.

Results: Neighbourhood access to tobacco outlets was marginally positively associated with being a current versus a past smoker. Tobacco outlet access was also positively associated with heart disease for smokers but not non-smokers. For smokers, each additional outlet within 1600m of home was associated with a 2% increase in the odds of heart disease.

Conclusion: Smokers with greater access to tobacco outlets were more likely to be diagnosed with or admitted to hospital for heart disease. Regulating the density of tobacco outlets in the community has immense potential to improve health benefits and our results motivate the need for future longitudinal studies to confirm this hypothesis.

Keywords: environment, smoking, epidemiology, respiratory, cardiovascular

INTRODUCTION

Globally, almost 6 million people die each year from direct tobacco use or second-hand smoke.[1] Furthermore 71% of lung cancer, 42% of chronic respiratory disease and 10% of cardiovascular disease is attributable to smoking.[1] Ratification of the World Health Organization's Framework Convention on Tobacco Control[2] by almost 180 countries has accelerated efforts to curb tobacco use, which advocates for bans on tobacco advertising, promotion and sponsorship, smoking in indoor public areas and workplaces and strengthening of health warnings. However, there is still an estimated one billion smokers worldwide[1] and the widespread availability of tobacco products undermines the effectiveness and consistent messaging of other tobacco control measures. Hence there is growing policy and research interest in evidence to support reducing the availability and access of tobacco products.[3,4]

Emerging evidence demonstrates a link between higher neighbourhood access to tobacco outlets and smoking in both youth[5–7] and adults.[8–10] For example, Pearce et al. (2009) measured access to tobacco outlets across New Zealand as the car travel time to the nearest outlet, and identified a positive association with risk of being a smoker.[9] Chuang and colleagues (2005) found significant positive associations among Californian adults between smoking and three different measures of access to convenience stores: density of, distance to and number of stores within a one mile radius.[8] Research has also shown that retail availability of tobacco is positively associated with impulse purchases[11] and cessation relapse.[12] Furthermore, there is substantial evidence that access to tobacco outlets is greater in more disadvantaged areas.[6,8,9,13–15]

Research on area-level variations of alcohol[16–19] and unhealthy food[20–22] outlet access have moved beyond examining associations with prevalence and consumption patterns, to more complex relationships with health outcomes. However, the same cannot be said for research explicitly exploring tobacco outlet access and tobacco-related health outcomes. It is plausible that greater retail access to tobacco can lead to poorer health outcomes via a number of pathways, as tobacco outlet density has been identified as an impediment to successful cessation among smokers[12] and associated with higher smoking prevalence in adults[8–10] and young people.[5–7] Research in this area remains scarce despite calls for further exploration[3] and governments demanding evidence that proposed tobacco control strategies will work.[23] Yet currently there is insufficient evidence on the relationship between access to tobacco outlets and tobacco-related disease and death; this evidence is necessary to attract the attention of governments to enforce retail regulations. In the tobacco control literature to date, only one study appears to investigate the relationship between access to tobacco outlets and tobacco related health outcomes. This US study found that number of tobacco outlets was associated with changes in the geography of chronic obstructive pulmonary disease hospitalization.[24]

The overall purpose of this study was to investigate the association between neighbourhood access to tobacco outlets and smoking behaviour and tobacco-related health outcomes using a

large, representative Western Australian sample of adults (18+ years). This study had three aims: (1) to examine the relationship between neighbourhood tobacco outlet access and smoking status; (2) to investigate the relationship between tobacco outlet access and self-reported morbidity and objectively measured hospital admission for tobacco-related health outcomes among smokers; and (3) to test for an interaction between the association of tobacco outlet access and health outcomes and smoking status.

METHODS

Study Population

Cross-sectional survey data from the Health and Wellbeing Surveillance System (HWSS) were linked with objectively measured data on hospital admissions and tobacco outlets located across the Perth metropolitan area in Western Australia (WA). The Department of Health in Western Australia (DoHWA) collects self-reported information about health, wellbeing and lifestyle factors on a continuous basis through the HWSS.[25] Monthly computer-assisted telephone interviewing was used to administer cross-sectional surveys and responses obtained from a representative stratified random sample of the WA population (N=1 959 088, 2006 Census). The WA Data Linkage System matches respondents' names and other identifiers in order to link available administrative health data. Respondents to the HWSS are asked to consent to having their survey data linked with other datasets through a de-identifying process conducted by the DoHWA. The Hospital Morbidity Database System is one of the data systems routinely linked to the HWSS and provides inpatient discharge data from all WA hospitals, both public and private. The combined database is close to complete with 98.5% of records linked.[26] For this study, 2003-2009 HWSS adult (18+ years) data were examined with a five-year window of Hospital Morbidity Database System data centred on the year the HWSS was completed. These protocols were approved by the Human Research Ethics Committees of The University of Western Australia and the DoHWA (#2010/1). The final sample (n=12 270) excluded those who either did not consent to data linkage or could not be linked based on available data.

Measures

Neighbourhood access to tobacco outlets

A geocoded list of the addresses of all retail outlets within WA with a license to sell tobacco (e.g. supermarkets, convenience stores, liquor stores, nightclubs) was provided to the Cancer Council WA by the WA Department of Health (DoHWA) with permission for this to be linked in May 2011. For respondents who consented to data linkage, neighbourhood buffers were generated at a 1600 meter distance (along the street network) from their home address using Geographic Information Systems software (ArcGIS, version 10.0). The number of tobacco outlets within the neighbourhood buffer was then computed. The 1600 meter distance (approximately ½ a mile) was selected as it approximately represents a 15 minute walk for an average adult.[27] Walkable accessibility of tobacco was mooted in the New South Wales study by Paul et al (2010), who found that 85.7% of smokers reported that they would be within walking distance of a tobacco outlet during the course of their day to day activities.[11]

Demographics, smoking status and diagnosis with diseases

Demographic characteristics, smoking status and disease diagnosis were sourced from the HWSS. The demographic characteristics included sex, age, highest level of education completed, household income and socioeconomic indexes for areas (SEIFA) (Index for relative socioeconomic advantage and disadvantage 2006). SEIFA is calculated at the Census Collection District level[28] which has an average of 225 households per Census Collection District.[29] For smoking status, respondents were asked which of five categories best described them in terms of smoking behaviour i.e., 'I smoke daily', 'I smoke occasionally', 'I don't smoke now but I used to', 'I've tried it a few times but never smoked regularly' and 'I've never smoked'. These items were similar to those used in previous studies.[11,30] Respondents indicating daily or occasional smoking were classified as 'smokers' and this sub-sample was the focus of the tobacco outlet access and health outcome analyses (n=1873). For diagnoses with tobacco-related health outcomes, respondents were asked if a doctor had ever told them that they had a respiratory disease other than asthma (non-specified), heart disease, stroke and cancer. For diagnosis with asthma, respondents were asked if they had taken treatment for or had symptoms of asthma in the last 12 months.

Hospital admissions

Respondents providing consent for data linkage had their survey data linked with their hospital admissions data (1999-2011) through the DoHWA data linkage system.[25] A 5-year window of hospital data was obtained centred on the year they completed the HWSS. Hospital admission data for asthma, other respiratory diseases (non-specified), heart disease, coronary heart disease, stroke and cancer were obtained for this study. In addition, hospital data for a range of known tobacco-related diseases including lung cancer, oesophageal cancer and heart failure were combined into a single measure as the case numbers for each disease were too low to examine specifically. The full list of diseases and health outcomes combined into this measure is presented in Table 1.

Table 1. Disease/Conditions Included in the Tobacco-Related Disease Outcome Measured Among Western Australian Adults who Responded to the Health and Wellbeing Survey (2003-2009) With Linked Environmental and Hospital Data

Diseases and conditions	ICD-10 codes
Oropharyngeal cancer	C00-14
Oesophageal cancer	C15
Stomach cancer	C16
Pancreatic cancer	C25
Laryngeal cancer	C32
Lung cancer	C33-34
Cervical cancer 12	C53, D06
Bladder cancer	C67
Kidney cancer	C64-66, C68
Ischaemic heart disease	I20-25
Chronic obstructive pulmonary disease	J40-44
Tobacco abuse 13	F17, T65.2, Z72.0
Pulmonary circulation disease 12	I26.0, I27-28
Cardiac dysrhythmias 12	I46-49
Heart failure 12	I50-51, I97.1
Stroke	I60-69, G45
Peripheral vascular disease	I70.0-I70.8, I72-74
Lower respiratory tract infection	J10-13, J15-18, J20.0, J20.2-20.9, J21-22
Crohn’s disease	K50
Ulcerative colitis	K51
Antepartum haemorrhage 11	O20, O44.1, O45-46, P02.0-02.1
Low birth weight	P05-07, P22
SIDS	R95
Fire injuries	X00-19
Asthma (under 15 years)	J45-46
Macular degeneration 14	H35.3-52.4
Otitis media 13	H65-66

Statistical analysis

Logistic regression was used to identify the odds of being a smoker for each additional tobacco outlet within 1600 meters of home, with and without adjusting for potential confounders of sex, age (and age^2), household income, and socio-economic status (SEIFA). Analyses compared daily smokers with: (1) participants who have never smoked; and (2) those currently classified as non-smokers (i.e., past smokers, experimental smokers and those who have never smoked). Additional analyses compare those classified as 'current' smokers (i.e., daily and occasional smokers) with: (1) those who have never smoked; and (2) those currently classified as non-smokers. Current smokers (i.e., daily and occasional smokers) were also compared with past smokers to investigate whether tobacco outlet access might impact a smoker's ability to successfully quit. To examine whether tobacco outlet access was associated with the amount smoked daily smokers were compared to occasional smokers, as easy access to tobacco might facilitate more frequent smoking. Finally, to compare effects of any smoking, including past smoking, all those who ever smoked (i.e., daily, occasional and past smokers) were compared to those who never smoked. Odds of diagnosis with or hospital admission for diseases per each additional tobacco outlet was then examined among smokers only, adjusting for sex, age and socio-economic status using logistic regression. The whole sample including non-smokers was then used to test an interaction term between tobacco outlet access and smoking status in models predicting health outcomes, again adjusting for sex, age and socio-economic status. All statistical analyses were conducted in 2013-2014 using Statistical Package for the Social Sciences, version 21.

RESULTS

The mean age for the full study sample was 53 years, with more females than males. Almost 23% of the sample had a university education (Table 2). Smokers (daily and occasional) were on average younger, with a mean age of 46 years, and a more even gender balance. Approximately 15% of the smoking sample had a university education and over one third had a household income of $40 000 or less.

Both the full study sample and smoking sub-sample had access to an average of eight tobacco outlets within 1600 meters of home. This varied markedly with some respondents having access to 174 outlets within 1600 meters. In addition, the median number of neighbourhood tobacco outlets was 6 (lower quartile 3 and upper quartile 11) for both the full sample and smoker subsample.

Table 2. Sample Characteristics of Western Australian Adults who Responded to the Health and Wellbeing Survey (2003-2009) With Linked Environmental and Hospital Data

	Study population: Full sample Smokers and non-smokers (n=12 270)			Study population: Sub-sample Smokers only (n=1873)		
	Mean (SD)			Mean (SD)		
Age	53 (18.1)			46 (15.6)		
	Mean (SD)	**Mode**	**Range**	**Mean (SD)**	**Mode**	**Range**
Tobacco outlets within 1600m	8.1 (9.1)	4	0-174	8.3 (9.6)	4	0-173
	N (%)			N (%)		
Sex						
Male	5119 (41.7)			835 (44.6)		
Female	7151 (58.3)			1038 (55.4)		
Education						
Less than Year 10	959 (8.1)			121 (6.5)		
Year 10 or 11	2295 (19.4)			450 (24.0)		
Year 12	1694 (14.3)			289 (15.4)		
TAFE/Trade qualification	4191 (35.5)			693 (37.0)		
Tertiary	2675 (22.6)			276 (14.7)		
Household income						
Less than $20,000	2088 (17.0)			314 (17.2)		
$20,001-$40,000	2497 (20.4)			336 (18.4)		
$40,001-$60,000	1747 (14.2)			317 (17.4)		
$60,001-$80,000	1593 (13.0)			279 (15.3)		
More than $80,000	3039 (24.8)			392 (21.5)		
Refused/don’t know	1304 (10.7)			185 (10.2)		
Smoking status						
Daily smoker	1464 (11.9)			1464 (80.3)		
Occasional smoker	360 (2.9)			359 (19.7)		
Past smoker	3895 (31.7)			NA		
Experimental smoker	1094 (8.9)			NA		
Never smoked	5456 (44.5)			NA		

SD, standard deviation.

Among the study population, 120 (6.4%) smokers had asthma (symptoms or treatment in the last 12 months) (Table 3). Fifty seven (3.0%) smokers had been diagnosed with a respiratory disease other than asthma, 119 (6.4%) with heart disease and 125 (6.7%) with cancer. There were few hospital admissions with the primary diagnosis relating to asthma. However, there were 51 (2.7%) relating to other respiratory diseases, 43 (2.3%) relating to heart disease, and 71 (3.7%) relating to cancer. Approximately 7% of the sample had had hospital contact for a tobacco-related disease.

Table 3. Sample Characteristics and Health Outcomes for Western Australian Adult Smokers Who Consented to Data Linkage and The Non-Linkable Population Who Did Not Consent to Data Linkage in the Health and Wellbeing Survey (2003-2009)[a]

	Study population (n=1873)			Non-linkable population (n=716)	
	Mean (SD)			Mean (SD)	*p*
Age	46 (15.6)			44 (15.3)	**0.009**
	Mean (SD)	**Mode**	**Range**		
Tobacco outlets within 1600m	8.3 (9.6)	4	0-173	NA	
	N (%)			N (%)	
Sex					
Male	835 (44.6)			341 (47.6)	0.164
Female	1038 (55.4)			375 (52.4)	
Education					
Less than Year 10	121 (6.5)			69 (9.6)	**0.006**
Year 10 or 11	450 (24.0)			163 (22.8)	
Year 12	289 (15.4)			126 (17.6)	
Tafe/Trade qualification	693 (37.0)			226 (31.6)	
Tertiary	276 (14.7)			119 (16.6)	
Household income					
Less than $20,000	320 (17.1)			100 (14.0)	0.189
$20,001-$40,000	343 (18.3)			133 (18.6)	
$40,001-$60,000	327 (17.5)			108 (15.1)	
$60,001-$80,000	288 (15.4)			75 (10.5)	
More than $80,000	404 (21.6)			128 (17.9)	
Asthma					
Current symptoms or treatment	120 (6.4)			36 (5.0)	0.397
Hospital admission	3 (0.2)			NA	NA
Other respiratory disease					
Ever diagnosed	57 (3.0)			18 (2.5)	0.747
Hospital admission	51 (2.7)			NA	NA
Heart disease					
Ever diagnosed	119 (6.4)			43 (6.7)	0.727
Hospital admission	43 (2.3)			NA	NA
Coronary heart disease					
Hospital admission	29 (1.5)			NA	NA
Stroke					
Ever diagnosed	38 (2.0)			20 (3.1)	0.244
Hospital admission	3 (0.2)			NA	NA
Cancer					
Ever diagnosed	125 (6.7)			41 (6.8)	0.612
Hospital admission	71 (3.7)			NA	NA
Tobacco-related disease					
Hospital admission	125 (6.7)			NA	NA

SD, standard deviation. [a]Sample characteristics and health outcomes for participants who: (1) consented to data linkage; and (2) did not consent to data linkage. A total of 2589 adult smokers (18+ years) responded to the Health and Wellbeing Surveillance System Survey (2003-2009) with 72% (n=1873) consenting to data linkage.

The unadjusted and adjusted associations between access to tobacco outlet and various levels of smoking status are presented in Table 4. A marginal association was identified between current and past smokers where for every additional outlet within 1600 meters, the odds of being a current smoker compared to a past smoker increased by almost 1% (odds ratio=1.007, 95% CI: 1.000,1.014).

Table 4. Associations Between Tobacco Outlet Access and Smoking Status Among Western Australian Adults who Responded to the Health and Wellbeing Survey (2003-2009) With Linked Environmental and Hospital Data

Smoking outcomes	Unadjusted			Adjusted[c]		
	N (%)	OR	95% CI	N (%)	OR	95% CI
Daily smoker vs never smoked	1463 (21.9)	0.997	0.991, 1.004	1307 (21.5)	0.997	0.990, 1.004
Daily smoker vs non-smoker[a]	1464 (12.3)	0.999	0.993, 1.005	1307 (12.3)	1.000	0.993, 1.007
Daily/occasional smoker vs never smoked	1824 (25.1)	0.999	0.994, 1.005	1632 (25.5)	0.999	0.993, 1.006
Daily/occasional smoker vs non-smoker[a]	1824 (14.9)	1.001	0.995, 1.006	1631 (14.9)	1.002	0.996, 1.008
Daily smoker vs occasional smoker	1463 (80.3)	0.992	0.981, 1.003	1305 (80.3)	0.991	0.979, 1.002
Daily/occasional smoker vs past smoker	1823 (31.9)	1.003	0.997, 1.009	1632 (31.5)	1.007	1.000, 1.014
Ever smoked[b] vs never smoked	5456 (21.1)	1.002	0.999, 1.006	4777 (43.8)	1.003	0.998, 1.007

CI, confidence interval; OR, odds ratio; vs, versus.

[a]Non-smoker includes past smokers, experimental smokers and those who have never smoked.

[b]Ever smoked includes daily/occasional and past smokers

[c]Results adjust for sex, age, income and area-level SES (SEIFA).

For smokers, having more tobacco outlets within 1600 meters of home was associated with both diagnosis with (95% CI: 1.002,1.032) and hospital admission for (95% CI: 1.000,1.037) heart disease (all types) and hospital admission for coronary heart disease specifically, whereby for each additional outlet there was approximately a 2% increase in odds (Table 5). The full adjusted models for these findings are presented in the Appendix. When the full sample including smokers and non-smokers was examined, smoking status was found to be a positive moderator of the association between access to tobacco outlets and heart disease (diagnosis and hospital admission measures); indicating that the finding was only observed if the respondent was a smoker (interaction odds ratio for diagnosis=1.024, 95% CI: 1.006,1.041; interaction odds ratio for hospital admission=1.025, 95% CI: 1.002,1.049). No other outcomes were associated with access to tobacco outlets.

Table 5. Odds Ratios for Diagnosis With or Hospital Admission For Tobacco-Related Diseases For Each Additional Tobacco Outlet Within 1,600m of Homes of Western Australian Adult Smokers who Responded to the Health and Wellbeing Survey (2003-2009) With Linked Environmental and Hospital Data

Outcome	Unadjusted		Adjusted[a]	
	OR	95% CI	OR	95% CI
Asthma				
Current symptoms or treatment	1.013	0.986, 1.041	1.016	0.988, 1.045
Hospital admission	0.814	0.573, 1.157	0.808	0.570, 1.146
Other respiratory disease				
Ever diagnosed	0.965	0.923, 1.008	0.959	0.913, 1.006
Hospital admission	0.969	0.926, 1.014	0.969	0.925, 1.014
Heart disease				
Ever diagnosed	1.015	1.002, 1.029	1.017	1.002, 1.032
Hospital admission	1.018	1.000, 1.036	1.018	1.000, 1.037
Coronary heart disease				
Hospital admission	1.020	1.001, 1.039	1.019	1.000, 1.039
Stroke				
Ever diagnosed	0.983	0.939, 1.030	0.975	0.925, 1.028
Hospital admission	1.001	0.890, 1.124	0.996	0.858, 1.157
Cancer				
Ever diagnosed	1.001	0.982, 1.019	1.002	0.982, 1.022
Hospital admission	0.994	0.967, 1.023	0.996	0.966, 1.027
Tobacco-related disease				
Hospital admission	1.004	0.987, 1.021	1.006	0.988, 1.025

CI, confidence interval; OR, odds ratio.

[a]Adjusted for sex, age and area-level SES (SEIFA).

DISCUSSION

To our knowledge, this is the first study to investigate neighbourhood access to tobacco outlets in relation to both hospital admissions and self-reported morbidities. This study provides evidence of an association between neighbourhood access to tobacco outlets and heart disease among smokers. This relationship remained after adjustment for important demographic factors. The finding was observed for smokers but not non-smokers suggesting that it is not due to another environmental attribute associated with access to tobacco outlets.

Our findings also support the contention that exposure to an environment with more tobacco outlets might adversely impact a smoker's ability to successfully quit, with current smokers more likely than ex-smokers to live in areas with higher outlet access. In other words, smokers are more likely to still smoke (as opposed to being an ex-smoker) when there are more tobacco outlets in the proximity of where they live. While the odds ratio appears small (OR=1.007), an increase of 5 outlets within 1600 meters would correspond to a 3.5% increase in the odds of being a current compared to a past smoker. This indicates potentially large disparities between individuals given that the number of local tobacco outlets in this study ranged from zero to 174. This finding was only marginal (95% CI: 1.000, 1.014) but adds support to the argument that reducing the availability of tobacco will benefit smokers who wish to quit.[11,31] A number of reasons are put forth in the literature for this; these include the normalization of smoking perpetuated by ready availability, the higher 'cost' of purchasing if you have to travel further to obtain cigarettes, and the influence of availability on impulse purchasing and cessation relapse.[11] A cross-sectional study in Victoria, Australia found that a quarter of adult smokers reported impulse purchasing, and a third of recent ex-smokers experienced urges to recommence smoking after seeing tobacco products displayed.[32] Similarly, residential proximity to outlets was associated with increased odds of relapse in a US sample.[11] Although WA laws now require tobacco products to be dispensed from cabinets at the check-out point, this does not equate to 'out of sight'. The fact that these dispensing units are prominently located directly behind the sales person at checkouts results in them being in the direct line of sight for customers. This is a ready and visible reminder of tobacco product existence and availability. The brand names of

cigarettes are also often displayed on the outside of these cabinets, and this may also serve as a cue for purchase (or cessation relapse).

Neighbourhood access to tobacco outlets was not however directly associated with smoking status (smoker versus non-smoker) in our sample. This is in contrast to the findings in two previous studies.[8,9] The lack of a direct association between neighbourhood access to tobacco outlets and smoking in our study may in part be because of selection bias due to survival if smoking, for example, caused death among potential respondents. Alternatively, the lack of association may be due to other determinants of smoking behaviour not measured, such as the effects of smoking campaigns, interventions and social support for quitting or prevention of uptake. However, as the identified association between the number of tobacco outlets and heart disease was observed only for smokers, it may be that smokers do not have greater access to tobacco *outlets* but that for people who smoke their health risks are higher if they have greater access to tobacco. This could be due to greater consumption of tobacco, for example, which we were not able to examine in this study. Further, no associations would be expected if the exposure variable did not represent where smokers traverse their neighbourhood.

Our finding of no association between neighbourhood access to tobacco outlets and respiratory diseases is in contrast to findings for chronic obstructive pulmonary disease (COPD) by Lipton and colleagues (2005).[24] We examined whether the inclusion of young adults might have influenced our findings by restricting the dataset to adults aged 40 and over for whom prevalence of these diseases is higher and found a negative association between tobacco access and hospital admissions for other respiratory diseases (OR=0.976; 95% CI:0.956,0.996). The negative association is also in contrast to Lipton and colleagues' (2005) COPD finding. Our respiratory disease variable is however a broad measure including all types of respiratory disease, some of which may have several known causes other than tobacco, as is the case with asthma. This may have contributed to our findings. Other health outcomes were also not associated with tobacco outlet access in our study. Given the paucity of studies investigating this topic it is not possible at this stage to conclude whether this means a relationship does not exist. Many of the outcomes

used in this study had low case numbers, for example there were only three hospital admissions for asthma and stroke in our current smoker sample. This may have contributed to the findings. The time-lag for onset of tobacco-related cancers may also in part explain why no associations were observed with cancer. Further research, including studies with wider time windows is needed to help understand the different findings for the various tobacco-related diseases. Again, there could also be an issue if the exposure variable did not capture where smokers travel within their neighbourhood.

The strengths of this study include the individual level analysis, large sample size and objective hospital data. However, the study may be limited by its cross-sectional study design as we cannot determine causal effects or ensure certainty that exposure preceded diagnosis or hospital admission. A key assumption is that the current exposure to tobacco outlets reflects longer term exposure for residents. According to data from the Tobacco Control Branch at the Department of Health, Western Australia, the spatial distribution of tobacco outlets across Western Australia does not change substantially from year to year, with numbers varying approximately between 3500 and 3800 (Tobacco Control Branch, Department of Health, Western Australia. Unpublished data Jan 22, 2016). There were also differences in mean age and education level between our study sample and non-linkable population which may have introduced bias. It is also possible that the findings can be reflecting unmeasured differences related to living in high density inner city areas versus low density suburban areas such as pollution levels and socioeconomic factors. This seems less applicable in Perth which is characterised by predominantly suburban living (in contrast to high density down town areas observed in some cities). The potential role of pollution as a confounder is also less of an issue in this study population where there is low urban density and low levels of air pollution compared to many other populations.[33,34] In terms of the sociodemographic profiles, those living in areas with the highest number of outlets in our sample (quartile four) were more likely to be older, have a lower household income, have a university degree and be in a lower socioeconomic area (as measured by the SEIFA index) compared with those in quartile one and we controlled for age and socioeconomic differences. These are important considerations for future studies of this nature. Although we assessed a wide range of morbidities, we were not able to comprehensively investigate morbidities associated with tobacco exposure for which no information was collected by the HWSS survey, or those not necessarily captured by records

hospital admission. Further studies are needed to examine associations with early life endpoints (e.g., perinatal health), late endpoints (e.g., mortality), and diseases at a stage in their natural history prior to when the individual would be hospitalized. The HWSS also did not collect information on smoking intensity which is a major limitation of the study as we could not assess whether higher access to tobacco outlets was associated with more individual tobacco consumption. In this study we used access measures relating to the residential address of participants. Although this is common in studies of neighbourhood environments and health outcomes, it is acknowledged that the pre-defined buffer of 1600m distances from home may not necessarily be representative of individuals' activity spaces (i.e., where they actually traverse). Future studies may need to examine, for example, tobacco availability close to work, or on the commute between work and home.

CONCLUSION

There has been very little research to date investigating the relationship between access to tobacco outlets and health outcomes, and most of the research relating to smoking status and outlet access has focused on children and adolescents. The identified relationships with heart disease add further weight to calls to consider reducing the pervasive retail availability of a product that is a major preventable cause of death and disease, and augurs for further quasi-experimental studies where exposure over time can be determined. It is also plausible however that even if exposure has not preceded incidence, it exacerbates the problem as other studies demonstrate that tobacco access is linked to smoking. We are aware of only one other study that investigated associations between access to tobacco outlets and health outcomes.[24] These are important research questions, as greater evidence is needed to compel governments to restrict the widespread availability of tobacco. That tobacco remains as readily available as bread and milk is an anathema, and it is disturbing to note that some individuals in this study are exposed to as many as 174 outlets selling tobacco within a 1600 meter radius of their home. This widespread retail availability of tobacco not only perpetuates the normalization of a lethal product, but may also precipitate cessation relapse or unplanned purchases.

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Conflict of interest statement Drs. Barnes, Foster and Wood report receiving grants to their institution from the Cancer Council, WA during the conduct of the study.

Ethics approval Human Research Ethics Committees of The University of Western Australia and the DoHWA (#2010/1).

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Appendix. Odds Ratios for Diagnosis With or Hospital Admission For Heart Disease For Each Additional Tobacco Outlet Within 1,600m of Homes of Western Australian Adult Smokers who Responded to the Health and Wellbeing Survey (2003-2009) With Linked Environmental and Hospital Data

	Ever diagnosed			Hospital admission		
	OR	**95% CI**	***p***	**OR**	**95% CI**	***p***
Number of tobacco outlets within 1600m	1.017	1.002,1.032	0.023	1.018	1.000,1.037	0.048
Sex						
Male	1.000			1.000		
Female	0.549	0.369,0.817	0.003	0.570	0.303,1.072	0.081
Age	1.073	1.057,1.089	<0.001	1.068	1.044,1.091	<0.001
SEIFA	0.999	0.997,1.001	0.300	0.998	0.994,1.002	0.277