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The effect of liquor licence concentrations in local areas on rates of assault in New South Wales

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Aim: *To investigate the relationship between liquor licence concentrations and assault rates in Local Government Areas (LGAs) in New South Wales.*

Method: *Police, liquor licensing and socio-demographic data were analysed. Spatial regression analyses were conducted to measure associations between liquor licence concentrations and domestic violence (DV) and non-domestic violence (non-DV) assault rates.*

Results: *The concentration of hotel licences in an LGA, particularly at higher density levels, was strongly predictive of both DV and non-DV assault rates. A similar, but slightly weaker, association was found for the concentration of packaged licences and DV and non-DV assault rates. On-premises concentrations also predicted DV and non-DV assault rates at the LGA level but, unlike hotel concentration effects, in this case there was no evidence of stronger effects at higher density levels. Significant non-linear relationships were found between the concentration of clubs and DV and non-DV assault rates respectively with each increasing once club concentration exceeded one per 1,000 population.*

Conclusion: *Regulatory authorities should be concerned about increases in liquor outlet density. In particular, increases in the density of hotels above 2 per 1,000 residents are of greater concern than increases in the density of premises with other types of liquor licence.*

Keywords: *assault, liquor licence concentrations, outlet density, linear regression, spatial autocorrelation, simultaneous autoregressive (SAR) models.*

INTRODUCTION

There is good evidence of a relationship between liquor outlet concentrations in local areas and alcohol-related harm (Escobedo & Oritiz, 2002; Gruenewald, Freisthler, Remer, LaScala, & Treno, 2006; Lipton & Gruenewald, 2002). Higher concentrations of liquor outlets have consistently been found to be associated with increased social harms, such as higher assault rates (Chikritzhs, Catalano, Pascal, & Henrickson, 2007; Zhu, Gorman, & Horel, 2004) and motor vehicle injury rates (Gruenewald, Johnson, & Treno, 2002; Jewell & Brown, 1995; LaScala, Gerber, & Gruenewald, 2000).

A number of studies in the USA have shown a relationship between liquor outlet density and assault incidents. For example, Scribner, Mackinnon, and Dwyer (1995) analysed assault rates across 74 cities in Los Angeles County and found that both packaged (e.g. bottle shops) and on-site outlet (e.g. bars, restaurants) density was positively associated with the rate of assault controlling for socio-demographic variables. On the basis of their statistical modelling, these authors estimated that one liquor outlet was associated with an extra 3.4 incidents of assault per year. Gorman, Speer, Gruenewald and Labouvie (2001) analysed rates of violent crimes, including assault, in geographical 'blocks' in Camden, New Jersey and found that liquor outlet concentrations accounted for one-fifth of the variability in violent crime. This outlet density effect was independently predictive after adjustment for socio-economic factors.

Toomey et al. (2012) examined the effect of outlet density on assault and robbery in 83 neighbourhoods of Minneapolis. On-premises and off-premises densities/concentrations were calculated for each neighbourhood based on roadway miles. As overall outlet density increased so did adjusted counts of assaults and robberies. It was also found that the outlet density effect estimates for each of assault and robbery were stronger for the on-premises analyses compared with the off-premises analyses. Pridemore and Grubesic (2013) examined the relationship between concentrations of liquor outlets and assault rates per square mile in block groups in Cincinnati. Specific licence types included bars, off-premises and restaurants. For less serious assaults the outlet density of each of the three licence types were predictive of more crime, however the off-premises concentration effect appeared to be the strongest. For 'aggravated' (more serious) assaults, the off-premise density was a very strong predictor, while restaurant density had a more modest effect. Bar density was not predictive. Overall, Pridemore and Grubesic (2013) found that the outlet density effect for each type of premises was stronger for less serious assaults compared with 'aggravated' assaults.

The two studies described above present conflicting results. Pridemore and Grubesic (2013) found off-premises density to be a stronger predictor of assault than on-premises density, while Toomey et al. (2012) found the opposite effect. Livingston, Chikritzhs and Room (2007), in their review of outlet density research, observe that higher outlet concentrations are generally associated with increased problems such as violence, but there can be important differences across jurisdictions in terms of which types of licences are most problematic. In a systematic review of the availability of alcohol, Holmes et al. (2014) argue that it is important to disaggregate outlet types in order to get a better understanding of the relationship between the concentration of licensed premises and problem levels in particular locations.

In terms of Australian data, Stevenson, Lind and Weatherburn (1999) conducted analyses at the local government area (LGA) level using both recorded crime data and the then existing wholesale sales data in New South Wales (NSW). For LGA's in Sydney, a very strong positive correlation was found between the degree of outlet density and alcohol sales, and both were found to predict rates of assault even after statistically controlling for various socio-demographic factors. For rural NSW however, outlet density was not independently predictive of rates of assault after controlling for alcohol sales and socio-demographic factors. Further, only sales from certain types of licenced premises were predictive of higher assault rates, namely hotels and off-licences (or packaged liquor licences). The effect of outlet density within the Sydney Local Government Area (LGA) was recently investigated by Burgess and Moffatt (2011) using spatial methods. This showed that zones immediately around licensed premises had more assaults compared with zones immediately around commercial premises.

Livingston (2008) measured the effects of the concentration of specific licence types on assault rates in Melbourne. This investigation also found that postcodes with higher outlet density levels generally had higher assault rates. A notable feature of the analyses conducted by Livingston (2008) was that the outlet density effect was generally non-linear in nature. Specifically, for 'General licences' (e.g. hotels), the statistical model that best fit the data included non-linear terms (squared and cubed) in addition to the linear term. Put more simply, the analysis showed that, as the number of general licences in a postcode increased to 10 there was only a very small increase in assault rates; increases of between 11 and 25 premises had no additional impact on postcode assault rates; increasing the number of premises beyond 30 or more resulted in very large increases in assault rates. Different non-linear relationships were found for different types of licensed premises, particularly for on-premises and packaged licence types. Non-linear liquor licence concentration effects were also found by Donnelly, Poynton, Weatherburn, Bamford and Nottage (2006) in a study which measured the effects of proximity to licensed premises on rates of problems with neighbourhood drunkenness and property damage.

Liquor concentration effects have also been found for the subgroup of assaults that occur within domestic relationships. In his longitudinal analyses, Livingston (2011) found that an increase in the density of packaged liquor licences in Melbourne postcodes was predictive of an increase in domestic violence rates. Using sales data (which is still collected in Western Australia), Liang and Chikritzhs (2011) found that increases in the mean volume of alcohol sold per packaged liquor outlet was predictive of more assaults at private residences.

THE CURRENT STUDY

The primary aim of this research is to investigate whether there is an association between liquor licence concentrations and rates of assault incidents at the local area level in NSW. The study unit in this research is LGAs in NSW.

Specifically, this research aims to answer the following two research questions:

Question 1: Is there an association between liquor licence concentrations and the rate of domestic violence (DV) related assaults in LGAs after controlling for other variables?

Question 2: Is there an association between liquor licence concentrations and the rate of non-domestic violence (non-DV) related assaults in LGAs after controlling for other variables?

For each of these two questions the following issues are addressed:

a) Is the concentration of particular licence types (e.g. hotel licences, packaged liquor licences, on-premises licences and club licences) associated with higher rates of assault?
b) For each licence type, is the relationship between liquor licence concentration and assault rates linear or non-linear?
c) Is there any spatial autocorrelation between LGAs and assault rates that must be controlled for?

METHOD

DATA SOURCES

Recorded crime data

Recorded crime data were extracted from the NSW Police Computerised Operational Policing System (COPS). Data from COPS included all incidents of domestic violence (DV) and non-DV assaults over the period January through December 2011. These criminal incident data were aggregated into Local Government Area (LGA) units based on the postcode within which the incident occurred. Assaults involving police officers were excluded from the analysis. This minimises any potential for assaults associated with licensed premises concentration being related to enforcement activity. An incident of assault can involve a number of different victims and persons of interest (offenders). The current analyses focus on an incident of assault as a single unit for the calculation of rates (weights for the number of victims or offenders involved have not been applied).

Liquor licensing data

Liquor licensing data were obtained from the NSW Office of Liquor Gaming and Racing (OLGR). OLGR provided us with Government Licensing Service (GLS) data. These data contain details of all liquor licences operating in NSW during 2011, including the liquor licence number, liquor licence name, liquor licence type, location (address), LGA and when the licence commenced trading. To ensure that the liquor outlet concentration levels were accurate for the 2011 calendar year, OLGR provided us with a GLS extraction which occurred in September, 2011.[1]

In 2011 OLGR had six primary classifications for licence premises in NSW: (i) hotels; (ii) packaged liquor; (iii) clubs; (iv) on-premises; (v) limited licences and; (vi) producer/wholesaler.[2] Producer/wholesaler licences were excluded from the analyses because their primary function relates to the production and/or wholesaling of alcohol rather than retailing to the general consumer. Limited licences were excluded as they are authorised to provide alcohol on a small number of occasions during the calendar year for specific purposes. In terms of on-premises licences, the business type was important in determining whether they be included in concentration estimates. Catering, special events, aircraft and vessel licences were excluded as their location of alcohol sales was not fixed to a particular locality. Airport licences were also excluded. The remaining on-premises group still covered a wide range of business types including licensed restaurants, wine bars, nightclubs, theatres, public entertainment venues and accommodation.[3] It specifically includes both licensed restaurants that are required to provide meals to customers when serving alcohol as well as those with a Primary Service Authorisation (PSA), which can serve alcohol without a meal.[4]

Australian Bureau of Statistics (ABS) data

ABS data were used to define denominators and covariates at the LGA level. The denominator for each LGA was the estimated residential population (ERP) size measured in the 2011 Census. ERP data from 2011 were also used to provide age group and gender breakdowns. The percentage of Aboriginal and Torres Strait Islander (ATSI) residents in each LGA in 2011 was also obtained (Indigenous percentage).

Accessibility/Remoteness Index of Australia (ARIA) data were used to define LGAs into the categories of city, inner regional, outer regional, remote and very remote (Australian Bureau of Statistics, 2003). Socio-Economic Index for Areas (SEIFA) in 2011 was also obtained. The SEIFA scale used was the Index of Relative Socio-Economic Disadvantage (IRSD) with lower scores indicating more socio-economic disadvantage (Wise & Mathews, 2011).

Public Health Information Development Unit (PHIDU) data

Data obtained from the Public Health Information Development Unit (PHIDU) website[5] included: (i) the percentage of each LGA whose residents were born in a predominantly non-English speaking (NES) country and; (ii) the percentage of each LGA whose labour force was unemployed.

STATISTICAL ANAYSIS

Data definitions and variable transformation

DV and non-DV related assault incidents were analysed separately. Unit record crime incident data was aggregated at the LGA level and the rates per 1,000 population calculated. The denominator for the rates was the 2011 Census ERP estimate. To deal with the skewness of DV and non-DV assault rates both variables were log transformed.[6]

For each LGA, licence concentration rates (per 1,000 persons) were calculated for: (i) hotel licences; (ii) packaged liquor licences; (iii) on-premises licences; and (iv) club licences. To calculate these rates, the number of licensed premises of a given type in an LGA (e.g. hotels) was divided by the LGA population size (ERP) and multiplied by 1,000. These rates were used to examine the linear association between each licence type concentration measure and the respective DV and non-DV assault rates.

Non-linear associations occur where the same change in a liquor outlet concentration rate produces a different change in the assault rate at higher liquor concentration levels compared with lower concentration levels. In order to measure non-linear associations between liquor outlet concentrations and assault rates, squared and cubed transformations of the outlet rates were calculated. These non-linear transformations involved firstly centering the concentration rate for each premises type by subtracting the mean of the premises type concentration rate (across all relevant LGAs) from each LGA's premises type concentration rate (in order to minimise problems of multi-collinearity). These centered linear rates were then squared (raised to the power of two) or cubed (raised to the power of three) to produce two non-linear terms. The resulting variables were named according to whether they were linear, squared or cubed (e.g. hotels linear, hotels non-linear squared, hotels non-linear cubed).[7]

A number of covariates were included in the regression. Population density was defined for each LGA as the number of persons divided by the total square kilometres of area. Linear terms were included which measured the percentage of each LGAs ERP population who were: (i) Indigenous (ATSI); (ii) males aged between 15 and 34 years of age; (iii) born in a predominantly non-English speaking (NES) country and; (iv) unemployed members of the labour force. The SEIFA IRSD index was analysed as a linear term with lower values indicating greater socio-economic disadvantage and higher values indicating greater socio-economic advantage. The ARIA measure was categorised into three groups; (i) city; (ii) inner regional and; (iii) outer regional, remote and very remote. Note that the percentage unemployed in each LGA was not included in the final models because of the strong association between unemployment rate and the SEIFA ISRD socio-economic disadvantage measure.

Spatial information

ArcMap v10.2 was used to map the LGAs and their boundaries, as well as to compute the spatial distribution of the LGAs. In addition, ArcMap v10.2 was used to assign covariate information to each LGA.

Spatial regression analyses

The aim of this analysis is to find and quantify the relationship between liquor licence concentration levels and DV and non-DV assault rates controlling for other covariates and for any spatial autocorrelation between neighbouring LGAs.

In order to conduct the aforementioned analysis, regression models which include linear and non-linear effects for the explanatory variables were computed. The explanatory variables in this study consisted of:

1. hotel concentration
2. packaged liquor concentration
3. on-premises concentration
4. club concentration
5. population density
6. Indigenous percentage (ATSI)
7. males aged 15-34 percentage
8. socio-economic disadvantage (SEIFA IRSD score)
9. percentage born in a non-English speaking (NES) country
10. location (ARIA category)

Three different types of regression models were considered. The first was a linear regression model of the form:

$$y_t = X\beta + \varepsilon \qquad (1)$$

where β are the effects for the explanatory variables X and $\varepsilon \sim N(0, \sigma^2 I)$ are the independent identically distributed random errors. This model was estimated by ordinary least squares (OLS).

The second was a spatial simultaneous autoregressive model (SAR), which attempts to control for spatial autocorrelation (Cressie & Wikle, 2011):

$$y_t = X\beta + \lambda W(y_t - X\beta) + \varepsilon \qquad (2)$$

where λ (lambda) is the spatial autocorrelation parameter and W is a matrix that represents spatial dependence. The errors (ε) are defined as in model (1) and the model was fitted using maximum likelihood estimation. A third (Model 3) was the same as Model 2 (SAR), except that LGAs were given spatial weights that reflected the size of their resident population. This is called a SAR weighted regression model (Bivand, Pebesma, & Gomez-Rubio, 2013).

For all the models, various diagnostic methods were employed to check the residuals and were used to decide which model best fit the data. Normality of the residuals was checked via the Shapiro-Wilk test. In order to test whether the residuals were spatially independent, Moran's I test was used to determine whether or not spatial autocorrelation was present in the residuals from the OLS model (Moran, 1950; Cliff & Ord, 1981). If statistically significant spatial autocorrelation was evident from this test, then SAR regression was the preferred method as the residuals were not independent.

For SAR models, the likelihood ratio (LR) test was used to compare models where spatial autocorrelation was present (i.e. λ was different from 0) versus those which do not include a spatial autocorrelation component (i.e. λ = 0). It is important to account for spatial autocorrelation otherwise the regression estimates might be biased (Bivand et al., 2013).

In addition to these model diagnostic checks, we paid special attention to outliers. If any significant outliers were identified from the model diagnostics, they were removed and the models re-estimated in order to assess whether they are points of influence (Johnson & Wichern, 2002; Kleinbaum, Kupper, & Muller, 1988). Finally, the homogeneity of variance of residuals assumption was checked for each model.

If lambda (λ) from the SAR model was significantly different from zero, SAR weighted regression was used to attempt to remove the remaining spatial autocorrelation.[8] The spatial weights used in these models were calculated as the inverse of the population size of each LGA (Bivand et al., 2013). After a SAR weighted regression model had been estimated, the residuals were again examined and lambda (λ) tested to be certain that all spatial autocorrelation in the data had been accounted for.

Goodness of fit was also assessed when comparing across different regression models. The Akaike information criterion (AIC) was used for this purpose (Akaike, 1974). Lower values of AIC indicate a better fit to the data. All analyses were carried out using R v3.0.2 (R Development Core Team, 2014) and the spdep package (Bivand, 2006).

LGAs included in the analyses

Although data was extracted for all of NSW, a small number of areas were excluded from the analysis. Sydney LGA was excluded because this area has a high transient population (visitors and/or tourists) which makes it difficult to calculate an accurate per capita offence rate. The unincorporated area of NSW is not an LGA and is also comprised of spatially distinct parts of NSW (e.g. unincorporated far west, Jervis Bay, Lord Howe Island). The Snowy River LGA was also excluded due to the high visitor population during the winter months and also the high numbers of on-premises licences which tend to only operate during the winter season. Broken Hill LGA was excluded because it has no neighbouring LGAs which could be spatially adjusted for (it is located in the middle of the far west component of unincorporated NSW). Urana LGA was also excluded because while its population is small, its concentration rate of clubs was very high which ended up producing high leverage and influence on the regression models during the preliminary data analyses. Conargo LGA was excluded because it had a zero DV and non-DV assault rate in 2011.[9] This resulted in 147 of the total 152 LGAs in NSW in 2011 being considered for inclusion in the analyses (96.7% of all LGAs).

RESULTS

Descriptive statistics are shown in Table 1 for the DV and non-DV assault rates in the 147 LGAs. The mean rate was higher for non-DV assault than DV assault. The distance between the 75th and 25th percentiles (interquartile range) was also greater for non-DV assault indicating that it had a higher variability. Table 1 also provides descriptive statistics for the four types of licenced premises. On-premises licences had the highest mean rate closely followed by hotel licences.

SPATIAL DISTRIBUTION OF ASSAULTS IN NSW, 2011

Map 1 shows the DV assault rate at LGA level across all of NSW broken into quintile categories of the rate. Darker colours for a category indicate higher DV assault rates. The lightest colour represents the quintile with the lowest assault rate range while the darkest colour represents the quintile with the highest assault rate range. Map 2 shows the DV assault rate for LGAs across the Greater Sydney area as these could not be clearly identified in Map 1.

Map 3 shows the non-DV assault rate at LGA level across all of NSW again broken into quintile categories of the rate. Map 4 shows the non-DV assault rate across LGAs in the Greater Sydney area. Clearly there is a range of assault rates across different LGAs.

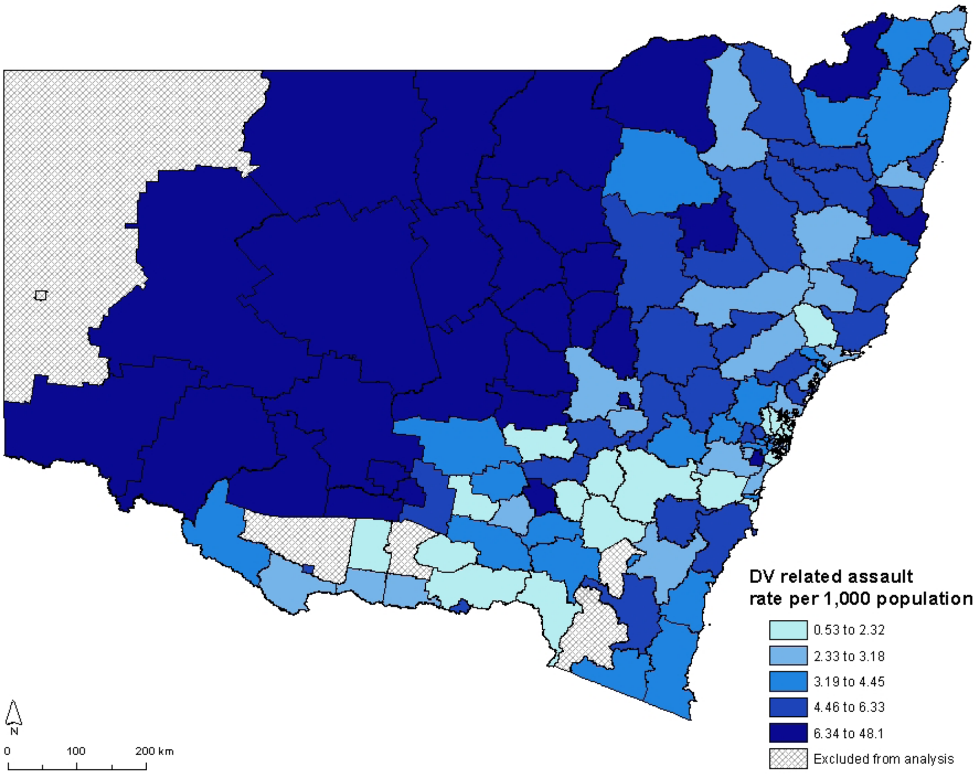
DV ASSAULT RATE AND LIQUOR LICENCE CONCENTRATIONS

We begin by looking at the effect of licence concentration on DV assault. Comparison of the three models for DV assault revealed that the SAR model best dealt with problems of spatial autocorrelation and heterogeneity of residuals. The findings are shown in Table 2 (the other models tested are shown in Appendix Table A1).[10]

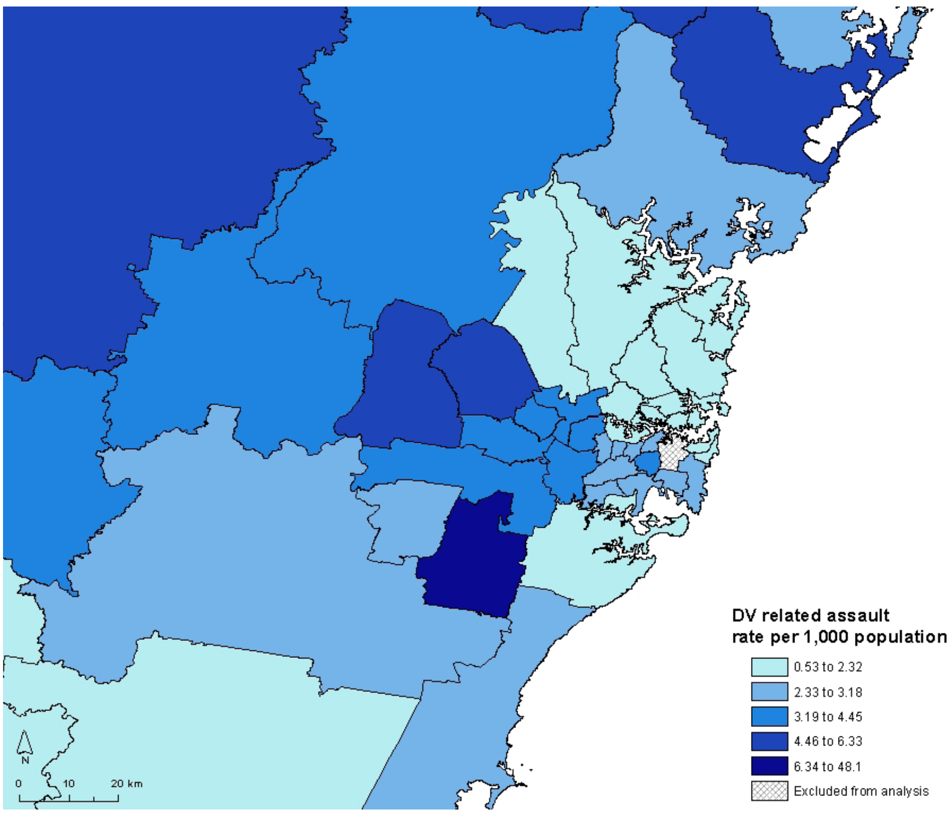
Table 1. Descriptive statistics for assault and liquor licence concentration rates *(n = 147 LGAs)*

	Mean	Median	25th percentile	75th percentile	Interquartile Range
DV related assault rate (per 1,000 population)	5.13	3.67	2.55	5.68	3.13
Non-DV related assault rate (per 1,000 population)	5.88	4.83	2.88	7.30	4.42
Hotel licence rate (per 1,000 population)	0.73	0.49	0.18	1.15	0.97
Packaged licence rate (per 1,000 population)	0.39	0.33	0.23	0.48	0.25
On-Premises licence rate (per 1,000 population)	0.94	0.90	0.53	1.22	0.69
Club licence rate (per 1,000 population)	0.45	0.32	0.17	0.65	0.48

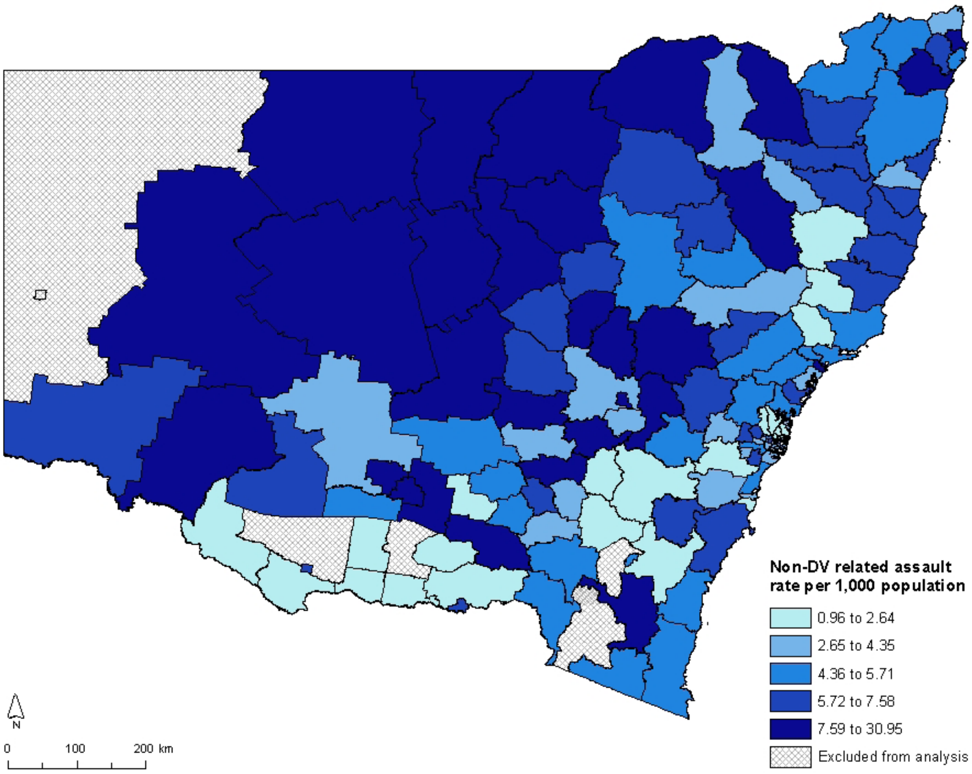
Map 1. Domestic Violence assault rate for LGAs in NSW



Map 2. Domestic Violence assault rate for LGAs across the Greater Sydney area



Map 3. Non-Domestic Violence assault rate for LGAs in NSW



Map 4. Non-Domestic Violence assault rate for LGAs across the Greater Sydney area

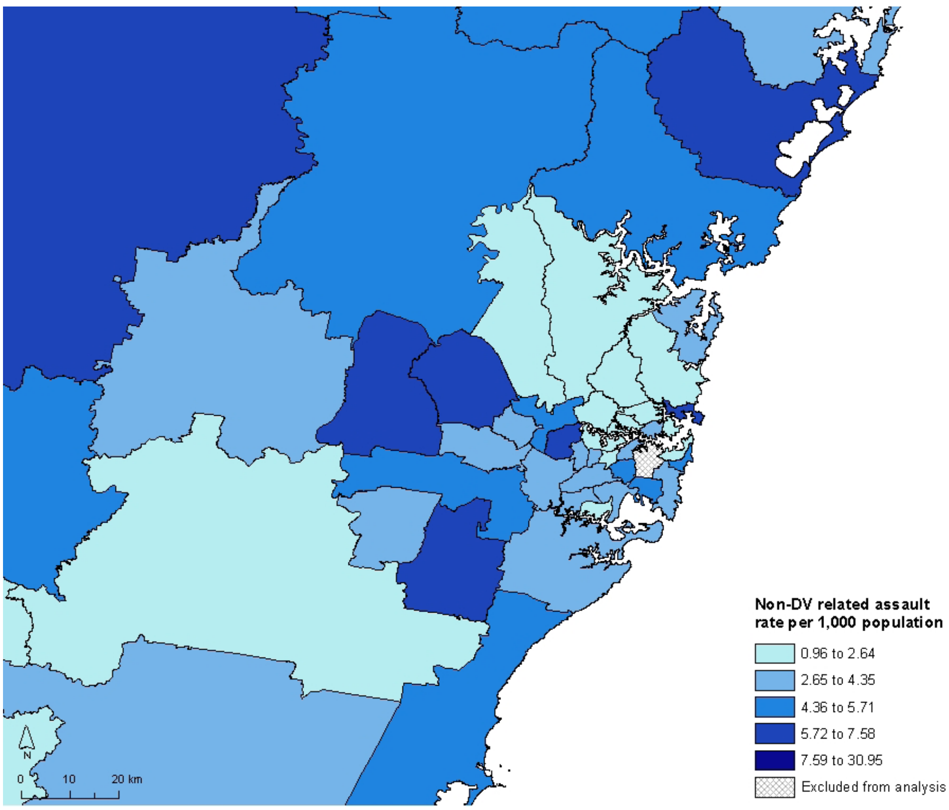


Table 2. SAR regression model of DV related assault rates (logarithm) in LGAs, 2011

	SAR model (*n* = 147)		
	Estimate	SE	*p* value
Constant	6.579	0.803	< .001 *
Hotels linear	-0.141	0.124	= .258
Hotels non-linear squared	-0.353	0.148	= .017 *
Hotels non-linear cubed	0.194	0.048	< .001 *
Packaged linear	-0.604	0.249	= .015 *
Packaged non-linear squared	-0.506	0.777	= .515
Packaged non-linear cubed	3.872	1.660	= .020 *
On-Premises linear	0.131	0.054	= .015 *
Clubs linear	-0.518	0.217	= .017 *
Clubs non-linear squared	0.555	0.213	= .009 *
Population density#	0.000	0.000	= .181
Indigenous (%)	0.031	0.006	< .001 *
Males 15-34 years (%)	0.055	0.017	= .001 *
Socio-economic disadvantage	-0.006	0.001	< .001 *
Born NES country (%)	-0.011	0.005	= .037 *
City	0.043	0.123	= .729
Outer regional/remote	0.166	0.090	= .065
	λ (lambda) = .343		
	LR test = 5.25, *p* = .022		

The parameter estimate is -0.0000509
* Significant at $p < .05$

Figure 1. Hotel concentration and DV assault rate

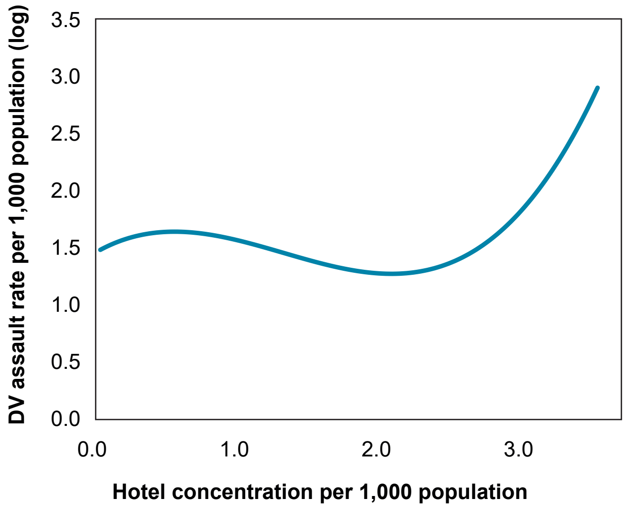
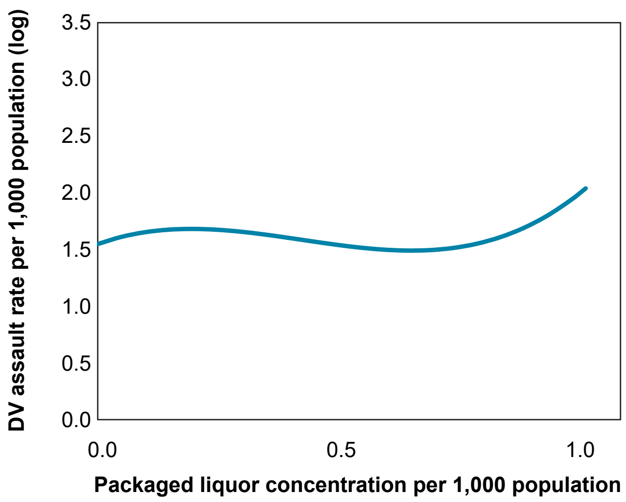


Figure 2. Packaged liquor concentration and DV assault rate



Inspection of Table 2 indicates that the rate of DV assault increases with the percentage of the population who are Indigenous, the percentage of males aged 15-34 and the level of socio-economic disadvantage (i.e. more disadvantaged, more DV assaults). An increase in the percentage born in a non-English speaking (NES) country was associated with less DV assaults. The ARIA category for outer regional/remote LGAs suggested higher DV assault rates though this effect was marginally non-significant. Turning to the key explanatory variables, note that the cubed terms in the SAR model are significant for the concentrations of both hotel and packaged licence types. It follows that the relationship between licence type density and domestic assault was non-linear for hotel and packaged licence types. Only a linear term was needed for on-premises licences but there was a significant squared term for clubs.[11]

The easiest way to see the different relationships is to fix the values of all variables in the model except the one of interest and then use the model to plot the relationship between that variable and the dependent variable (DV assault).[12] Figure 1 does this for the relationship between DV assault and the concentration of hotels. The curve shown in Figure 1 assumes other liquor outlet concentration variables in the model are set at their median values, that is: packaged liquor (0.33); on-premises (0.9); and clubs (0.33). These medians were centered by subtracting the mean from each. Other covariates are set at the following levels: population density (8.35); percentage Indigenous (4.0); percentage males aged 15-34 (12.0); SEIFA IRSD index of socio-economic disadvantage (968); and percentage born non-English speaking (NES) country (7.0). City is the ARIA location. Inspection of Figure 1 reveals that, while initially low, the DV assault rate increases sharply once the hotel concentration exceeds 2.0 per 1,000 of population. Note that, although the absolute magnitude of the effects shown in Figure 1 depends on the values of the remaining variables in the model, the form of the relationship does not. An increase in the percentage of males aged 15-34, for example, will simply shift the entire curve up.

Figure 3. On-Premises concentration and DV assault rate

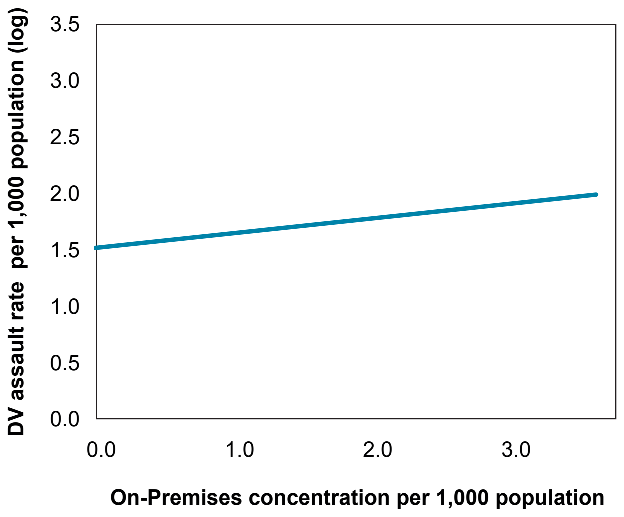


Figure 4. Club concentration and DV assault rate

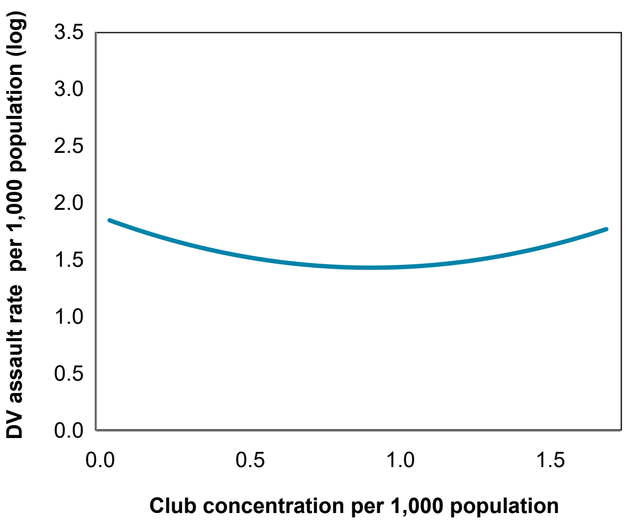


Figure 2 repeats the process for the relationship between DV assault and changes in the density of packaged liquor licences. The values of other variables in the model have been held at the values used to plot Figure 1.[13] Once again we see a sharp upward turn of the curve; this time when the packaged liquor licence concentration exceeds 0.75 per 1,000 of population. Comparing Figures 1 and 2, it can be seen that the magnitude of hotel concentrations across the LGAs was much higher than it was for packaged liquor concentration. More importantly, the effect of an increase in hotel concentration on DV assaults was much more pronounced than it was for packaged liquor concentration. The maximum value of the DV assault rate (log) was around three for the highest hotel concentration but was less than two for the highest packaged liquor concentration.

Figure 3 shows an example of the increase in DV assault associated with increases in on-premises concentrations, while Figure 4 shows a non-linear effect for increases in club concentrations.[14]

Looking at the slope of the curve in Figure 3, it is apparent that as the concentration of on-premises increased so too did the DV assault rate. A 10 per cent increase in on-premises concentration (evaluated at its mean level) produced a 1.2 per cent increase in the DV assault rate.[15] While initially showing a decrease Figure 4 shows that once club concentration passes one per 1,000 population the DV assault rate increased.

NON-DV ASSAULT RATE AND LIQUOR LICENCE CONCENTRATIONS

Preliminary analysis once again revealed the SAR model to be superior to the OLS model in terms of its diagnostics (see Appendix Table A2) and spatial weights were not required.[16] Table 3 shows the results of the SAR regression model. The errors from this model showed no spatial autocorrelation (λ = .109, p = .342). As for the DV assault rate analyses for the SAR weighted regression, it was necessary to remove the same influential observation from the non-DV assault SAR regression model to ensure that the normality assumption had not been violated (Warren LGA).

As with DV assault, the rate of non-DV assault increases with the percentage of the population who are Indigenous, the percentage of males aged 15-34 and the level of socio-economic disadvantage (i.e. more disadvantaged, more non-DV assaults). Like DV assault the rate of non-DV assault decreases with the percentage born in a non-English speaking (NES) country. Another difference compared with analyses for DV assault rates was that as population density increased non-DV assault rates decreased, albeit this adjusted effect was marginally non-significant. All the relationships with liquor licence density are non-linear except the relationship between non-DV assault and on-premises licences.[17] Figures 5-8 show how the non-DV assault rate changes with higher hotel concentrations (Figure 5), higher packaged liquor concentrations (Figure 6), higher on-premises concentrations (Figure 7) and higher club concentrations (Figure 8).[18]

Figure 5 shows that the non-DV assault rate, like the DV assault rate, was relatively flat up to the point where the density of hotels exceeded 2 per 1,000 persons. After this point the assaults increased markedly. Figure 6 also shows a pattern similar to that for DV assault, with non-DV assaults accelerating when the packaged liquor concentration level goes past 0.75 per 1,000 population. Similar to DV assaults it was found that the effect of an increase in hotel concentration on non-DV assaults was much

Figure 5. Hotel concentration and non-DV assault rate

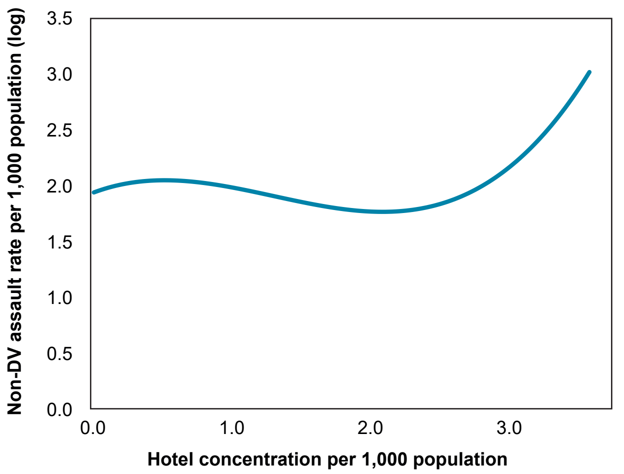


Figure 6. Packaged liquor concentration and non-DV assault rate

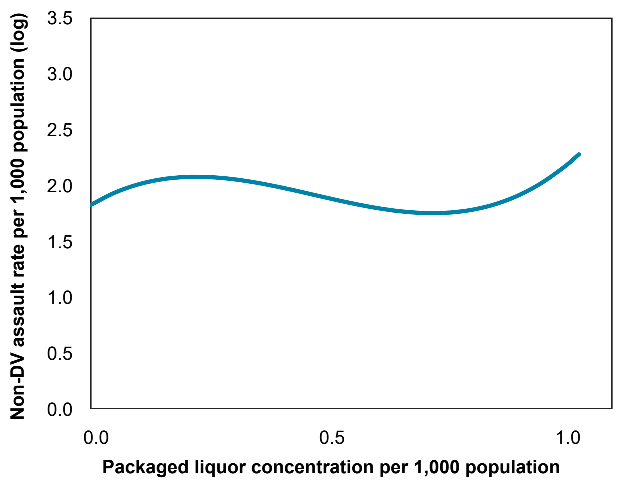


Figure 7. On-Premises concentration and non-DV assault rate

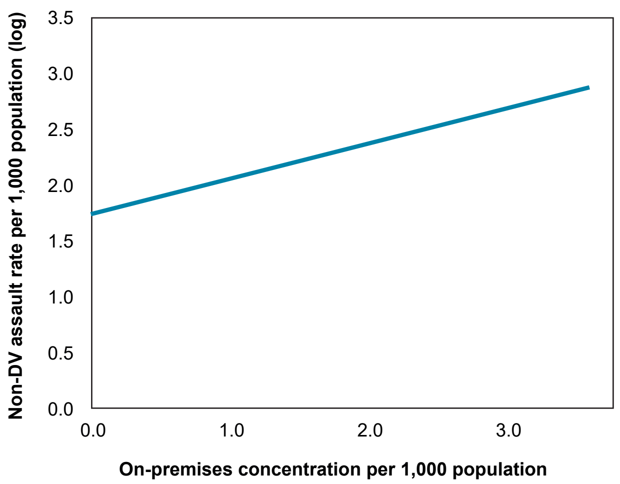


Figure 8. Club concentration and non-DV assault rate

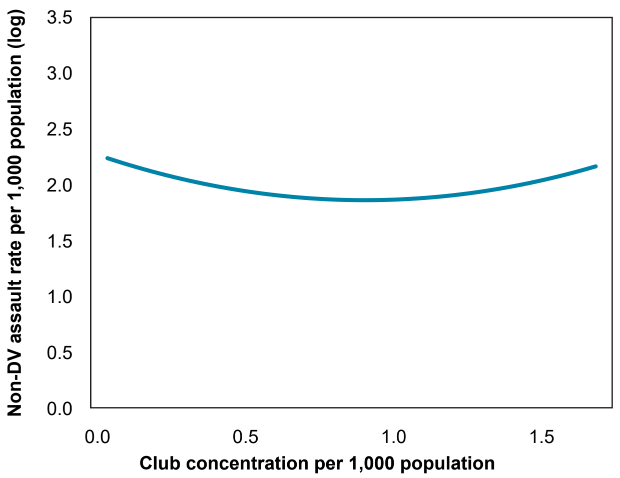


Table 3. SAR regression model of non-DV related assault rates (logarithm) in LGAs, 2011

	SAR model (*n* = 146)		
	Estimate	SE	*p* value
Constant	6.638	0.681	< .001 *
Hotels linear	-0.119	0.108	= .270
Hotels non-linear squared	-0.258	0.128	= .045 *
Hotels non-linear cubed	0.146	0.044	= .001 *
Packaged linear	-0.852	0.237	< .001 *
Packaged non-linear squared	-1.330	0.713	= .062
Packaged non-linear cubed	5.177	1.569	= .001 *
On-Premises linear	0.314	0.051	< .001 *
Clubs linear	-0.463	0.200	= .021 *
Clubs non-linear squared	0.494	0.199	= .013 *
Population density#	0.000	0.000	= .057
Indigenous (%)	0.029	0.005	< .001 *
Males 15-34 years (%)	0.090	0.016	< .001 *
Socio-economic disadvantage	-0.006	0.001	< .001 *
Born NES country (%)	-0.014	0.004	= .001 *
	λ (lambda) = .109		
	LR test = 0.90, *p* = .342		

The parameter estimate is -0.0000586

* Significant at $p < .05$

more pronounced than it was for packaged liquor concentration. The maximum value of the non-DV assault rate (log) was around three for the highest hotel concentration but was less than 2.3 for the highest packaged liquor concentration.

From Figure 7 it is clear that as the concentration of on-premises per 1,000 population increased so did the non-DV assault rate. As only a linear term was used for on-premises concentration, it was possible to calculate the elasticity effect of on-premises concentration rate on non-DV assault rates. This showed that a 10 per cent increase in on-premises concentration (evaluated at its mean level) produced a 3.0 per cent increase in the non-DV assault rate.[19] Finally, although the rate of non-DV assaults accelerates as the concentration of clubs passes one per 1,000 population (Figure 8), the effect is nowhere near as strong as the associations between non-DV assault and the other licence types.[20]

DISCUSSION

This study set out to answer two main research questions: (1) is there a significant association between liquor licence concentrations and DV assaults rates in LGAs and (2) is there a significant association between liquor licence concentrations and non-DV assault rates in LGAs? Overall, the results of this investigation confirm that there is a relationship between the concentration of licensed premises in a particular area and levels of assault, even after controlling for other covariates and for spatial autocorrelation between LGAs. However, the nature of this relationship is complex; with differing patterns found across various types of liquor licences and types of assault (i.e. DV and non-DV related assaults).

For DV assaults, the relationship between hotel and packaged licence densities was found to be non-linear. The significant cubed terms in the regression models indicate that licence concentration levels have their greatest association on assault rates in LGAs where the number of these licences types is already relatively high. For hotels, the DV assault rate was found to increase sharply once the concentration level exceeded 2.0 per 1,000 residents. For packaged liquor, there was a sharp increase in DV assault rates once licence concentrations exceeded 0.75 per 1,000 residents. The effect of an increase in concentration levels on DV assault was much more pronounced for hotels than it was for packaged liquor, with the highest hotel concentration levels predicting much higher DV assault rates than the highest concentration levels of packaged liquor licences. The nature of the relationship between DV assault rates and both club and on-premises densities was different. The relationship between on-premises concentrations and DV assault rates was significantly linear. A 10 per cent increase from the mean of on-premises concentrations would produce a 1.2 per cent increase in DV assault rates. For clubs there was a significant squared non-linear relationship with DV assault rates. Once club concentration passed 1.0 per 1,000 residents the DV assault rate increased.

Consistent with the findings for DV assault, non-linear relationships between non-DV assaults and both hotel and packaged liquor licence densities were found. The results showed that non-DV assault rates increased markedly when the density of hotels exceeded 2.0 per 1,000 residents and when the packaged liquor concentration level surpassed 0.75 per 1,000 residents. Again, the effect for hotels was much more pronounced than for packaged liquor outlets. The maximum value of the non-DV assault rate (log) was around three for LGAs with the highest hotel concentration but was less than 2.3 for LGAs with the highest packaged liquor concentration. A non-linear relationship was also evident for clubs. However, the overall effect for clubs was relatively small compared to other licence types. Finally, as for DV assaults, linear increases in on-premises concentrations predicted higher non-DV assault rates. It was estimated that a 10 per cent increase from the mean of on-premises concentrations produced a 3.0 per cent increase in the non-DV assault rate, a much larger effect size than was found for DV assaults.

There were some different covariate relationships found in the final regression models for DV and non-DV assault rates. Population density was almost statistically significant for the non-DV assault rate but was non-predictive for DV assault. The ARIA category for outer regional/remote LGAs was almost predictive for higher DV assault rates but was not predictive of non-DV assault.

In summary the SAR regression analyses identified licence concentration effects on DV and non-DV assault rates at the LGA level. Importantly a major advantage of each final model was that important covariates and population density had been controlled for. This helps ensure that regional differences across LGAs were accounted for. While the SAR regressions for non-DV assault rates had removed spatial autocorrelation, the same cannot be said for DV assault rates. While the amount of spatial autocorrelation was smaller for the SAR regression compared with SAR weighted regression for DV rates some caution is required when interpreting the magnitude of the outlet density effects.

These findings have important implications for local decisions about the potential impact of additional liquor licences in an area. From our final regression models we were able to plot the relationship between each of the four types of licence premises and the assault rate. As seen from these graphs (and discussed above), there are certain thresholds above which increases in particular licence types, especially hotels and packaged liquor outlets, have a substantial correlation with assaults (both DV and non-DV assaults). Importantly, our research shows that even though the magnitude of these effects will vary across geographical areas with different population characteristics (e.g. socioeconomic disadvantage, age distribution), the form of this relationship will remain. So, for example, a LGA with a higher proportion of younger males or a greater level of socio-economic disadvantage (factors also predictive of assault rates) will have higher assault rates overall, but the thresholds for liquor licence density above which assault rates are likely to increase markedly will still be the same. Our work suggests that new hotel licences in areas where the concentration of hotels is already above two per 1,000 residents should be of particular concern to regulatory authorities.

One limitation of our research is that no wholesales data were available to include in the regression models. Previous studies, including the work undertaken by Liang and Chikritzhs (2011) and Stevenson et al. (1999) were able to combine sales data with outlet density data when examining the relationship between licensed premises and violent crime. This would certainly be a useful addition to our regression models and may result in more of the variance in assault rates across LGAs being explained (Loxley, Catalano, Gilmore, & Chikritzhs, 2012). What would be needed though would be for the sales data in each LGA to be broken down by the four specific licence types which we examined. Currently this information is not collected in NSW.

Further analyses using additional information about the licensed premises, such as trading hours and patronage, would also be useful (Holmes et al. 2014). In a systematic review of studies examining the effect of licence premises trading hours, Stockwell and Chikritzhs (2009) found that extended trading hours was associated with increased alcohol consumption levels and greater alcohol-related harms such as violence and motor vehicle accidents. These authors argue that the ideal design would be to have a baseline period before the trading hours were either extended or reduced and also to have a comparison group of licensed premises where no change to trading hours occurred. When measuring assaults which occur inside the licensed premises it is important to collect data on what time the crime incident occurred and relate this to authorised trading hours.

Another limitation of this study is that it is cross-sectional in nature. This type of study can only answer questions about the relationship between liquor licence concentrations and assault rates in one calendar year. In their review of the liquor outlet density literature, Livingston et al. (2007) highlight the need for more longitudinal research to be undertaken in this field. Longitudinal research can help us understand how changes in liquor outlet concentrations affect changes in assault rates over time (Popova, Giesbrecht, Bekmuradov, & Patra, 2009). For example, Gruenewald and Remer (2006) examined six years of licence and hospital discharge data from zip codes in California. They found that increases in 'bar' and 'off-premises' licences were associated with increases in interpersonal violence discharges from hospital after adjusting for covariates. A longer term study conducted by Norstrom (2000) found that over the period 1960-1995 as the rate of liquor licences increased over time so did the rate of violent crime.

Longitudinal research conducted in Canada examined changes in outlet densities and the amount of alcohol sold and how these related to hospital admissions and mortality rates (Stockwell et al., 2013; Zhao et al., 2013). This research used all local health areas (LHAs) in British Colombia (BC) province over eight years with adjustment for temporal and spatial dependencies. There was an increase in the concentration of private liquor stores and restaurants over time which was associated with increases in the amount of alcohol sold within each licence type. By contrast government liquor stores showed a decline in sales of alcohol over the same period (Stockwell et al., 2009). Importantly these increases in the concentration of 'private' alcohol licences were associated with small though statistically significant increases in acute and chronic alcohol-related hospitalisations (Stockwell et al., 2013), and acute and chronic alcohol-attributable mortality rates (Zhao et al., 2013).

Livingston (2011) examined changes in domestic violence in Melbourne over the period 1996 to 2005. This study found that increases in total licences over this period were predictive of increases in DV assault rates over time, with a particularly strong effect found for changes in packaged licences. Replication of this work in the NSW context would be valuable.

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NOTES

1. The OLGR data extraction occurred on September 9, 2011.
2. Clubs have previously been referred to as registered clubs.
3. Nightclub is used to denote the business type called 'Other public entertainment venue, Restaurant' in the OLGR GLS data.

4. Preliminary analyses were conducted which also used a more restricted definition of On-Premises licences which excluded the large number of licensed restaurants which did not have PSA. These analyses found stronger concentration effects with both DV and non-DV assault rates when including the larger non-PSA group of licensed restaurant in the On-Premises concentration rate.

5. Public Health Information Development Unit (PHIDU), University of Adelaide website (accessed on November 28, 2014): http://www.adelaide.edu.au/phidu/

6. The logarithmic transformation of each assault rate meant that the variance of the regression residuals was better stabilised. This is a critical assumption of linear regression methods.

7. Preliminary analyses were conducted to assess the need for non-linear terms for each licence type concentration rate. This found that linear and non-linear (squared and cubed) terms were required for hotels and packaged outlet densities. Only a linear term for on-premises density was required. For club density a linear term was required for DV assault while linear and non-linear (squared) terms were required for non-DV assault.

8. In some cases the spatial autocorrelation is due to the heterogeneity of the population size.

9. As it was necessary to take the logarithm of the highly skewed assault rates to be able to conduct linear regression methods it was decided to exclude Conargo to ensure the assumption of stabilised variance was not seriously violated.

10. Table A1 shows that for the SAR regression spatial autocorrelation had not been removed (LR test = 5.25, p = .022). A SAR weighted regression was also used. Inspection of the residuals from this regression found an outlier and the normality assumption was violated. The weighted SAR regression was conducted without this influential observation (this LGA was Warren). The amount of spatial autocorrelation was much larger in the SAR weighted regression (LR test = 9.16, p = .002).

11. Additional SAR weighted regression analyses were conducted to assess whether the relationships between the licence concentration variables and DV assault may be different for the city and other/regional/remote categories. These analyses included adding interaction terms between licence concentrations and location category. However, these models had major multi-collinearity problems and the estimates could not be relied upon (Kleinbaum et al., 1988).

12. Each of Figures 1-8 only extend to the maximum concentration rate for the licence type of interest which was found in the data.

13. The set value for hotel concentration rate was its median (0.5) which was centered by subtracting the mean from it.

14. The set values for the other licence types and covariates are the same as was used in Figures 1 and 2.

15. The mean level of on-premises concentration was 0.94 per 1,000 persons.

16. Preliminary analyses found that ARIA categories were not significant predictors of non-DV assault rates. Therefore no terms for ‘city’ or ‘outer regional/remote’ were included.

17. Additional SAR regression analyses were conducted to assess whether the relationships between the licence concentration variables and non-DV assault may be different for the city and outer regional/remote categories. These analyses included adding interaction terms between licence concentrations and location category. Again major multi-collinearity problems were found and the estimates could not be relied upon.

18. Figures 5-8 adopted the same approach which was used for Figures 1-4. The same fixed values were used for licence concentrations and covariates. As there were no ARIA variables in Model Non-DV-2, there were no fixed values required for these variables.

19. The mean level of on-premises concentration was 0.94 per 1,000 persons.

20. We provided reasons for excluding five LGAs from the data. Sensitivity analyses have now been conducted for all LGAs. As Conargo LGA had zero DV and non-DV assault rates these analyses are for 151 LGAs. Table A3 provides the final SAR model for DV related assaults (logarithm). While this model had spatial autocorrelation (LR = 8.27, p = .004 *), so did the SAR weighted model (LR = 7.65, p = .006 *). Compared with Table 2 the only consistent outlet density effect was for hotels non-linear cubed. Table A4 provides the final SAR model for non-DV related assaults (logarithm). This model did remove spatial correlation (LR = 0.08, p = .779). This was more consistent with Table 3 with significant hotel cubic and on-premises linear effects. The effects for packaged and clubs were not significant. This certainly means we cannot extrapolate the results of the main analyses to all LGAs in NSW. The large transient population in Sydney LGA overall and in the Snowy River LGA during winter makes it very difficult to use the estimated resident population as the denominator for assault rates.

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APPENDIX

Table A1 shows the results from three different regression models predicting DV assault rates from liquor licence concentrations, controlling for other covariates. The first column called DV-1 shows estimates from a linear regression using ordinary least squares (OLS) analysis. The problem with model DV-1 was that the residuals showed spatial autocorrelation. The Moran's I for spatial autocorrelation was .102 and statistically significant (p = .007).

The DV-2 model includes the same independent variables but was estimated using the simultaneous autoregressive (SAR) approach. The spatial autocorrelation parameter (λ) for this model was .343 and statistically significant (p = .022). This means that the spatial autocorrelation had not been adequately controlled for. Examination of the residuals from DV-2 also indicated that heterogeneity of the variance of the residuals was a problem for this model. A SAR weighted model was used.

The results from this final regression model (DV-3) are shown in Table A1. DV-3 differs from DV-2 in that one independent variable (the non-linear squared term for clubs) and one influential outlier have been excluded. This model contained large spatial autocorrelation in the residuals (λ = .355, p = .002). DV-2 was the final model.

Table A2 shows the results from two different regression models predicting non-DV assault rates from liquor licence concentrations, controlling for other covariates. Both these regressions were conducted using 146 LGAs, as inspection of the Q-Q plot raised similar concerns about the same influential LGA identified in the DV assault analyses. The OLS regression approach was used in model Non-DV-1 but the magnitude of the spatial autocorrelation was still of concern even though it was (marginally) non-significant (Moran's I = .056, p = .062).

A SAR model was conducted with the estimates shown in the second column of Table A2 (model Non-DV-2). The residuals from this model showed no spatial autocorrelation (λ = .109, p = .342). Non-DV-2 was the final model.

Table A3 shows the SAR regression for DV assault rates from 151 LGAs. The spatial autocorrelation parameter (λ) for this model was .411 and statistically significant (p = .004). This model contained spatial autocorrelation.

Table A4 shows the SAR regression for non-DV assault rates from 151 LGAs. The spatial autocorrelation parameter (λ) for this model was .038 and was not statistically significant (p = .779). This model did not contain spatial autocorrelation.

Table A1. Regression models of DV related assaults rates (logarithm) in LGAs, 2011

	DV-1 OLS model (n = 147)			DV-2 SAR model (n = 147)			DV-3 SAR weighted model (n = 146)		
	Estimate	**SE**	***p* value**	**Estimate**	**SE**	***p* value**	**Estimate**	**SE**	***p* value**
Constant	6.372	0.803	< .001 *	6.579	0.803	< .001 *	5.691	0.517	< .001 *
Hotels linear	-0.140	0.131	= .286	-0.141	0.124	= .258	-0.032	0.150	= .832
Hotels non-linear squared	-0.310	0.161	= .057	-0.353	0.148	= .017 *	-0.022	0.174	= .900
Hotels non-linear cubed	0.178	0.054	= .001 *	0.194	0.048	< .001 *	0.048	0.079	= .548
Packaged linear	-0.719	0.279	= .011 *	-0.604	0.249	= .015 *	0.077	0.346	= .825
Packaged non-linear squared	-0.329	0.841	= .696	-0.506	0.777	= .515	2.962	0.977	= .002
Packaged non-linear cubed	4.169	1.846	= .026 *	3.872	1.660	= .020 *	-4.129	2.594	= .111
On-Premises linear	0.153	0.060	= .012 *	0.131	0.054	= .015 *	0.079	0.059	= .182
Clubs linear	-0.461	0.242	= .059	-0.518	0.217	= .017 *	-0.781	0.225	= .001 *
Clubs non-linear squared	0.497	0.234	= .036 *	0.555	0.213	= .009 *			
Population density	0.000	0.000	= .128	0.000	0.000	= .181	0.000	0.000	= .176
Indigenous (%)	0.033	0.006	< .001 *	0.031	0.006	< .001 *	0.047	0.012	< .001 *
Males 15-34 years (%)	0.062	0.018	= .001 *	0.055	0.017	= .001 *	0.089	0.014	< .001 *
Socio-economic disadvantage	-0.006	0.001	< .001 *	-0.006	0.001	< .001 *	-0.006	0.001	< .001 *
Born NES country (%)	-0.009	0.005	= .071	-0.011	0.005	= .037 *	-0.017	0.003	< .001 *
City	0.023	0.131	= .863	0.043	0.123	= .729	-0.024	0.081	= .771
Outer regional/remote	0.273	0.090	= .003 *	0.166	0.090	= .065	0.167	0.127	= .189
	Adjusted R-squared = .77 Moran's I = .102, *p* = .007 *			λ (lambda) = .343 LR test = 5.25, *p* = .022 * Final model			λ (lambda) = .355 LR test = 9.16, *p* = .002 *		

* Significant at $p < .05$

Table A2. Regression models of Non-DV related assaults rates (logarithm) in LGAs, 2011

	Non-DV-1 OLS model (n = 146)			Non-DV-2 SAR model (n = 146)		
	Estimate	**SE**	***p* value**	**Estimate**	**SE**	***p* value**
Constant	6.577	0.696	< .001 *	6.638	0.681	< .001 *
Hotels linear	-0.105	0.112	= .352	-0.119	0.108	= .270
Hotels non-linear squared	-0.284	0.135	= .037 *	-0.258	0.128	= .045 *
Hotels non-linear cubed	0.154	0.047	= .001 *	0.146	0.044	= .001 *
Packaged linear	-0.874	0.252	< .001 *	-0.852	0.237	< .001 *
Packaged non-linear squared	-1.443	0.749	= .056 *	-1.330	0.713	= .062
Packaged non-linear cubed	5.479	1.669	= .001 *	5.177	1.569	= .001 *
On-Premises linear	0.308	0.054	< .001 *	0.314	0.051	< .001 *
Clubs linear	-0.452	0.212	= .035 *	-0.463	0.200	= .021 *
Clubs non-linear squared	0.471	0.210	= .027 *	0.494	0.199	= .013 *
Population density	0.000	0.000	= .074	0.000	0.000	= .057
Indigenous (%)	0.029	0.005	< .001 *	0.029	0.005	< .001 *
Males 15-34 years (%)	0.090	0.016	< .001 *	0.090	0.016	< .001 *
Socio-economic disadvantage	-0.006	0.001	< .001 *	-0.006	0.001	< .001 *
Born NES country (%)	-0.014	0.005	= .003 *	-0.014	0.004	= .001 *
	Adjusted R-squared = .77 Moran's I = .056, *p* = .062			λ (lambda) = .109 LR test = 0.90, *p* = .342 Final model		

* Significant at $p < .05$

Table A3. SAR regression model of DV related assault rates (logarithm) in LGAs, 2011

	SAR model (n = 151)		
	Estimate	SE	*p* value
Constant	6.507	0.791	< .001 *
Hotels linear	-0.197	0.121	= .103
Hotels non-linear squared	-0.311	0.143	=.029 *
Hotels non-linear cubed	0.183	0.047	< .001 *
Packaged linear	-0.478	0.241	= .047 *
Packaged non-linear squared	-0.077	0.743	= .918
Packaged non-linear cubed	2.890	1.621	= .074
On-Premises linear	0.040	0.035	= .253
Clubs linear	-0.239	0.188	= .203
Clubs non-linear squared	0.068	0.082	= .411
Population density#	0.000	0.000	= .611
Indigenous (%)	0.027	0.006	< .001 *
Males 15-34 years (%)	0.063	0.017	< .001 *
Socio-economic disadvantage	-0.006	0.001	< .001 *
Born NES country (%)	-0.013	0.005	= .011 *
City	0.044	0.127	= .728
Outer regional/remote	0.147	0.091	= .107
	λ (lambda) = .411		
	LR test = 8.27, *p* = .004 *		

The parameter estimate is -0.000019
* Significant at *p* < .05

Table A4. SAR regression model of non-DV related assault rates (logarithm) in LGAs, 2011

	SAR model (n = 151)		
	Estimate	SE	*p* value
Constant	6.445	0.764	< .001 *
Hotels linear	-0.166	0.121	= .170
Hotels non-linear squared	-0.210	0.142	= .141
Hotels non-linear cubed	0.128	0.050	= .011 *
Packaged linear	-0.440	0.269	= .101
Packaged non-linear squared	-0.777	0.793	= .327
Packaged non-linear cubed	2.686	1.790	= .134
On-Premises linear	0.120	0.037	= .001 *
Clubs linear	-0.135	0.200	= .502
Clubs non-linear squared	-0.027	0.092	= .769
Population density#	0.000	0.000	1.000
Indigenous (%)	0.027	0.006	< .001 *
Males 15-34 years (%)	0.103	0.017	< .001 *
Socio-economic disadvantage	-0.006	0.001	< .001 *
Born NES country (%)	-0.019	0.005	< .001 *
	λ (lambda) = .038		
	LR test = 0.08, *p* = .779		

The parameter estimate is 0.00000001
* Significant at *p* < .05

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