Addiction

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Alcohol outlet density and assault: a spatial analysis

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ABSTRACT

Aims A large number of studies have found links between alcohol outlet densities and assault rates in local areas. This study tests a variety of specifications of this link, focusing in particular on the possibility of a non-linear relationship. **Design** Cross-sectional data on police-recorded assaults during high alcohol hours, liquor outlets and socio-demographic characteristics were obtained for 223 postcodes in Melbourne, Australia. These data were used to construct a series of models testing the nature of the relationship between alcohol outlet density and assault, while controlling for socio-demographic factors and spatial auto-correlation. Four types of relationship were examined: a normal linear relationship between outlet density and assault, a non-linear relationship with potential threshold or saturation densities, a relationship mediated by the socio-economic status of the neighbourhood and a relationship which takes into account the effect of outlets in surrounding neighbourhoods. **Findings** The model positing non-linear relationships between outlet density and assaults was found to fit the data most effectively. An increasing accelerating effect for the density of hotel (pub) licences was found, suggesting a plausible upper limit for these licences in Melbourne postcodes. **Conclusions** The study finds positive relationships between outlet density and assault rates and provides evidence that this relationship is non-linear and thus has critical values at which licensing policy-makers can impose density limits.

Keywords Alcohol availability, assaults, outlet density, violence.

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INTRODUCTION

This paper examines the nature of the link between alcohol outlet density and assault in Melbourne, Australia. Alcohol-related violence in Australia is a substantial problem. In 1998/99, an estimated 62 534 alcohol-related assaults were reported to the police, and 8661 people were admitted to hospital for injuries sustained from alcohol-related assaults [1]. The links between alcohol consumption and violence have been well established in the international research literature [2]. In turn, alcohol consumption levels have been linked to the degree of alcohol availability through retail outlets and on-premise drinking establishments [3]. A series of studies have linked violence directly to alcohol outlets, with alcohol-related assaults often taking place in or around licensed premises [4] and substantial proportions of all assault victims injured while on licensed premises [5].

In recent years, a growing body of literature has examined the relationship between violence rates and alcohol outlet densities in local areas [6]. These studies, largely from urban areas of the United States, have focused on the cross-sectional associations between violence and alcohol outlets in small areas such as census tracts, while adjusting for a series of socio-economic and demographic factors. The results of these studies have almost uniformly suggested significant positive relationships between outlet density and violence [7–15], with units of analysis varying from cities down to street blocks. The results of the one study that found no relationship between outlet density and violence at the city level in New Jersey [16] were explained later as an artefact of the geographic units used [17]. In addition, one US study has shown that changes in outlet density over time are related to changes in violence rates [18]. A handful of studies from outside the United States have also found positive relationships between outlet density and violence, both cross-sectionally [19] and over time [20].

Despite the broadly consistent results found in these studies, the specifics of the relationships between outlet

density and violence have varied substantially. The effect of specific outlet types has been variable, with bars [13], off-premise outlets [11] and both types (sometimes in differing ways) [12,21] significant in various studies. When the interactions between outlet density and neighbourhood disadvantage have been studied, the results have also varied. Smith *et al.* [22] found that the relationship between outlets and violence was stronger in socially disorganized areas, while Nielsen & Martinez [21] found no significant interaction and Gruenewald *et al.* [12] found that bars were related to violence in unstable, poor areas *and* in rural middle-income areas, but not otherwise. Some studies have examined how the characteristics of surrounding areas affect violence in the target area using spatially lagged data (e.g. the average outlet density in neighbouring areas), with varying results. Gorman *et al.* [23] found that outlets in surrounding areas were not related to violence in the target area, while Zhu *et al.* [15] found that spatially lagged outlet density was related positively to violence. In addition, studies that have focused on population characteristics of surrounding areas have found powerful effects for population density [12,24].

Outlet density control policies, theory and non-linear outlet density effects

The theories that motivate the analyses of the relationship between outlet density and violence have been reviewed in two recent publications [6,25] and will be addressed here only to explore the expected form of the relationship between outlet density and assault rates. Livingston *et al.* [6] disaggregate the effect of outlet density on alcohol-related problems into two kinds of effects: proximity and amenity. They posit that proximity effects will be most relevant when exploring outcomes relating to consumption levels and that the increase in these outcomes related to outlet density will decelerate as outlet density increases towards 'saturation'. Contrastingly, they suggest that amenity effects may demonstrate accelerating increases as outlet density increases, bringing increasing numbers of drinkers into close contact with each other in entertainment districts ([6], p. 561). Gruenewald's theory of assortative drinking suggests that the increase in alcohol-related harm as outlet density increases may be non-linear, with phase transitions in harm rates at particular outlet densities ([25], p. 876).

These theorized non-linear effects have important policy implications. One obvious suggestion flowing on from studies that draw a link between alcohol outlet densities and violence rates is the application of local limits on outlet density to minimize the associated problems. The obvious question raised by this idea is how to determine outlet density limits for a particular region. If the relationships between alcohol outlet density and harms are strictly linear, then the decision is simply a matter of weighing up predicted levels of alcohol-related harm with the benefits of alcohol outlets, as each extra outlet contributes the same increase in harms. On the other hand, if the relationship is non-linear there may be more obvious threshold points, after which increases in alcohol outlet density lead to marked increases in associated harms, or saturation points, where any further increases have less or no effect.

Few studies have explored whether the effect of alcohol outlet on density is a linear one. An Australian study examining neighbourhood disorder rather than violence [26] used a categorical variable for outlet density, finding that the effect of outlets on alcohol-related problems was non-linear, with problems increasing more steeply at higher outlet densities. In a more rigorous examination of non-linearity, Gyimah-Brempong & Racine [27] used a non-parametric method to determine the best specification of the relationship between outlet density and crime at the census tract level in an unnamed US city, finding non-linear relationships, with the expected increase in crime for each additional licence rising as the number of licences increased.

The current study

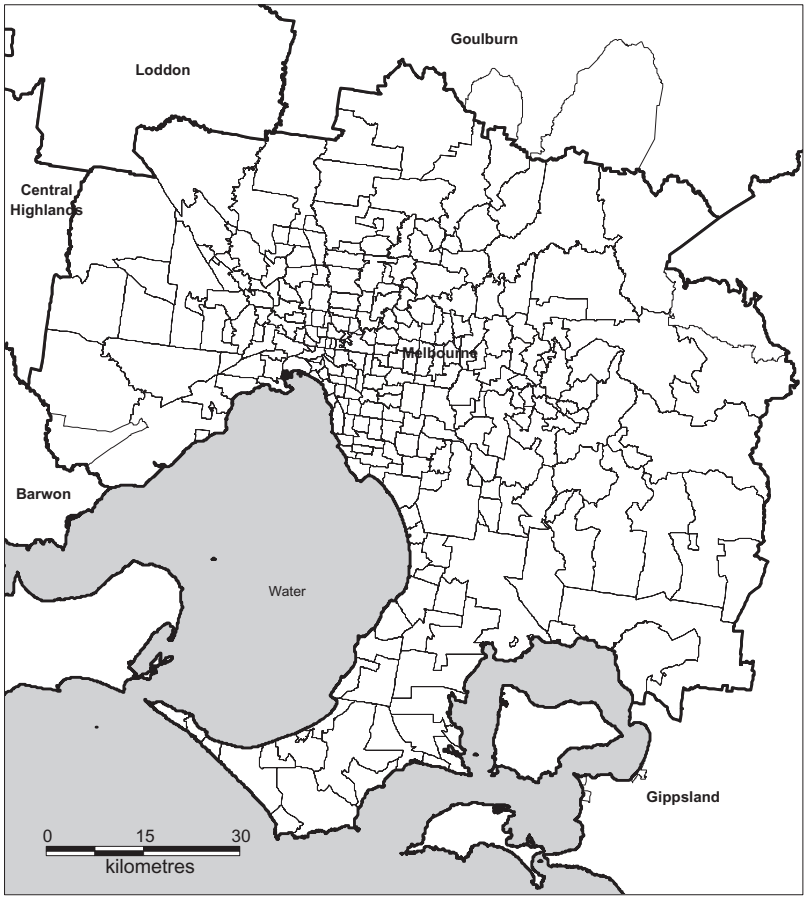
This study examined the spatial relationship between alcohol outlet density and alcohol-related assaultive violence in Melbourne, Australia, controlling for a range of socio-demographic factors. Models exploring non-linear relationships between outlet density and violence, interactions between outlet density and socio-economic disadvantage and the effect of spatially lagged outlet density were developed and compared.

METHODS

Aggregated administrative data were used to assess whether the number of active liquor licences was related to police recorded assaults when a range of neighbourhood characteristics were controlled. The analysis was undertaken using data from 2001, ensuring demographic data from the 2001 national census could be used without inconsistencies in the study timeframe.

Geographical units

The study focused on the Greater Melbourne area, approximately 5600 km^2 containing the city of Melbourne, the second largest city in Australia, and its surrounding suburbs. The study was undertaken using postcodes as the unit of analysis. These regions are an administrative unit, defined by Australia Post, and represent the smallest geographical units for which reliable



Boundaries are based on the Australian Bureau of Statistics 2001 Census boundaries

Figure 1 Postcodes within Melbourne Statistical Division, based on 2001 Australian Standard Geographical Classification boundaries

data were available for all the variables required for this study. Within the study region there were 223 postcodes and, at the time of the 2001 census, approximately 3 350 000 residents. A map of the postcodes in Melbourne is provided in Fig. 1. Postcodes generally represent local suburbs or communities, although in the outer areas of the city some encompass large non-residential areas including state parks or industrial zones. Geographical data relating to postcodes (e.g. area, neighbouring postcodes) were extracted from the digital boundaries released as part of the Australian Standard Geographical Classification (ASGC) [28]. Assault rates and outlet densities were calculated for each postcode on a population basis as rates per 1000 residents. Some previous studies have used roadway miles to denominate their measures (e.g. [12]), but studies using either area or population as denominators in rates have found similar results [8]. Two postcodes that represented particularly unusual land uses and low residential populations (i.e. an airport and a military base) were excluded from all analyses. In addition, initial analyses highlighted three outliers (central postcodes with high outlet and assault numbers and very low resident populations) that were excluded from the regression models. With these five units excluded, the final analyses were undertaken using 217 postcodes.

Licensing data

The Licensing Branch of the Victorian Department of Consumer Affairs provided data on active liquor licences. The licensing data include postcode information for each premise location and this field was used to assign outlets to postcodes. A check on the addresses of 110 random records found that the postcode data were accurate in 97% of cases. In this study, three types of licences are examined: general, on-premise and packaged. These three licence categories made up more than three-quarters of the licences in Victoria in 2001. General licences allow the licensee to sell alcohol for consumption both on and off the premises, and apply to taverns, hotels and pubs. On-premise licences allow the licensee to sell alcohol on the premises only, and generally apply to restaurants, bars and nightclubs. Packaged licences allow alcohol to be sold for off-premise consumption only and apply to retail liquor stores (including some supermarkets). The models in this paper include densities for all three of the licence categories. Separate models were

developed including only one category at a time, with broadly similar results.

Assault data

Assault data were provided by the Victorian Police from their Law Enforcement Assistance Program (LEAP) database. Due to the lack of a reliable indicator of alcohol involvement in the police data, assaults taking place between 8 p.m. and 6 a.m. on Friday and Saturday were considered 'alcohol-related' [29]. Thus the term 'alcohol-related assaults' in this paper refers to assaults that that took place between these times. It should be noted that these data may be influenced by policing practices and that it was not possible to assess the validity of police recording of postcode data. However, it is expected that these influences will be minor and that police-recorded assault data provide a reasonable basis for analysing postcode-level rates of violence. Alcohol-related assault rates were calculated on a per 1000 population basis. To ensure that the rates used were stable, the average assault rates over 3 years (1999/00–2001/02) were used.

Census data

Data from the 2001 Australian Census of Population and Housing were used for a range of socio-demographic variables in this study. Postcode level socio-economic status was measured using a composite measure, the Index of Relative Socio-Economic Disadvantage (IRSED) [30] derived from census data. The other census variables used were: the number of people counted in the area; the percentage of the population male and aged between 15 and 34 years (the population subgroup most involved in assaults); population per km^2; average number of people per household; percentage of the population that had moved house in the previous year; percentage of the population that spoke a language other than English at home; and the percentage of the population counted in the postcode who were not usual residents (as a proxy for tourist activity). Two other variables (the percentage of households that were owner-occupied; the percentage of the population who were born overseas) were considered, but were excluded from the final analysis as they resulted in multicollinearity in the final models.

Analyses

All statistical analyses were undertaken using the R software package [31], with the 'spdep' package [32] used for spatial analyses.

The dependent variable for this study was the 3-year average of the rate of alcohol-related assaults. The independent variables were the outlet densities for each of the three licence types, the population density, the IRSED index and the Census-derived variables listed above. Using these variables, a series of multiple regression models were developed.

The initial model included only linear effects for each independent term. This model was then expanded in three ways. First, cubic polynomial terms for the significant outlet density variables were included in a multiple regression model. An initial quadratic model was also fitted, but it was significantly poorer than the cubic model and is not discussed further. This provides an opportunity to explore whether the impact of outlets on alcohol-related assaults is steady (i.e. each extra outlet has the same effect on the alcohol-related assault rate) or whether there are non-linearities in the relationship suggesting densities beyond which extra outlets have either little impact or a more pronounced impact on violence. Secondly, interaction effects between outlet densities and the IRSED indicator were included to assess whether outlet density was related differentially to assaults in neighbourhoods of differing levels of socio-economic disadvantage. Finally, a model incorporating spatial lags was developed, to assess whether the characteristics of neighbouring postcodes were related to the assault rate in the target postcode.

In order to assess whether the final models were biased due to the lack of independence of the geographic units, each of these models was examined for evidence of spatial autocorrelation (see [12] for a good discussion of spatial autocorrelation in outlet density studies). In each case, the Moran coefficient (MC) was non-significant, precluding the need for more sophisticated spatial error models. Despite the non-significant MC, generalized least-squares models incorporating spatial error terms were developed to ensure spatial autocorrelation was not influencing the study's results. These models did not produce markedly different results from the regular ordinary least squares (OLS) models presented in this paper. Finally, the four fitted models were compared to ascertain which provided the best explanation of the observed data.

RESULTS

The zero-order correlations between the dependent variables and the alcohol-related assault rate provided in Table 1 demonstrate that without other control variables, each measure of outlet density is associated positively with the alcohol-related assault rate.

The results of the four regression analyses are presented in Table 2, models 1–4. Model 1 includes linear effects for each of the outlet density measures and socio-demographic factors, model 2 includes cubic polynomial functions for each of the three outlet density measures, with linear, quadratic and cubic terms, model 3 incorpo-

Table 1 Descriptive statistics of measures used in analysis.

	Min	*Max*	*Mean*	*SD*	*Correlation with alcohol-related assault rate*
Alcohol-related assault rate	0.0	4.4	0.6	0.7	1.00
General licence density	0.0	3.3	0.1	0.3	0.65**
On premise licence density	0.0	10.9	0.5	0.9	0.57**
Packaged licence density	0.0	1.5	0.2	0.3	0.17*
IRSED index	707.0	1152.0	1048.0	1034.0	–0.02
% Males aged 15–34 years	10.2	34.3	14.3	15.0	0.26
Population density	5.6	6405.0	1593.0	1637.0	0.19**
% Moved in the last year	5.9	41.8	14.8	16.2	0.47**
Average household size	1.7	3.7	2.7	2.7	–0.38**
% Non-English-speaking background	1.8	77.1	20.0	24.0	0.05
% In postcode who were not usual residents	0.0	22.1	0.8	1.3	0.69**

*Significant at the 0.05 level. **Significant at the 0.01 level. SD: significant difference. IRSED: Index of Relative Socio-Economic Disadvantage.

rates interaction terms between socio-economic disadvantage and outlet density and model 4 incorporates spatially lagged measures for a each of the outlet density measures, the IRSED measure of socio-economic disadvantage and population density. The results for the socio-demographic factors are largely consistent across the four models, with socio-economic disadvantage related positively to violence rates and household size and the percentage of the population from non-English-speaking backgrounds related negatively to violence.

The results for the outlet density measures varied slightly depending upon the model specification, although it is clear across all models that general and on-premise outlets were much more relevant than packaged outlets. In model 1, both general and on-premise outlet densities were related positively to assault rates, while there was no significant effect for packaged outlet density. In model 2, there were significant non-linear effects for general and packaged outlet densities and a positive, linear effect for on-premise density. General licence density remained associated positively with violence in model 3, while effects for on-premise and packaged densities and all interaction terms were non-significant. In model 4, both general and on-premise densities were related positively to assault rates, but only for local densities, while there was a negative effect for the spatially lagged density of packaged licences.

The four models produced were compared using the Akaike information criterion (AIC), which measures the goodness-of-fit of regression models, with a penalty for increasing the number of parameters that are estimated [33]. Lower values of the AIC represent models that use the fewest parameters possible to fit the data most effectively. The AIC values for the models fitted in this study are provided in Table 3. Clearly, model 2, incorporating non-linear effects for outlet densities, is the best fit to the data. Thus, the remainder of this paper will focus on model 2, and particularly on the implications of the non-linear terms for the outlet density measures. It should be noted that standard regression diagnostics were run on all models, with no substantial problems discovered. There was some evidence of inflated multicollinearity in the non-linear model, with a condition index of 35 due to the correlation between the polynomial terms. This is higher than normal, but is not indicative of substantial problems with the final model.

Comparing non-linear and linear relationships between outlet density and assault

The final model (model 2) includes cubic polynomial terms for each outlet density measure. This formulation allows the relationship between outlet density and alcohol-related assault rate to vary, so that the effect of an extra outlet is not fixed. That is, the effect on the assault rate in a particular postcode of changing the number of outlets from two to three may not be the same as the effect of changing the number of outlets from 20 to 21. This is demonstrated in Figs 2–4, which illustrate the relationship between alcohol outlets (general, on-premise and packaged, respectively) and alcohol-related assaults in a hypothetical community. All the characteristics of this illustrative community, except for the particular outlet type being examined, have been set to the median values in the sample and multiplied by the regression coefficients to provide model-based predictions for assault numbers. Thus, in Fig. 2, the hypothetical community has the number of on-premise and packaged outlets specified by the median on-premise and packaged densities, while the effect of general licence density is plotted between the minimum and maximum rates found in the data. In Fig. 3 everything is fixed at median levels except for

Table 2 Regression models of alcohol-related assaults.

	Model 1			*Model 2*			*Model 3*			*Model 4*		
Variable	*Parameter estimate*	*SE*	*Significance*	*Parameter estimate*	*SE*	*Significance*	*Parameter estimate*	*SE*	*Significance*	*Parameter estimate*	*SE*	*Significance*
Constant	5.259	0.767	<0.001**	4.825	0.763	<0.001**	6.064	1.024	<0.001**	5.333	0.995	<0.001**
General licence density	0.413	0.082	<0.001**	0.840	0.309	0.007*	2.437	1.098	0.028*	0.409	0.088	<0.001**
On premise licence density	0.168	0.033	<0.001**	0.265	0.104	0.011*	−0.532	0.473	0.263	0.158	0.033	<0.001**
Packaged licence density	−0.227	0.143	0.113	0.892	0.625	0.155	−3.146	2.175	0.150	−0.240	0.145	0.098
IRSED index	−0.003	0.001	<0.001**	−0.004	0.001	<0.001**	−0.004	0.001	<0.001**	−0.004	0.001	<0.001**
Population per km^2	<0.001	<0.001	0.249	<0.001	<0.001	0.211	<0.001	<0.001	0.422	<0.001	<0.001	0.807
Average household size	−0.333	0.143	0.021*	−0.218	0.145	0.134	−0.359	0.150	0.018*	−0.354	0.159	0.027*
% Population that were males aged 15–35 years	0.007	0.018	0.753	0.011	0.018	0.520	0.008	0.018	0.664	0.007	0.018	0.675
% Population that had moved in last year	−0.007	0.010	0.494	−0.009	0.010	0.345	−0.008	0.010	0.409	−0.011	0.010	0.273
% Non-English speaking background	−0.011	0.003	<0.001**	−0.012	0.003	<0.001**	−0.011	0.003	<0.001**	−0.011	0.003	0.002**
% In postcode who were not usual residents	−0.027	0.019	0.163	−0.017	0.019	0.376	−0.031	0.020	0.114	−0.041	0.021	0.052
(General licence density)^2				−0.845	0.314	0.007**						
(General licence density)^3				0.251	0.076	0.001**						
(On premise licence density)^2				0.005	0.030	0.878						
(On premise licence density)^3				−0.002	0.002	0.271						
(Packaged licence density)^2				−2.647	1.317	0.046*						
(Packaged licence density)^3				1.327	0.674	0.050						
IRSED × general licence density							−0.002	0.001	0.068			
IRSED × on premise licence density							0.003	0.002	0.182			
IRSED × packaged licence density							0.001	0.001	0.142			
Lag (general licence density)										−0.002	0.171	0.993
Lag (on premise licence density)										0.102	0.064	0.114
Lag (packaged licence density)										−0.656	0.312	0.037*
Lag (IRSED)										0.001	0.001	0.574
Lag (population per km^2)										<0.001	<0.001	0.581
Adjusted R^2	0.580			0.620			0.581			0.587		
Moran's coefficient	−0.024		0.913	−0.039		0.662	−0.029		0.826	−0.024		0.994

*Significant at 0.05 level. **Significant at 0.01 level. IRSED: Index of Relative Socio-Economic Disadvantage; SE: standard error.

Table 3 Akaike information criterion (AIC) for model comparison.

Model	*AIC*
Model 1 (linear, main effects)	274.5
Model 2 (non-linear)	258.9
Model 3 (interaction terms)	276.0
Model 4 (lagged terms)	274.8

on-premise outlet density, and for Fig. 4 only packaged outlet density varies. The number of alcohol-related assaults in the postcode predicted by model 1 (linear) and model 2 (non-linear) are both included to demonstrate the benefits of considering non-linear relationships compared with the standard linear relationships.

The linear model shows that as the number of general licences in this postcode increases from zero to 42, the predicted annual number of alcohol-related assaults increases steadily from seven to 25. The non-linear model, on the other hand, shows little difference in the number of assaults expected between zero and 25 licences (approximately 12) and a sharp increase between 30 and 42. This more complex relationship provides some indication of a crucial threshold level of general licences for the postcode (approximately 30), above which each new licence results in a marked increase in the expected number of alcohol-related assaults.

The non-significance of the non-linear terms for on-premise outlet density is illustrated clearly in this plot, with the minimal differences between the linear relationship from model 1 and the non-linear relationship from model 2.

The relationship between packaged liquor outlets and alcohol-related assaults in model 1 is negative (but non-significant), while the borderline-significant non-linear relationship from model 3 shows a similar, if slightly steeper, decline until the number of outlets reaches 15, after which each extra outlet results in a sharp increase in the predicted number of assaults. It is not clear that this represents a genuine effect, as the coefficients are only marginally significant.

DISCUSSION

The results of this study provide further evidence of a cross-sectional link between alcohol outlet densities and violence. The study examined the relationship between the density of three types of outlets, general (hotels and taverns), on-premise (restaurants, bars and nightclubs) and packaged (retail outlets) and alcohol-related assault rates. The best model (model 2) included non-linear relationships between some outlet densities and assault, suggesting that the effect of outlet density on violence differs with outlet density. This model was a significant improvement on the basic linear model, and the implications of the non-linear outlet density effects for determining plausible outlet limits were examined for a hypothetical community.

The broadly positive relationship between density of general licence premises and assaults is not surprising. Previous studies have found that tavern densities are related to violence [14], and studies in settings where licences combine on- and off-premise consumption have also found significant links between outlet density and violence [23,34]. The non-linearity in the relationship between general licences and alcohol-related assaults in this study provides evidence that, while the overall relationship is positive, with alcohol-related assaults increasing with the number of outlets, there may be a point after which each additional outlet contributes increasing numbers of additional assaults. Given the nature of the licensing data used for this study it is impossible to determine fully whether the assaults associated with general licence density are related to on- or off-premise consumption. However, with the assault measure used in this study (assaults recorded by police between 8 p.m. and 6 a.m. on Friday and Saturday), it seems reasonable to assume that a substantial proportion of the assaults are related to on-premise consumption, as these times represent the peak times for customers frequenting on-premise drinking establishments.

Regarding on-premise licences, only the linear term was significant in the final model, suggesting a fairly simple relationship between on-premise outlet density and alcohol-related assault rates. This relationship is similar to many results found for density of bars in other settings [13,21]. In addition, the work undertaken by Smith *et al.* [22] combined restaurants and bars into a single index (providing a comparable metric to the on-premise licences as defined in Victoria) and found a significant positive relationship between this index and street robberies. Contrastingly, Zhu *et al.* [15] found a negative relationship between restaurant density and violence, while finding a positive link with bar density. The nature of liquor licensing in Victoria makes replication of their work impossible, with data for on-premise licences on the licensing database not disaggregated easily into restaurant and bar subcategories.

The differing relationships for general and on-premise licences require further examination. General licences are provided for hotels, while on-premise licences cover a wide array of other drinking establishments including restaurants, bars, cafes and nightclubs. In general, a hotel is a place that patrons visit for the specific purpose of drinking alcohol and previous Australian work has highlighted hotels as particularly problematic premises in

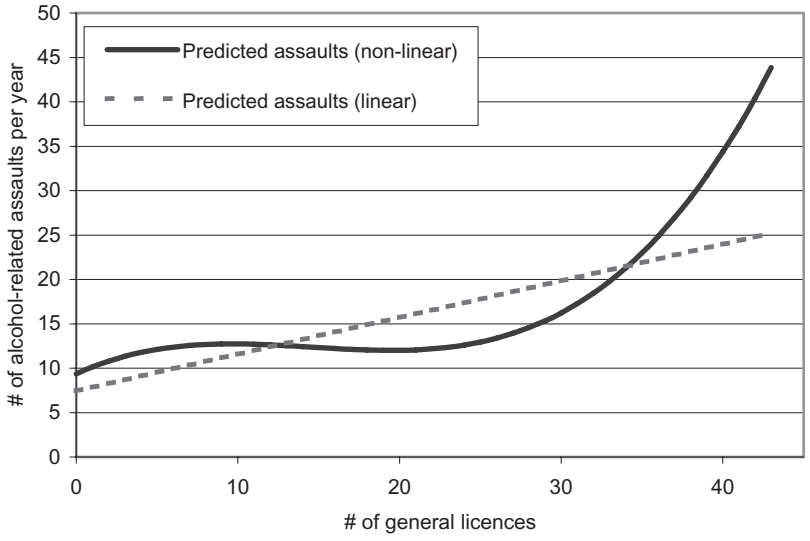


Figure 2 Linear and non-linear relationships between general licences and alcohol-related assaults in a hypothetical postcode

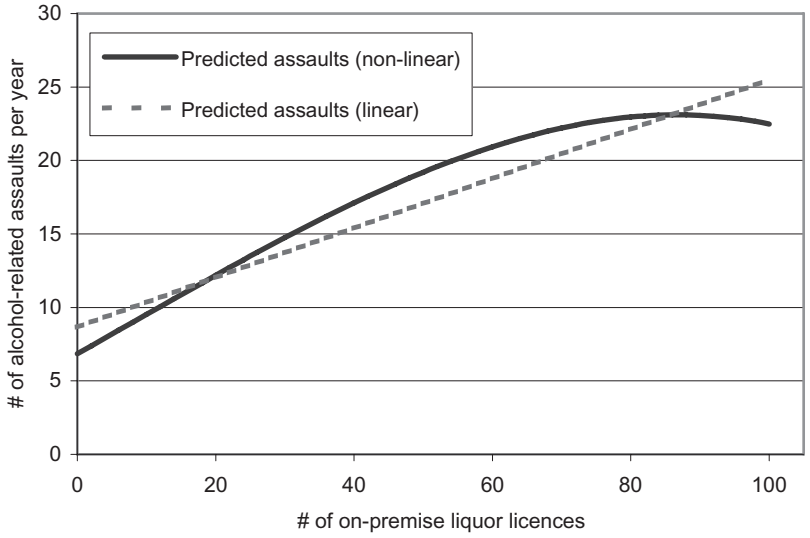


Figure 3 Linear and non-linear relationships between on-premise licences and alcohol-related assaults in a hypothetical postcode

terms of violence [35]. The on-premise licence category includes a wide array of premises, including places where drinking alcohol is not the primary focus of patrons (e.g. restaurants, cafes). It is conceivable that the relationship found between general licences and violence would be similar for the subset of premises within the on-premise licence category where drinking is the main activity (e.g. nightclubs); however, this cannot be tested with the current data.

Packaged outlet density has been linked repeatedly with violence in the US studies [11,12,36], and the lack of a clear positive relationship in this study was surprising. The non-linear relationship found in the final model suggests a possible positive relationship between packaged outlet density and violence when packaged outlet density is high (see Fig. 3), but the effect is only marginally statistically significant. It is difficult to compare the results of this study with previous work examining off-premise outlet density and violence. For example, it is conceivable that the definition of alcohol-related assaults used for this study focused the analysis on assaults more likely to be related to on-premise consumption. However, it is also worth noting the cultural differences between the use of packaged liquor outlets in Melbourne and those in some of the other study sites. Off-premise outlets have been suggested as hubs for a range of other violence-related activities. In particular, Alaniz *et al.* [36] discuss the relationship between drug use, gang activity and other risky behaviours and liquor outlets, while other authors [37] have pointed to the sale of drug paraphernalia by packaged outlets in California as an indication of their role as attractors of problem behaviours. These associations have not been examined in Australian studies, but these problems do not appear to be linked strongly with packaged liquor outlets in an Australian context.

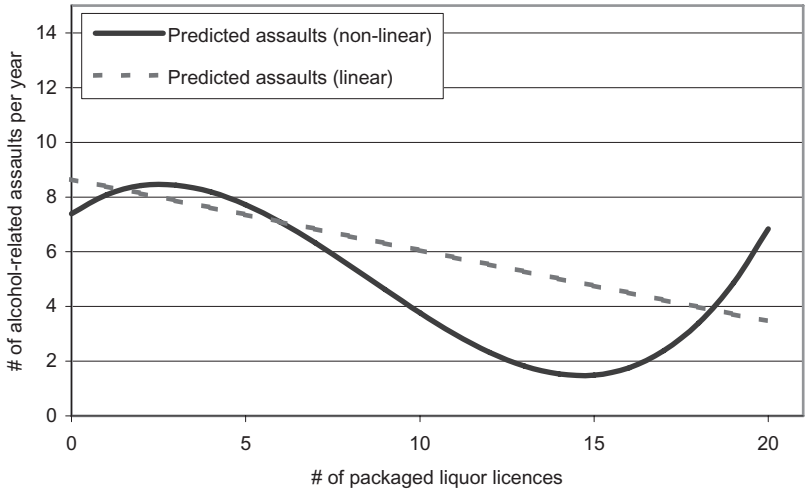


Figure 4 Linear and non-linear relationships between packaged licences and alcohol-related assaults in a hypothetical postcode

While this study provides good evidence of a spatial association between alcohol-related assaults and alcohol outlet density, it should be noted that its cross-sectional design prevents strong conclusions being drawn around causality. Furthermore, previous work [35] has highlighted that assaults on licensed premises disproportionately take place in a small number of establishments, highlighting the need to further examine the types of outlets that are related to assaults. Further data, such as alcohol sales, opening hours, capacity and venue style, could provide substantial insights into how different outlets contribute to the effect of outlet density on assault.

This study has shown a significant positive relationship between alcohol outlet density and assault rates. In particular, the examination of non-linear effects of outlet density demonstrated a critical threshold for general licence density, after which rates of violence increase sharply. This effect requires further examination, but suggests that alcohol-related problems do not necessarily increase consistently with outlet density and provides an avenue for the development of appropriate caps on liquor licences in local areas, an avenue that is being examined increasingly by local governments in Australia. The overall positive link between outlet density and violence found in this study provides more evidence that the ongoing liberalization of liquor licensing policy in Australia, driven in part by the National Competition Commission [38,39], has the potential to result in significant increases in public order and public health problems.

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