

# The association between alcohol outlet density and alcohol use among urban and regional Australian adolescents

Denise Azar<sup>1</sup>, Victoria White<sup>1</sup>, Kerri Coomber<sup>1,2</sup>, Agatha Faulkner<sup>1</sup>, Michael Livingston<sup>3,4</sup>, Tanya Chikritzhs<sup>5</sup>, Robin Room<sup>3,6</sup> & Melanie Wakefield<sup>1</sup>

Centre for Behavioural Research in Cancer, Cancer Council Victoria, Melbourne, Australia 3004;<sup>1</sup> School of Psychology, Faculty of Health, Deakin University, Geelong, Australia 3220;<sup>2</sup> Centre for Alcohol Policy Research, Turning Point Alcohol and Drug Centre, Melbourne, Australia 3065;<sup>3</sup> Drug Policy Modelling Program, National Drug and Alcohol Research Centre, University of New South Wales, Sydney, Australia 2052;<sup>4</sup> National Drug Research Institute, Curtin University, Perth, Australia 6008<sup>5</sup> and Melbourne School of Population and Global Health, University of Melbourne, Melbourne, Australia 3010<sup>6</sup>

## ABSTRACT

**Aims** While recent evidence suggests that higher alcohol outlet density is associated with greater alcohol use among adolescents, influence of the four main outlet types on youth drinking within urban and regional communities is unknown. This study provides the first investigation of this relationship. **Design** Repeated cross-sectional surveys with random samples of secondary students clustered by school. Mixed-effects logistic regression analyses examined the association between each outlet type and the drinking outcomes, with interaction terms used to test urban/regional differences. **Setting** Australia, 2002–11. **Participants** Respondents participating in a triennial survey (aged 12–17 years); 44 897 from urban settings, 23 311 from regional settings. **Measurements** The key outcome measures were past month alcohol use, risky drinking among all students and risky drinking among past week drinkers. For each survey year, students were assigned a postcode-level outlet density (number of licences per 1000 population) for each outlet type (general, on-premise, off-premise, clubs). **Findings** Interaction terms revealed a significant association between off-premises outlet density and risky drinking among all adolescents in urban (odds ratio = 1.36, 95% confidence interval CI = 1.05–1.75,  $P < 0.05$ ) but not regional areas. Similarly, club density was associated with the drinking outcomes in urban communities only. General and on-premises density was associated with alcohol use and risky drinking among all adolescents. **Conclusions** Higher densities of general, on- and off-premises outlets in an adolescent's immediate neighbourhood are related to increased likelihood of alcohol consumption among all adolescents. The density of licensed clubs is associated more strongly with drinking for urban than for regional adolescents.

**Keywords** Adolescent, alcohol, Australia, outlet density, risky drinking, survey.

Correspondence to: Victoria White, Behavioural Science Division, Centre for Behavioural Research in Cancer, Cancer Council Victoria, 615 St Kilda Road, Melbourne, Victoria, 3004 Australia. E-mail: vicki.white@cancervic.org.au

Submitted 23 October 2014; initial review completed 30 January 2015; final version accepted 13 August 2015

## INTRODUCTION

Despite policies and strategies being in place to discourage youth from consuming alcohol, harmful drinking is a leading cause of disease and injury for adolescents and young adults [1,2]. Short-term risky drinking behaviour (defined commonly as five or more drinks in one session) is associated with physical injury, road traffic accidents and high-risk sexual behaviours among young people [3]. Drinking experience among Australian adolescents is far more common than in the United States, with rates of past-month and risky drinking two to four times higher among

Australian grades 7 and 9 students than for US students [4]. Adolescents and young adults living in regional, rural and remote areas are more likely to consume alcohol, particularly at risky levels, and experience alcohol-related harm, than those living in urban areas [5,6].

Adolescents under the drinking age are legally prohibited from purchasing alcohol, although they commonly obtain alcohol from parents, older siblings and friends [7]. While smaller proportions of adolescents purchase alcohol, there is greater reliance on commercial sources with increasing age [8]. Adolescents' perceived ease of obtaining alcohol from commercial sources is

associated with increased alcohol consumption [9]. Furthermore, the density of alcohol outlets within a specific geographic boundary may increase drinking rates and alcohol-related harm through greater availability and normalising drinking behaviours [10].

The majority of alcohol outlets can be categorised into four main types: on-premise, off-premise, general (hotels and taverns) and clubs (sporting and social). While all licence types contribute to the 'alcogenic' environment of an area, each type may encourage different drinking behaviours and adolescents may have more or less interaction with the specific licence types. While a recent systematic review reported that overall higher outlet density may be associated with greater alcohol use among adolescents [11], the evidence for the influence of the individual outlet types on underage drinking is mixed. For example, two studies have found a significant positive association between off-premises outlets and adolescent alcohol consumption [12,13], while two other studies found no such links for rural adolescents [14,15]. A US longitudinal study found no association between density of on-premises outlets (specifically bars) and past-year alcohol use or heavy drinking after controlling for drinking beliefs [16]. Studies examining the relative influence of off- and on-premises outlet density also indicate conflicting findings. While some have reported positive relationships between higher on-premises—but not off-premises—outlet density and drinking frequency and quantity consumed [17,18], the opposite pattern has also been found [19,20]. Further, Truong & Sturm [7] reported a link between on- and off-premises outlet density in urban areas and binge drinking, but not with consuming alcohol in the previous 30 days. Only two studies have examined the impact of on-premises and off-premises density on adolescent drinking in predominantly rural populations [21,22]. These US studies combined the two licence types to form a single measure, and minimal or no association was found between the aggregate density measure and adolescent drinking.

To the authors' knowledge, only one study has examined the individual influence of on-premises, off-premises and general outlet density. This Australian study found that 16–24-year-olds living in areas with high off-premises outlet density were more likely to engage in very high-risk alcohol consumption, with no effect for on-premises or general licence outlet density [23]. Lastly, one study has examined the association between the four main outlet types and adolescent recent alcohol use [24]. Rowland *et al.* found that increases in the density of each of the four alcohol outlet types was associated positively with past 30-day drinking among 12–14-year-olds, although little effect was found for adolescents aged 15–17 years. This study provides preliminary evidence of a link between the density of the main outlet types and alcohol consumption

among young adolescents, although while the authors controlled for urban/regional location, how the relationship varied between adolescents residing in these locations was not assessed.

The inconclusive literature, in addition to the lack of studies in regional and remote communities, needs to be addressed. Given the higher rates of alcohol use and alcohol-related harms for regional adolescents, in conjunction with data suggesting that outlet density is higher in rural areas compared to metropolitan areas [25], investigation of the impact of outlet density for both metropolitan and regional adolescents is warranted. Understanding which types of liquor licences may be more likely to influence adolescent drinking within specific regions can help to guide policymakers to advocate for more targeted liquor licensing restrictions and controls.

## AIMS OF THIS STUDY

The aims of this study were (1) to determine whether there is an association between density of the four main outlet types and adolescent alcohol use and risky drinking, with control for individual demographic characteristics and adult drinking; and (2) to determine whether the association between outlet density and adolescent alcohol use and risky drinking differs among youth living in urban and regional/remote communities.

## METHODS

### Study population

Data were from the Australian Secondary Students' Alcohol and Drug (ASSAD) survey—a triennial national cross-sectional survey conducted since 1984. The survey was designed to assess the self-reported use of tobacco, alcohol and over-the-counter and illicit drugs in nationally representative samples of students aged 12–17 years. The current study draws upon survey data collected in four Australian states (New South Wales, Queensland, Victoria, Western Australia) and one territory (Northern Territory) for which we could obtain historic liquor licensing data in 2002, 2005, 2008 and 2011. The same sampling and administration procedures were used in all survey years. The methodology is described in greater detail elsewhere [26]; in brief, a stratified two-stage probability sample was used, with schools selected proportionally from the three education sectors at the first stage and students at the second. Students completed paper-and-pencil surveys anonymously. Surveys were administered on school premises by external research staff between May and December. All surveys had ethics approval. A total of 68 208 students (44 897 from urban settings, 23 311 from regional settings) across the four survey waves were included in the analysis. A small proportion of respondents

who did not report their current postcode (2.7%) were excluded from the analyses.

### Alcohol consumption variables

Questionnaire items were identical in all surveys. Three alcohol consumption outcome variables were used. Past-month alcohol use was assessed by asking 'have you had an alcoholic drink in the last four weeks?' (yes, no). Students also indicated how many alcoholic drinks they had consumed on each of the previous 7 days. Following recommendations for low-risk drinking among adults [27], risky drinking was defined as consuming five or more alcoholic drinks on at least one of the previous 7 days. Two risky drinking outcome variables were used: risky drinkers among all respondents ('risky drinking among all students') and risky drinkers only among those who drank in the past week ('risky drinking among current drinkers'). Reductions in risky drinking at a population level may be due to declines in the prevalence of drinking, rather than a reduction in risky drinking among drinkers. Therefore, the risky drinking among current drinkers variable was included to assess whether the impact of outlet density on consumption differs between these two heavy drinking measures.

### Alcohol outlet density

The unit of analysis in this paper is the individual, with each student's survey data matched with outlet density information according to their residential postcode. Licence type and postcode of all liquor licences between 2002 and 2011 in five jurisdictions were provided by the relevant state licensing authorities. Licence information obtained for two jurisdictions (Victoria and Queensland) represented the licences active on 30 June each year, while the remaining jurisdictions provided licences active within the calendar year. For the current study, the following licence types were excluded: wholesalers, producers, restricted clubs, limited licences and bring your own (BYO) permits. In addition, the following licence types were excluded from the New South Wales data: caterer's licence, certificate of registration and governor's licence. Data for the Northern Territory exclude vessel licences. Excluding these licence types ensured comparability between jurisdictions and has little impact on actual measures of alcohol availability due to either limited contact with underage youth or the small volumes of alcohol sold through them. The remaining licences were categorized into four types: off-premise (sale of unopened alcohol to take-away; e.g. bottle shops and supermarkets), on-premise (for consumption at the venue; e.g. restaurants, cafes, bars), general (for consumption at the venue and take-away; e.g. hotels) and clubs (sale of alcohol to members and

guests of members; e.g. sporting clubs, returned soldiers clubs). The total number of off-premises, on-premises, general and club licences in each postcode in each survey year was computed. We defined alcohol outlet density as the number of each type of licensed outlet per 1000 residents within a postcode. Postcode-level population data were obtained from the Australian Bureau of Statistics for each survey year. Outlet density was operationalised using a per-capita rate to allow for the population size variation between urban and regional areas.

### Geographic location

Australian Standard Geography Standard (ASGS) remoteness structure [28] was used to classify each student postcode into the following categories: major city, inner regional, outer regional, remote and very remote. The latter four categories were combined due to small *ns* in each of these areas. Thus, geographic location was dichotomized into 'urban' and 'regional/remote'.

### Control variables

With heavy drinking rates among Indigenous Australians typically higher than those among non-Indigenous Australians [29], this was included as a covariate (Aboriginal or Torres Strait Islander descent: yes, no). Given that adolescent smoking prevalence is correlated with drinking alcohol [30], student past-month smoking status (yes, no) was also included. Socio-economic status (SES) was coded based on the respondents' postcode using the 2011 national Socio-Economic Index for Areas (SEIFA) Index of Relative Advantage and Disadvantage (IRSAD) [31]. Student postcode-level SES was categorized into quintiles, with a low score indicative of relative disadvantage and a high score of relative advantage. As adult drinking rates may influence adolescent drinking rates through social norms [32], proportions of at least weekly alcohol use in adults aged 18 and older within urban and regional areas for each jurisdiction were obtained for the year prior to the ASSAD survey from the National Drugs Strategy Household Survey (see <http://www.aihw.gov.au/alcohol-and-other-drugs/ndshs/>) and included as a covariate in analyses.

### Statistical analysis

Bivariate  $\chi^2$  tests were generated to check for statistically significant changes in alcohol consumption proportions across the study period in urban and rural areas. Linear regressions were used to identify significant changes over time in per-capita outlet density. Mixed-effects logistic regression models were performed for each drinking outcome. To test whether the association between outlet density and drinking differed for urban and regional areas,

each outlet type was included as an interaction term with the urban/regional variable (Table 2). When interactions were statistically significant, logistic regressions were performed separately for urban and regional areas (Table 3). If not significant, the interaction terms were dropped and the main effects were reported from the model including both areas. Model 1 tested the bivariate associations between outlet density and drinking. The following covariates were then included in model 2: gender, age, state, SES, Indigenous status, smoking status and adult drinking rates. In all models, data were clustered with two random components—a time (survey wave) variable (level 2) and a school-level variable nested within each survey year (level 1). Analyses were conducted using xtmelogit procedures in Stata version 12.1.

## RESULTS

### Descriptive statistics

Descriptive statistics for each survey sample are shown in Table 1. Prevalence rates for past-month alcohol use and the risky drinking variables were higher in regional and remote areas compared to urban areas in each survey year.

Bivariate analyses indicated that the proportion of past-month and risky drinking among all students declined over time in both areas ( $P < 0.05$ ). However, there was no significant difference in the proportion of risky drinkers among current drinkers across the survey years in both urban and regional areas. Per-capita outlet density was substantially higher in regional areas, with more than twice the total average density compared to urban areas. The most prevalent type of outlet was on-premises, which increased over time for urban and regional communities ( $P < 0.01$ ). The density of off-premises licences also increased significantly, but only in urban areas ( $P < 0.01$ ). In urban areas, both general and club density decreased ( $P < 0.05$ ), while in regional areas licensed clubs decreased, although the density of general licences showed no statistically significant change over time.

Interaction terms between each outlet type and adolescent's geographic location (urban/regional) were performed to determine whether the association between outlet density and alcohol use varied by location (Table 2). Statistically significant interactions were observed between location and club outlet density with drinking in the past month ( $\chi^2 = 4.20$ ,  $df = 1$ ,  $P = 0.04$ ), risky drinking among

**Table 1** Sample characteristics of participants and outlet density in each survey year, by geographic location.

	Metropolitan areas				Regional/remote areas			
	2002	2005	2008	2011	2002	2005	2008	2011
Sample size	10 072	10 508	11 491	12 826	6547	4981	6302	5481
Average number of students sampled from each school	53	54	53	64	40	31	39	38
Age group (years) (%)								
12–15	71.6	72.2	70.7	70.3	74.2	75.4	75.5	73.2
16–17	28.4	27.8	29.4	29.7	25.8	24.6	24.6	26.8
Sex (%; male)	49.1	49.9	49.5	49.4	49.4	50.9	52.3	50.5
Indigenous heritage (%)	3.1	3.2	3.2	3.1	6.5	5.2	5.6	7.8
SEIFA quintile (%)								
1 (most disadvantaged)	13.2	14.3	17.0	12.3	21.6	20.1	35.0	28.6
2	15.3	11.9	16.8	11.6	31.9	36.6	27.7	31.6
3	21.2	17.9	17.8	17.5	28.6	20.8	20.5	29.0
4	22.7	23.5	21.3	24.1	12.3	17.8	14.9	7.8
5 (least disadvantaged)	27.6	32.6	27.2	34.6	5.6	4.0	2.0	3.1
Smoked tobacco in the past month (%)	16.6	12.8	10.5	8.6	19.7	12.4	9.9	10.2
Consumed alcohol in the past month (%)	45.6	42.1	35.0	26.2	55.2	45.9	40.1	35.4
Risky drinkers among all students (%)	9.4	10.0	7.4	5.2	13.8	11.8	8.2	9.6
Risky drinkers (current drinkers) <sup>a</sup> (%)	30.3	35.7	34.2	34.5	36.5	39.2	34.6	42.7
Average postcode outlet density (number of outlets per 1000 residents)								
General	0.16	0.16	0.15	0.15	0.66	0.60	0.59	0.70
On-premise	0.52	0.58	0.65	0.61	0.71	0.95	0.96	0.92
Off-premise	0.20	0.23	0.21	0.22	0.35	0.37	0.36	0.36
Clubs	0.15	0.14	0.13	0.11	0.40	0.35	0.35	0.38
Total	1.02	1.10	1.14	1.09	2.12	2.28	2.26	2.37

Population-weighted percentages. SEIFA: Socio-Economic Index For Area (ABS, 2013). <sup>a</sup>Current drinkers: consumed alcohol on at least 1 of the previous 7 days.

**Table 2** Significance of interactions between alcohol outlet density variables and geographic location in adjusted mixed-effects logistic regression models of past month use, risky drinking among all students and risky drinking among current drinkers.

<i>Interaction term</i>	<i>Past month alcohol use</i>	<i>Risky drinking among all students</i>	<i>Risky drinking among current drinkers</i>
Urban/regional $\times$ general	0.97	0.06	0.14
Urban/regional $\times$ on-premise	0.47	0.21	0.16
Urban/regional $\times$ off-premise	0.06	0.01	0.06
Urban/regional $\times$ clubs	0.04	< 0.01	< 0.01

These interaction terms are adjusted for state, gender, age, Indigenous heritage, socio-economic status, tobacco use and adult drinking rates.

all students ( $\chi^2 = 10.88$ ,  $df = 1$ ,  $P < 0.01$ ) and risky drinking among current drinkers ( $\chi^2 = 6.69$ ,  $df = 1$ ,  $P < 0.01$ ). A significant interaction was also found between location and off-premises density on risky drinking among all students ( $\chi^2 = 6.03$ ,  $df = 1$ ,  $P = 0.01$ ), although not with the other drinking outcomes.

The results of the logistic regression analyses are presented in Table 3. The significant interactions indicated that for urban students higher densities of club outlets were associated with consuming alcohol in the past month and both risky drinking outcome variables. While among regional students the association found between clubs and drinking outcomes were in the same direction as those for urban students (model 2), they were not statistically significant at  $P = 0.05$  level. A similar association was found for off-premises outlet density and risky drinking among all students, in that the effect of higher off-premises densities was associated with this drinking outcome in urban, but not regional communities. For models where data of all students were combined, higher densities of each of the licence types were associated with an increased likelihood of drinking. There was little difference between the unadjusted and adjusted models, except that off-premises density was no longer associated significantly with risky drinking among current drinkers after controlling for risk factors.

### Sensitivity analyses

We examined the effect of the previous year's (e.g. 2001 for students surveyed in 2002) outlet density on the three outcome measures and similar patterns were observed for the interaction analyses, the one exception being that the interaction between urban/regional and off-premises outlet density on risky drinking among current drinkers was noted as significant ( $\chi^2 = 4.20$ ,  $df = 1$ ,  $P = 0.04$ ).

**Table 3** Unadjusted and adjusted logistic regression models of the association between alcohol outlet density and drinking outcomes, separated by geographic location where appropriate.

<i>Predictors</i>	<i>Past month alcohol use</i>		<i>Risky drinking among all students</i>		<i>Risky drinking among current drinkers</i>	
	<i>Model 1</i>	<i>Model 2</i>	<i>Model 1</i>	<i>Model 2</i>	<i>Model 1</i>	<i>Model 2</i>
General	1.10 (1.07–1.13)**	1.10 (1.07–1.14)**	1.11 (1.07–1.15)**	1.10 (1.05–1.14)**	1.08 (1.03–1.13)**	1.07 (1.02–1.13)**
On-premise	1.03 (1.02–1.05)**	1.03 (1.02–1.05)**	1.06 (1.04–1.08)**	1.05 (1.03–1.08)**	1.05 (1.03–1.08)**	1.04 (1.02–1.07)**
Off-premise	1.15 (1.08–1.22)**	1.19 (1.11–1.28)**	–	–	1.15 (1.02–1.30)*	1.05 (0.91–1.21)
Urban	–	–	1.53 (1.23–1.91)**	1.36 (1.05–1.75)*	–	–
Regional/remote	–	–	1.03 (0.92–1.15)	0.94 (0.81–1.09)	–	–
Clubs	–	–	–	–	–	–
Urban	1.03 (0.87–1.22)	1.32 (1.09–1.59)**	1.44 (1.11–1.87)**	1.94 (1.46–2.59)**	1.56 (1.13–2.15)**	1.86 (1.32–2.63)**
Regional/remote	0.96 (0.90–1.04)	1.05 (0.98–1.14)	0.99 (0.88–1.10)	1.11 (0.99–1.25)	1.03 (0.90–1.17)	1.11 (0.97–1.28)

\* $P < 0.05$ ; \*\* $P < 0.01$ ; – = model not analysed. Model 2 is adjusted for state, gender, age, Indigenous heritage, socio-economic status, tobacco use and adult drinking rates.



## DISCUSSION

To our knowledge, this is the first study to examine the impact of the four main outlet types among a large sample of urban and regional adolescents with multiple survey years. Overall, the density of three of the outlet types (general, on-premise and off-premise) was associated with adolescent's alcohol consumption, irrespective of geographic location. Urban and regional differences in the relationship between outlet density and alcohol use were observed for off-premises outlets with risky drinking among all students and club outlets for all alcohol consumption measures. Despite evidence from the current study and previous research indicating that adolescents living in regional and remote communities are exposed to higher densities of alcohol outlets, in general our findings suggest that outlet density may have a stronger influence on adolescent drinking in metropolitan areas than regional/remote areas. This finding may reflect that while regional adolescents may be exposed to more alcohol outlets on a population basis, outlets are spread over a greater distance; therefore, alcohol may not actually be more available compared to urban areas. Thus, there may be other factors besides alcohol outlet density that explain why adolescents residing in regional and remote communities report higher alcohol consumption prevalence rates. The social norms associated with alcohol in rural areas may be one such factor, given the embedded nature and acceptance of alcohol consumption and the notion that drinking practices are learnt from a young age within these communities [33]. Other factors such as adult drinking patterns and how adolescents typically access alcohol may be good indicators of social norms, and may help to explain the differences in alcohol consumption between urban and regional areas. As adult alcohol consumption levels are higher in regional than in urban areas in Australia [34], the adolescent patterns observed in this study appear to be mirroring adult patterns. While we controlled for adult drinking in the analyses, future research that investigates the direct impact of adult alcohol use and other social influences on non-urban underage drinkers in particular is warranted.

Unlike previous studies, we analysed the impact of licensed clubs separately to other licence types. Our results suggest that clubs have a stronger influence on urban adolescents' drinking behaviours than adolescents living in regional areas. Club licences include a mix of drinker groups, including local sporting clubs that host weekend football, cricket and other sports but also workers' clubs, large commercial clubs associated with organisations such as Australia's Returned Soldier Leagues (RSL) and ethnic social clubs. Australia has a strong sporting and social club membership, and while there have been 'nation-wide initiatives' such as the Good Sports programme (which affects only approximately 20% of Australian clubs), aiming to

develop responsible alcohol service and consumption practices and to create family-friendly environments [35], a drinking culture remains ingrained in the ethos of these clubs. For example, a study involving mainly athletes and officials at sporting clubs found that the majority of participants endorsed drinking at their club as a way for their family to socialize [36]. Thus, the influence of club outlets on youth drinking rates in urban communities may be that relatively high numbers of licensed clubs expose adolescents to regular drinking by their parents, siblings and older peers. This role-modelling behaviour and approval of alcohol may translate to perceptions of positive drinking norms and encourage alcohol use and risky drinking.

We found that general and on-premises outlet density was related positively to an increased risk of recent alcohol use and risky drinking among adolescents living in metropolitan and regional areas. Previous studies have found on-premises density to be associated with adolescent drinking [7,18]. However, few studies have examined the association between general licences, such as hotels and taverns, and adolescent drinking. One study found a link between off-premises outlet density but not on-premises and general density and very high-risk drinking among a sample of adolescents and young adults [23]. Further research needs to examine the relative impact of general licence establishments on adolescent drinking.

Our findings indicated that urban neighbourhoods with a higher density of off-premises outlets were associated with overall risky drinking, although not among regional communities. Off-premises outlets were related similarly to past-month alcohol use for all adolescents in the study. While past research suggests that off-premises density is associated with recent alcohol use [12,13,19,20,24] and heavy drinking [7,23], some studies have reported non-significant associations with this type of outlet and a range of drinking outcomes [14,15,17]. Liquor retail stores often have branding (including cartoon images) and prominent window displays which can appeal to children and adolescents. Additionally, the greater number of outlets selling take-away alcohol may provide increased availability for people purchasing alcohol for adolescents [37]. As high off-premises density has been associated with underage youth making successful alcohol purchase attempts [17], strict enforcement of laws prohibiting alcohol sales to minors through repeated compliance checks is needed, with a stronger emphasis possibly required in metropolitan communities.

There are several limitations to the current study. While we examined the relationship between outlet density and alcohol consumption using four waves of self-report survey data, each survey included a different group of participants. Thus, the cross-sectional design precludes the ability to draw causal inferences. The risky drinking variable was based on the number of beverages consumed; however, the

number of standard drinks may have provided a more accurate measure of consumption. As mentioned previously, measuring outlet density as per-capita counts may be an insensitive measure in some circumstances, as it assumes that each outlet within a licence category is equal and fails to take into account varying capacity of outlets to influence drinking in the community. The addition of alcohol sales data would be beneficial to quantify more accurately the relative impact of specific licence types on consumption, especially in relation to off-premises outlets [38]. Given that population-based measures for outlet density may not reflect alcohol availability accurately when comparing metropolitan and regional/remote areas, a distance-based measure (e.g. outlets per mile) using geocoding software may have been more appropriate. However, as we were unable to obtain the full address of liquor licences in two states, and residential addresses of students were not recorded, geocoding was not an option for this study. Finally, we were limited by the range of control variables available. Other unmeasured factors may explain some of the relationships observed; for example, perceived alcohol availability and friends with access to a car have been found to interact with outlet density and adolescent drinking.

Our findings provide evidence that the density of the four main types of alcohol outlets is related to adolescents' alcohol use. Regulating the number of general, on- and off-premises establishments in all communities and licensed clubs, particularly in urban communities, may reduce underage drinking as a result of exposing them to fewer opportunities to access alcohol and modelling of drinking behaviour. Future work could include qualitative research to understand more clearly the mechanisms of influence by geographic location, as well as further quantitative examinations of the differences in underage drinking and alcohol-related harms by different outlet types at varying distances to individual's homes.

#### Declaration of interests

None.

#### Acknowledgements

We would like to acknowledge the work of Professor David Hill in establishing the conduct of the triennial national secondary students survey. Funding for data collection for the different surveys used in this paper was made available from the following organizations: the Cancer Council Victoria, the Cancer Council NSW, the Cancer Council Northern Territory, the Cancer Council Queensland, Victorian Department of Health and Human Services, the NSW Health Department, the Department of Health Western Australia, Northern Territory Government Department of Health and Community Services, Queensland Education Department, Queensland Health, and the

Australian Government Department of Health and Ageing. This study was supported by a National Health and Medical Research Council (NHMRC) Partnerships grant no. 1037104 with VicHealth and the Foundation for Alcohol Research and Education (FARE). M.L. was supported by a NHMRC Early Career Fellowship and by FARE, an independent, charitable organization working to prevent the harmful use of alcohol in Australia. R.R. is supported by the Victorian Department of Health and Human Services and FARE. T.N. is supported by a NHMRC Career Development Fellowship. M.W. is supported by a NHMRC Principal Research Fellowship.

#### References

1. Australian Institute of Health and Welfare. *Young Australians: their Health and Wellbeing*. Canberra: Australian Institute of Health and Welfare; 2007.
2. US Department of Health and Human Services. *The Surgeon General's Call to Action To Prevent and Reduce Underage Drinking*. Rockville, MD: US Department of Health and Human Services, Public Health Service, Office of the Surgeon General; 2007.
3. Hingson R., Kenkel D. Social, health, and economic consequences of underage drinking. In: Bonnie R. J., O'Connell M. E., editors. *Reducing Underage Drinking A Collective Responsibility*. Washington, DC: The National Academies Press; 2004, pp. 351–82.
4. Toumbourou J. W., Hemphill S. A., McMorris B. J., Catalano R. F., Patton G. C. Alcohol use and related harms in school students in the USA and Australia. *Health Promot Int* 2009; **24**: 373–82.
5. Coomber K., Toumbourou J. W., Miller P., Staiger P. K., Hemphill S. A., Catalano R. F. Rural adolescent alcohol, tobacco, and illicit drug use: a comparison of students in Victoria, Australia, and Washington State, United States. *J Rural Health* 2011; **27**: 409–15.
6. Miller P. G., Coomber K., Staiger P., Zinkiewicz L., Toumbourou J. W. Review of rural and regional alcohol research in Australia. *Aust J Rural Health* 2010; **18**: 110–7.
7. Truong K. D., Sturm R. Alcohol environments and disparities in exposure associated with adolescent drinking in California. *Am J Public Health* 2009; **99**: 264–70.
8. Hearst M. O., Fulkerson J. A., Maldonado-Molina M. M., Perry C. L., Komro K. A. Who needs liquor stores when parents will do? The importance of social sources of alcohol among young urban teens. *Prev Med* 2007; **44**: 471–6.
9. Paschall M. J., Grube J. W., Black C., Ringwalt C. L. Is commercial alcohol availability related to adolescent alcohol sources and alcohol use? Findings from a multi-level study. *J Adolesc Health* 2007; **41**: 168–74.
10. Popova S., Giesbrecht N., Bekmuradov D., Patra J. Hours and days of sale and density of alcohol outlets: impacts on alcohol consumption and damage: a systematic review. *Alcohol Alcohol* 2009; **44**: 500–16.
11. Bryden A., Roberts B., McKee M., Petticrew M. A systematic review of the influence on alcohol use of community level availability and marketing of alcohol. *Health Place* 2012; **18**: 349–57.
12. Wang S. H., Lin I. C., Chen C. Y., Chen D. R., Chan T. C., Chen W. J. Availability of convenience stores and adolescent alcohol use in Taiwan: a multi-level analysis of national surveys. *Addiction* 2013; **108**: 2081–8.

13. Chen M. J., Grube J. W., Gruenewald P. J. Community alcohol outlet density and underage drinking. *Addiction* 2010; **105**: 270–8.
14. Chilenski S. M., Greenberg M. T., Feinberg M. E. The community substance use environment: the development and predictive ability of a multi-method and multiple-reporter measure. *J Community Appl Soc Psychol* 2010; **20**: 57–71.
15. Chilenski S. M., Greenberg M. T. The importance of the community context in the epidemiology of early adolescent substance use and delinquency in a rural sample. *Am J Community Psychol* 2009; **44**: 287–301.
16. Paschall M. J., Lipperman-Kreda S., Grube J. W. Effects of the local alcohol environment on adolescents' drinking behaviors and beliefs. *Addiction* 2014; **109**: 407–16.
17. Reboussin B. A., Song E. Y., Wolfson M. The impact of alcohol outlet density on the geographic clustering of underage drinking behaviors within census tracts. *Alcohol Clin Exp Res* 2011; **35**: 1541–9.
18. Kuntsche E., Kuendig H., Gmel G. Alcohol outlet density, perceived availability and adolescent alcohol use: a multilevel structural equation model. *J Epidemiol Community Health* 2008; **62**: 811–6.
19. Young R., Macdonald L., Ellaway A. Associations between proximity and density of local alcohol outlets and alcohol use among Scottish adolescents. *Health Place* 2013; **19**: 124–30.
20. Shamblen S. R., Harris M. S., Ringwalt C. L., Flewelling R. L., Clark H. K., Hanley S. M. Outlet density as a predictor of alcohol use in early adolescence. *Subst Use Misuse* 2011; **46**: 1049–59.
21. Lo C. C., Weber J., Cheng T. C. A spatial analysis of student binge drinking, alcohol-outlet density, and social disadvantages. *Am J Addict* 2013; **22**: 391–401.
22. Stanley L. R., Henry K. L., Swaim R. C. Physical, social, and perceived availabilities of alcohol and last month alcohol use in rural and small urban communities. *J Youth Adolesc* 2011; **40**: 1203–14.
23. Livingston M., Laslett A. M., Dietze P. Individual and community correlates of young people's high-risk drinking in Victoria, Australia. *Drug Alcohol Depend* 2008; **98**: 241–8.
24. Rowland B., Toumbourou J. W., Satyen L., Tooley G., Hall J., Livingston M. *et al.* Associations between alcohol outlet densities and adolescent alcohol consumption: a study in Australian students. *Addict Behav* 2014; **39**: 282–8.
25. Matthews S., Jayasekara H., Lloyd B. *The Victorian Alcohol Statistics Series: Alcohol-related Harms and use Across Victorian Local Government Areas 2000/01-2009/10*. Turning Point Alcohol and Drug Centre: Fitzroy, Victoria; 2012.
26. White V., Bariola E. *Australian Secondary School Students' use of Tobacco, Alcohol, and Over-the-Counter and Illicit Substances in 2011*. Centre for Behavioural Research in Cancer, Cancer Council Victoria: Melbourne, Australia; 2012.
27. National Health and Medical Research Council. *Australian Guidelines to Reduce Health Risks from Drinking Alcohol*. Canberra, Australia: NHMRC; 2009.
28. Australian Bureau of Statistics. *Australian Statistical Geography Standard (ASGS): Volume 5—Remoteness Structure, July 2011*. Canberra: Australian Bureau of Statistics; 2013. Archived at: <http://www.webcitation.org/6WN0dQDr7>; available at: <http://www.abs.gov.au/ausstats/abs@.nsf/mf/1270.0.55.005> (accessed 9 April 2014).
29. Brady M. *Indigenous Australia and Alcohol Policy: Meeting Difference with Indifference*. Sydney: University of New South Wales Press; 2004.
30. Dee T. S. The complementarity of teen smoking and drinking. *J Health Econ* 1999; **18**: 769–93.
31. Australian Bureau of Statistics. *Census of Population and Housing: Socio-Economic Indexes for Areas (SEIFA), Australia, 2011*. Canberra: Australian Bureau of Statistics; 2013. Archived at: <http://www.webcitation.org/6WN105FAc>; available at: <http://www.abs.gov.au/ausstats/abs@.nsf/mf/2033.0.55.001/> (accessed 10 April 2014).
32. Shortt A. L., Hutchinson D. M., Chapman R., Toumbourou J. W. Family, school, peer and individual influences on early adolescent alcohol use: first year impact of the Resilient Families programme. *Drug Alcohol Rev* 2007; **26**: 625–34.
33. Allan J., Clifford A., Ball P., Alston M., Meister P. 'You're less complete if you haven't got a can in your hand': alcohol consumption and related harmful effects in rural Australia: the role and influence of cultural capital. *Alcohol Alcohol* 2012; **47**: 624–9.
34. Australian Institute of Health and Welfare. *National Drug Strategy Household Survey detailed report: 2013*. Canberra: AIHW; 2014.
35. Australian Drug Foundation. Good Sports accreditation program. 2002. Archived at: <http://www.webcitation.org/6WMz8HHLB>; available at: <http://goodsports.com.au/> (accessed 26 May 2014).
36. Duff C., Scealy M., Rowland B. *The Culture and Context of Alcohol Use in Community Sporting Clubs in Australia: Research into 'Attitudes' and 'Behaviour'*. Australia: Centre for Youth Drug Studies, Australian Drug Foundation; 2004.
37. Chen M. J., Gruenewald P. J., Remer L. G. Does alcohol outlet density affect youth access to alcohol? *J Adolesc Health* 2009; **44**: 582–9.
38. Liang W., Chikritzhs T. Revealing the link between licensed outlets and violence: counting venues versus measuring alcohol availability. *Drug Alcohol Rev* 2011; **30**: 524–35.