

Revealing the link between licensed outlets and violence: Counting venues versus measuring alcohol availability

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Abstract

Introduction and Aims. Associations between alcohol-related harms and numbers of outlets at the neighbourhood level have been demonstrated; however, the degree to which alcohol consumption or sales plays a part in levels of violence is not clear. This has contributed to uncertainty regarding the actual mechanisms by which outlet density may influence levels of violence. This ecological cross-sectional study investigated the effect of outlet numbers and alcohol sales on the risk of assault in Western Australia. **Design and Methods.** For 2000/2001, information on type, number and wholesale alcohol purchases of all licensed outlets in operation, police-reported assault offences, socioeconomic/demographic data were obtained from official sources. Multivariate negative binomial regression was applied to at local government area level in order to assess associations between outlet density, alcohol sales and violence occurring in both licensed and domestic settings. **Results.** Average alcohol sales volume per off-site outlet was significantly associated with all measures of assault. Numbers of on-site outlets significantly predicted violence with the exception of assaults occurring at residential premises. Alcohol sales from off-site outlets predicted violence occurring at on-site outlets. **Discussion and Conclusions.** The link between on-site outlets and violence may be primarily underpinned by negative amenity effects while off-site outlet effects occur via increased availability. Alcohol sales volumes from off-site outlets influence levels of violence, which occur at both licensed and residential settings. The substantial and wide-ranging effects of liquor stores on alcohol-related harms may have been underestimated in the literature and by policy makers. [Liang W, Chikritzhs T. Revealing the link between licensed outlets and violence: Counting venues versus measuring alcohol availability. *Drug Alcohol Rev* 2011;30:524–535]

Key words: alcohol consumption, alcoholic beverage, violence, domestic violence, drinking behaviour.

Introduction

The occurrence of interpersonal violence and disorder in the night-time economy, where establishments licensed to sell alcohol predominate, has been well described [1]. The notion that alcohol and aggression are linked is also supported by substantial evidence and theory from a range of research domains. Meta-analyses of experimental studies have demonstrated that alcohol intoxication leads to more aggressive responses in laboratory settings [2]. A consistent body of evidence from observational studies also indicates that heavy alcohol use is associated with an increased risk of violence [3]. There have been a number of

theories postulated to explain the relation between alcohol and aggression [4].

In the last decade, evidence for a relation between numbers of liquor outlets (outlet density) and violence has grown in both sophistication and number. The recent trend has been towards more studies, which focus on demonstrating effects between harm and numbers of outlets at the neighbourhood level and over time. Assuming that the measures used to identify effects are sensitive and reliable, the strongest evidence for impact would be expected to come from such longitudinal studies (e.g. [5–7]). The weight of accumulated evidence indicating a positive relation between outlet density and violence is compelling [8,9].

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However, despite the fact that much of the focus, if not the central aim of these outlets, is typically to sell alcohol (licensed restaurants as a possible exception), the degree to which alcohol consumption or sales plays a part in increased levels of violence is not clear and this has contributed to uncertainty regarding the actual mechanisms by which outlet density may influence levels of violence.

With only a few exceptions (e.g. [10,11]), the outlet density and violence literature is dominated by studies, which are restricted to measuring outlet density by counting numbers of outlets and then converting them to a rate (e.g. per resident, per unit geographical area, per road miles) while excluding measures that actually quantify alcohol sales made by these outlets. This is, to be fair, much more often due to lack of access to detailed sales data than to oversight or preference by researchers [8]. It is nevertheless a limitation inherent to count-based models (even longitudinal studies) that they cannot account for the inevitable variation between outlets and their variable capacity to influence alcohol availability in the communities they serve. For example, a new off-sales liquor store with a large floor area and the backing of a national corporation may have the capacity to sell hundreds of beverage brands at discounted prices with many times the capacity to influence alcohol consumption within the surrounding population than a medium-sized store specialising in boutique beers or a liquor store that sells a substantial range of non-alcohol products (e.g. convenience store). A community that has one or more of the larger stores may be at greater risk of higher consumption and related harms than a neighbourhood that has a similar number of outlets per capita but with lower volumes of alcohol sales. A typical outlet density study that essentially measures counts of outlets but not alcohol sales volume would not be able to distinguish between these two different scenarios; it is unclear the degree to which such lack of measurement sensitivity would influence apparent outcomes.

Gruenewald *et al.* [9] have identified and described five theoretical models, which attempt to explain the relation between outlet density and harm: availability theory; social disorganisation theory; routine activities theory; drinking context theory; and niche theory. A framework developed by Livingston *et al.* [8] builds on and combines contemporary availability theory (as expressed by Stockwell and Gruenewald [12]) and routine activities theory. Livingston *et al.* [8] propose that outlets may potentially influence both 'proximity' of access to alcohol (availability) and the 'amenity' of the community surrounds. The proximity effect, which relates closely to alcohol availability theory, influences the convenience costs of obtaining alcohol, such as distance to travel (i.e. physical availability) and real price (i.e. economic availability). As new outlets appear, acces-

sibility and the intensity of competitive pricing practices may increase thus enhancing access to alcohol and the relative buying power of consumers. Amenity effects relate to the undesirable or negative effects, which outlets have on the physical environment of neighbourhoods. By virtue of their collective appeal, premises that are located in close proximity to one another (e.g. walking distance) may apply a multiplicative pressure on violence and disorder as they draw large numbers of potential perpetrators and victims into close contact with one another—they may function as magnets for violence, disorder and 'trouble'. Thus, greater numbers of alcohol outlets may influence violence via mechanisms other than changes to alcohol consumption levels, such as those described by niche theory [13]. As Livingston *et al.* [8] note, the impact of outlet density and the mechanism by which that impact operates may well depend on '... the setting, the type of outlet and the type of outcome being examined' (p. 562).

Apart from not accounting for alcohol sales made by outlets there are other gaps that exist in the literature. Evidence for the impact of numbers of outlets is especially compelling for outlets that require consumption of purchased alcohol on-site (e.g. hotels and nightclubs), but is arguably less well established for off-site outlets (e.g. [9]). It has rarely been possible for studies to distinguish between types of locations where violence occurs, for example, assaults occurring at on-site versus off-site outlets while accounting for alcohol sales made from those particular premises. As a result, there is little or no evidence for cross-outlet type effects, such as the potential for off-site outlets to influence levels of harms, which occur at on-site outlets.

While the relation between outlet density and general interpersonal violence appears robust, there have been few opportunities to demonstrate potential associations between outlet density and violence, which typically occurs in residential settings, such as child abuse and domestic violence. Freisthler and Weiss' [14] study of child abuse and outlet density and McKinney *et al.*'s [15] study of intimate partner violence are notable recent exceptions.

The main aim of this ecological cross-sectional study was to investigate the effect of numbers of outlets, alcohol sales and types of alcohol outlets on the risk of assault in Perth, Western Australia. It examined the relative effects of on-site and off-site outlets by simultaneously applying both counts of outlets and alcohol sales made by those same outlets to predict assaults occurring at residential and licensed settings.

In Western Australia, the large majority of licensed premises are on-site outlets, that is, their primary purpose is to sell alcohol for consumption on the premises (e.g. hotels, nightclubs, restaurants, cafes, social clubs). These outlets account for just over half of total

pure alcohol sold in the state. Liquor licenses referred to by the licensing authority as 'liquor stores' and which are only permitted to sell alcohol for consumption off the premises, make up less than 20% of all licensed outlets, but are responsible for over 45% of all alcohol sold in the state [16]. Large-scale mega-discount warehouse style off-site outlets that sell many times more alcohol than traditional liquor stores are an increasingly common feature of the Australian liquor landscape. The successful establishment and growth of such mega-stores by large corporations has been highlighted in the Australian media's coverage of community and police objections to liquor licensing decisions in recent years.

Methods

Geographic region, unit of analysis

Western Australia is the largest state in Australia, spanning more than two and a half million square kilometres (approximately one million square miles). Large areas of Western Australia are sparsely populated, in 2000/2001 the estimated residential population was approximately 1.9 million. The geographic measure used in this study was 'local government area' (LGA). LGA boundaries remain relatively stable from year to year and there were 140 Western Australian LGAs in 2000/2001 (see Figure 1). LGAs vary substantially in land area and are larger than 'postcodes', which typically function as 'neighbourhoods' (see Figure 1). On average there were approximately two and a half postcodes to every one LGA in 2000/2001 and some 70% of these were outside of the metropolitan area of the capital city Perth. The LGA denoting the central business district of Perth has relatively few local residents, but is affected by constant movement of non-residents who conduct business during the day or recreate in the entertainment districts at night. With its low residential population (accurate estimates of non-resident population are not available), large numbers of licensed premises and large volumes of alcohol purchases, the Perth central business district was excluded from analyses as an outlier.

Licensed outlets

Information regarding all licensed outlets in operation in 2000/2001 was obtained from the Western Australian Department of Racing, Gaming and Liquor, Liquor Licensing Division, including: trading name, type of licence, LGA and beverage specific volumes of wholesale alcohol purchases made for the purposes of retail sale in 2000/2001. It is mandatory for all wholesalers in Western Australia to provide data on purchases made from them by individual retailers licensed to sell alcohol to the general public. Although some wastage, breakage

and stockpiling may occur, these annual data are considered a close proxy for actual annual retail alcohol sales made to the public [17] and will be referred to hereafter as alcohol 'sales'. Alcohol volumes by beverage type were converted to pure alcohol using conversion factors identified in Catalano *et al.* [17] and summed to estimate total pure alcohol sold. Only volumes of pure alcohol sales were used in analyses.

There were 2576 licensed premises in Western Australia in 2000/2001. Five main types were identified: hotels (23%), restaurants/cafes/canteens/special functions (43%), nightclubs (1%), social clubs (15%) and liquor stores (18%). The first four outlet types are largely restricted to 'on-site' trading and are distinguished mainly in relation to their trading hours and/or requirement to sell alcohol only as an accompaniment to a substantial meal (e.g. restaurant). Hotels are typically required to close on or before midnight (unless they have been granted an extended trading permit) whereas nightclubs may operate up to 3 AM or 6 AM on weekends. Liquor stores are restricted to 'off-site' sales of packed liquor.

Off-site outlets contributed to 45% of total alcohol sales in 2000/2001. Hotels accounted for 34% of alcohol sales, restaurants/cafes/canteens/special functions contributed 17%, while social clubs (3%) and nightclubs sold relatively small amounts of alcohol (1%).

Violent assault offences

Details of assault offences reported by police as having occurred in 2000/2001 were obtained from the Western Australian Police Service. Assault data included the type of assault, age and sex of the victim, sex of perpetrator, time of event and location of the assault. There were 18 223 police-reported assault offences across the state. The majority of assaults (78%) were for common/bodily assault (i.e. meaning to strike, touch, move or otherwise apply force or any bodily injury, which interferes with health or comfort). Some 13.5% involved assaults of a sexual nature and 3.5% were for wounding offences. The remainder of assaults consisted of grievous bodily harm/manslaughter/homicide (1.5%) and a collection of minor assaults (7%).

Fifty police categories for the type of location where an assault occurred were collapsed into one of three groups: (i) on-site licensed outlets (8%); (ii) residential (49%); and (iii) other (43%). On-site outlets included: hotel (50%), nightclub (31%), restaurant/cafe (11%), hall/function centre (8%). Residential locations included: house/flat (95%), caravan/hostel/retirement village/holiday (5%). Locations defined here as 'other' included: street (42%), shop/shopping centre (13%), park and public space (11%), work place (8%) and

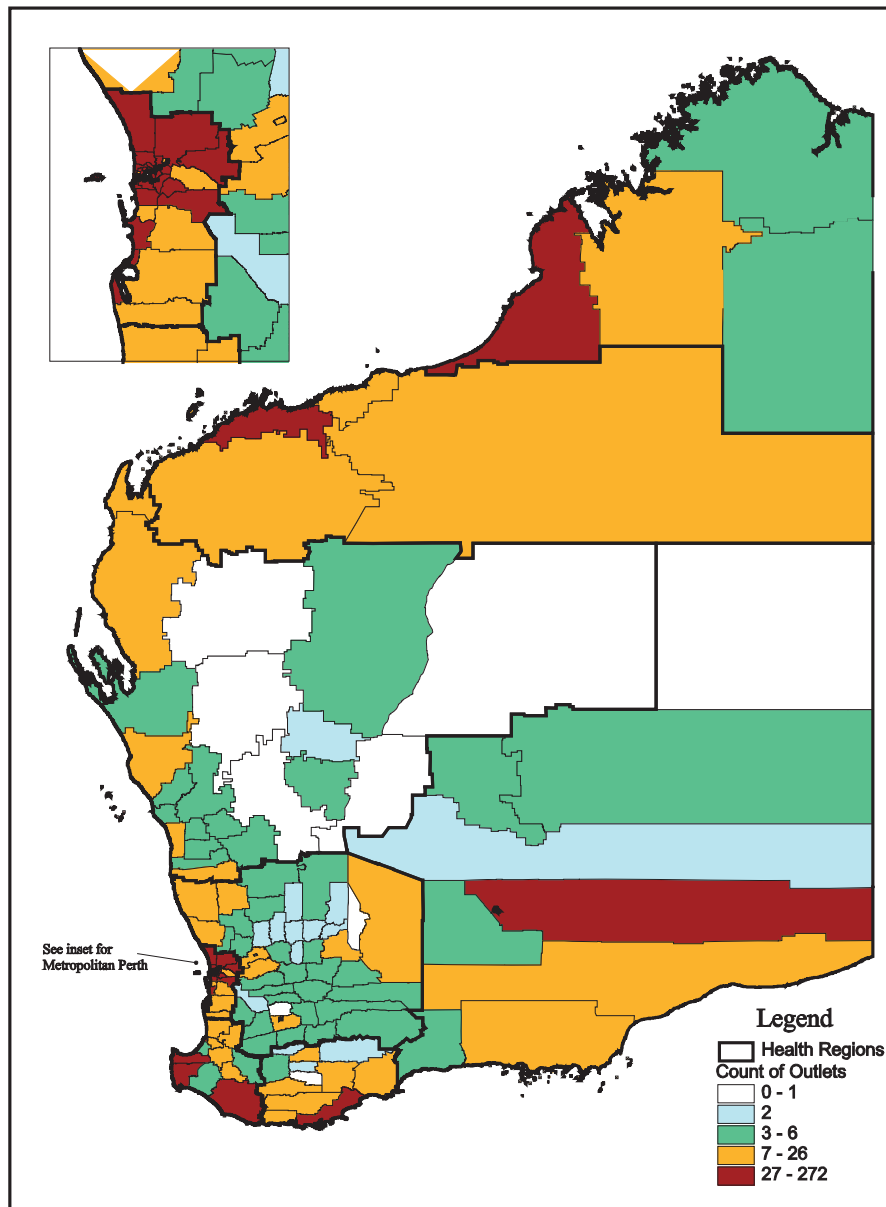


Figure 1. Geographic distribution of total counts of licensed outlets, local government areas, Western Australia, 2000/2001.

numerous others (26%). Police categorised off-site outlets under the broad heading 'shop/shopping centre' (6% of total) and thus a separate location category for these outlets could not be constructed.

Among assaults that occurred at residential locations the sex of both the victim and offender was recorded by police in 43% of cases. Over half involved a female victim and a male perpetrator (57%), a further 32% involved male to male violence. A further 6% of assaults involved female to female violence and 5% involved female perpetrators against male victims.

For assault offences that occurred at on-site licensed outlets, both sex of victim and offender were known in approximately 37% of cases. Among these, the majority

involved male to male violence (67%), approximately 14% involved female victims and male offenders, 11% involved female to female violence and 8% male victims and female offenders.

Demographic and socioeconomic characteristics of LGAs

A range of socioeconomic and demographic data by LGA for 2000/2001 were obtained from the Australian Bureau of Statistics and are based on Census data and the socioeconomic indexes for areas of advantage/disadvantage. Details of these variables are listed in Table 1. The index of advantage/disadvantage is a continuous composite measure of socioeconomic status

Table 1. Descriptive statistics for variables applied in analyses at LGA level

	Mean	Std. Dev.	Min	Max
Dependent variables				
Total assaults	121.59	224.90	0	1412
Assaults at on-site outlets	8.29	15.58	0	88
Assaults at residence	62.51	116.80	0	733
Assaults at other locations	51.53	97.42	0	608
Mean of total volume of alcohol sales (litres pure alcohol)				
On-site outlets	46 411.07	80 591.45	0	534 838.90
Off-site outlets	56 058.99	121 367.70	0	815 987.50
Mean of average volume of alcohol sales sold per outlet (litres pure alcohol)				
On-site outlets	3 556.78	2 598.97	0	15 284.50
Off-site outlets	12 754.79	13 471.11	0	101 998.40
Outlet numbers				
On-site outlets	10.29	13.98	0	82
Off-site outlets	3.23	5.05	0	32
Demographics and socioeconomic variables				
Total 15+ population (ERP)	9 859.65	19 508.41	101	147 574
Average age	35.07	3.04	26.24	40.65
Ratio Indigenous to non-Indigenous population (×100)	7.59	12.80	0	85.8
Ratio unemployed to employed population (×100)	6.48	2.90	1.4	15.6
Per cent young men (15–24 years)	6.24	1.63	3	11.8
Per cent male	52.64	3.68	42.50	70.16
SEIFA index of advantage/disadvantage	964.63	66.74	703	1 209

ERP, estimated residential population by the Australian Bureau of Statistics; LGA, local government area; SEIFA, socioeconomic indexes for areas.

and combines information relating to both disadvantage and advantage to produce a 'net' measure of socioeconomic status. The socioeconomic indexes for areas of advantage/disadvantage include indicators for education, income, employment, occupation, housing and a range others [18]. Urbanity ranks (similar to a measure of remoteness) applied in analyses (not shown in Table 1) were indicated as follows: 1 = major city; 2 = inner regional; 3 = outer regional; 4 = remote; 5 = very remote. Urbanity rank 1 served as the reference category.

Analysis

Multivariate negative binomial regression was the statistical test of choice given the relatively low number of assaults compared with the population and the extra-Poisson variation (i.e. over-dispersion as indicated by significant alpha tests). This is a more conservative test of significance than Poisson or linear regression [19]. STATA version 11 was used for the analysis. When geographically arranged by LGA these data indicate Moran's I close to zero and negligible spatial autocorrelation. This concurs with past analyses conducted at the LGA level in Western Australia [10].

Numbers of violent assault offences formed the dependent variable in all analyses arising in four indi-

vidual models: (i) total assaults; (ii) assaults at on-site outlets; (iii) assaults at residential premises; and (iv) assaults at 'other' places. All models simultaneously included measures of alcohol sales volumes and numbers of both on-site and off-site outlets as well as the full compliment of potential demographic and socioeconomic confounders.

Most studies convert alcohol sales to per capita consumption or transform counts of licensed premises into rates by use of a denominator, such as residential population, roadway miles or size of geographical area. We have adjusted for estimated residential population (ERP) as an independent variable. Using this approach we take the conservative view that residential population is a potential confounder rather than a calibrated measure, which can be used to 'standardise' alcohol sales and counts of outlets across geographic locations prior to analysis. It is our view that to assume the latter is problematic when there is potential movement between regions and where the actual drinking population and or population at risk is unknown or estimated.

Results

Table 2 presents the results from the four models using alternative measures of the dependent assault variable. When controlling for volume of alcohol sales, and all

Table 2. Model results for four assault measures

	0.1970		0.2138		0.2261		0.2031					
	Assaults at on-site outlets		Assaults at private residences		Assaults at other places		Total assaults					
	IRR	95% CI	IRR	95% CI	IRR	95% CI	IRR	95% CI				
Density/alcohol sales variables												
Mean volume alcohol per on-site outlet (in 1000 L)	1.049	0.957	1.151	1.028	0.968	1.092	1.010	0.953	1.070	1.021	0.965	1.082
Mean volume alcohol per off-site outlet (in 10 000 L)	1.198*	1.012	1.417	1.261*	1.113	1.430	1.175*	1.059	1.303	1.223*	1.091	1.371
Number of on-site outlets	1.048*	1.028	1.068	1.008	0.995	1.022	1.027*	1.015	1.040	1.021*	1.008	1.034
Number of off-site outlets	0.978	0.927	1.033	1.017	0.976	1.059	0.990	0.955	1.027	0.999	0.962	1.038
Demographic and socioeconomic variables												
Total 15+ population (ERP) (ln)	1.650*	1.191	2.288	2.118*	1.699	2.640	1.979*	1.601	2.445	2.011*	1.642	2.463
Average age	0.990	0.904	1.085	0.930*	0.874	0.989	0.958	0.904	1.015	0.945	0.894	1.000
Indigenous population	1.019	0.993	1.046	1.035*	1.017	1.054	1.033*	1.016	1.051	1.037*	1.020	1.054
Unemployment rate (%)	0.979	0.907	1.056	1.058*	1.003	1.116	1.055*	1.003	1.110	1.045	0.995	1.098
Per cent young men (15–24 years)	1.163	0.984	1.375	1.093	0.970	1.232	1.257*	1.120	1.411	1.153*	1.032	1.289
Per cent male	0.933	0.819	1.063	1.028	0.946	1.118	1.015	0.936	1.100	1.008	0.935	1.086
SEIFA index of advantage/disadvantage	1.002	0.999	1.005	0.999	0.997	1.001	1.000	0.998	1.002	1.000	0.998	1.002
Urbanity 1	1.000			1.000			1.000					
Urbanity 2	1.483	0.760	2.893	1.005	0.643	1.569	0.866	0.559	1.342	0.958	0.626	1.468
Urbanity 3	2.020*	1.002	4.074	1.094	0.664	1.804	0.853	0.533	1.365	1.009	0.634	1.606
Urbanity 4	2.856*	1.184	6.888	0.716	0.394	1.303	1.103	0.627	1.938	0.864	0.502	1.487
Urbanity 5	3.601*	1.240	10.454	1.069	0.511	2.238	1.152	0.571	2.325	1.158	0.587	2.288

* $P < 0.05$. CI, confidence interval; ERP, estimated residential population by the Australian Bureau of Statistics; IRR, incidence rate ratio; SEIFA, socioeconomic indexes for areas.

listed confounders, there was no evidence of a significant association between numbers of off-site outlets and violence. However, average alcohol sales volume per off-site outlet was significantly associated with all six measures of assault. The incidence rate ratio (IRR) was largest for assaults occurring at residential locations (1.26), that is, for every 10 000 additional litres of pure alcohol sold by an off-site outlet, the risk of violence on residential premises increased by 26% (in 2000/2001 an average off-site outlet sold 12 000 litres of pure alcohol). Furthermore, average alcohol sales made by off-site outlets significantly predicted violence, which occurred at on-site outlets (1.198).

Numbers of on-site outlets significantly predicted violence across all but one of the assault categories—the exception being those assaults occurring at residential premises. The strongest association was evident for assaults which occurred at on-site outlets (1.048), estimated as a 5% increase in violent assault for one additional on-site licence. For each assault group, the IRRs for numbers of on-site outlets were markedly and consistently smaller than for alcohol sales from off-site outlets.

Several demographic and socioeconomic variables also demonstrated significant associations across the four assault measures. As expected, estimated residential population was clearly an important variable, with a 170% increase in population estimated to increase offence counts between 64% and 146%. The proportion of Indigenous people among the residential population significantly predicted violence across each of the measures with the exception of those occurring on licensed premises. For a 1% increase in the Indigenous population of an LGA, the number of assault offences rose by approximately 3.5%.

The proportion of young men in an LGA was a substantial predictor for total assaults and those occurring at 'other places'. For a 1% increase in the proportion of men aged 15–24 years, the number of assaults in an LGA increased between 15% and 26%. Notably, young men most strongly predicted assaults occurring at 'other places', approximately 42% of which occurred in a street. Unemployment rate also predicted those assaults occurring at private residences and other places but not on-site licensed outlets.

Interestingly, in addition to the effect of off-site outlet alcohol sales and on-site numbers of outlets, urbanity was the only demographic variable besides population to significantly predict assaults, which occurred at on-site premises. Moreover, the effect of urbanity on assaults occurring at licensed premises was substantial. Compared with major city locations, LGAs that were ranked as regional, remote and very remote were between two and three and a half times more likely to report assaults at on-site premises.

Post-hoc analyses

Further analyses were conducted to identify whether, treating population as an exposure variable (i.e. violence per capita, which assumes violence equally spread across the residential population) as well as removing simultaneous controls for sales or outlet numbers altered the outcome for total assaults. Compared with the main analyses described above, treating population as an exposure variable with all variables fitted produced larger IRRs for each of the alcohol sales and number of outlets variables but substantially smaller R^2 (see Table 3). Using this approach, alcohol sales for on-site outlets also reached significance. This supports the notion that the main analyses presented above are a more appropriate approach to use of population estimates. Treating population as an exposure variable and when sales volumes were not adjusted for, the IRR for numbers of off-site outlets was larger than for the primary analysis of total assaults (i.e. 1.052 vs. 1.043), but still did not reach significance. These results support the notion that for off-site outlets, count-based measures are only a weak proxy measure for alcohol sales and may potentially result in outcomes biased towards the null.

Discussion

This study investigated the association between numbers of on-site and off-site licensed outlets and assaults occurring at residential and licensed settings while adjusting for simultaneous effects of volumes of alcohol sold by those outlets and a range of demographic and socioeconomic factors.

We observed that the higher the amount of alcohol sold per off-site outlet the greater the risk of reported assault within an LGA. This held for all types of locations. Notably, volume of alcohol sold appeared to have greatest impact on assaults occurring at private residences. When controlled for volume of alcohol sales, numbers of off-site outlets did not significantly predict risk of assault (even for private residences). Post-hoc analyses confirmed that counts of off-site outlets were a weak proxy measure for a measure of alcohol sales made by these premises.

For on-site outlets the results indicated the reverse to that found for off-site outlets, that is, greater numbers of such premises within an LGA predicted greater levels of assault even when controlled for alcohol sales made by those premises. Volume of alcohol sold by on-site outlets did not significantly predict violence when adjusted for number of outlets.

Across all of the assault measures (e.g. total offences, residential, on-site premises), investigated, the strongest associations were consistently found for volumes of

Table 3. Post-hoc analysis model results for total assaults

	IRR	95% confidence interval		IRR	95% confidence interval		IRR	95% confidence interval	
R^2		0.1680			0.1329			0.1128	
Mean volume alcohol per on-site outlet (in 1000 L)	1.081*	1.016	1.151	—	—	—	1.079	0.982	1.186
Mean volume alcohol per off-site outlet (in 10 000 L)	1.342*	1.165	1.545	—	—	—	1.466*	1.184	1.814
Number of on-site outlets	1.033*	1.017	1.049	1.041*	1.016	1.067	—	—	—
Number of off-site outlets	1.043	0.996	1.093	1.052	0.981	1.129	—	—	—
Average age	0.908*	0.854	0.966	0.897*	0.838	0.961	0.874*	0.802	0.952
Indigenous population	1.033*	1.013	1.054	1.017	0.997	1.039	1.032*	1.002	1.062
Unemployment rate (%)	1.077*	1.018	1.139	1.168*	1.090	1.251	1.120*	1.032	1.215
Per cent young men (15–24 years)	1.213*	1.065	1.380	1.390*	1.225	1.578	1.219*	1.006	1.478
Per cent male	0.958	0.882	1.040	0.966	0.905	1.031	0.904	0.807	1.011
SEIFA index of advantage/disadvantage	1.000	0.998	1.002	1.001	0.998	1.004	0.998	0.995	1.001
Urbanity 1	1.000			1.000			1.000		
Urbanity 2	0.836	0.517	1.349	0.868	0.462	1.634	0.298*	0.162	0.549
Urbanity 3	0.640	0.391	1.046	0.638	0.333	1.221	0.292*	0.156	0.546
Urbanity 4	0.519	0.290	0.928	0.763	0.368	1.578	0.196*	0.090	0.426
Urbanity 5	0.591	0.282	1.237	0.896	0.348	2.308	0.229*	0.082	0.639
Total 15+ population (ERP)		(Exposure)			(Exposure)			(Exposure)	

* $P < 0.05$. ERP, estimated residential population by the Australian Bureau of Statistics; IRR, incidence rate ratio; SEIFA, socioeconomic indexes for areas.

alcohol sold by off-outlets, the increased likelihood of violence ranged from 17% to 26% per additional 10 000 litres of pure alcohol sold (an average off-site outlet sells approximately 12 700 litres per annum).

Off-site outlets

The results from this study suggest that alcohol sold by off-site outlets is associated with increased interpersonal violence occurring in residential settings, on-site outlets and 'other places' (42% occurred in the street). When interpreted in the context of routine activities theory and the Australian drinking context, it is not difficult to arrive at an explanation for why quantities of alcohol sold from off-site liquor stores should be associated with violence in residential settings. First, drinking alcohol at private residences is a common occurrence in Australia. In 2001, the most common place for consuming alcohol among 30+-year-olds was their own home (approximately 85%), among 20- to 29-year-olds it was slightly less common (approximately 75%) [20]. Second, alcohol purchased at off-site outlets cannot be consumed on the premises and on-site outlets, such as hotels and nightclubs (but not all restaurants and social clubs), preclude patrons from bringing their own alcohol (which would most likely have been purchased at an off-site outlet). By default or by design, that leaves domestic settings as the most likely place for consuming alcohol purchased from off-

site outlets and thus, domestic settings are a prime location for violence associated with off-site alcohol purchases to occur. (It is possible for drinkers to consume off-site purchased alcohol at public places, such as parks and beaches or even in the street, but this is discouraged by legislation and policing activities.) Notably, the majority of assaults that occurred in residential settings involved a male assailant and a female victim, but it is not possible to know from these data whether they were family members, intimate partners or even known to each other. It is arguable nonetheless that violence in residential settings constitutes a reasonable proxy measure for that defined by some as 'domestic violence', that is, '... the physical, sexual, and emotional maltreatment of one family member by another' [21].

That average alcohol purchases made from off-site outlets should also statistically predict numbers of assaults at on-site outlets within the same LGA, albeit to a lesser degree than for residential settings, is less straightforward but may be explained in part by the phenomenon of 'pre-loading'. Pre-loading (i.e. front-loading, pre-nightlife drinking) refers to the potentially wide-spread practice (at least by relatively young people) of consuming alcohol prior to attending a venue licensed for on-site consumption. It typically involves consumption of alcohol purchased from an off-site outlet at either private premises (e.g. home) or public spaces (e.g. park, street) prior to attendance at

an on-site outlet (e.g. pub or nightclub). The cost differential between often discounted off-site prices and the more expensive on-site prices has been proposed as the main motivation [22]. It is plausible, therefore, that by virtue of their relatively cheaper retail prices, higher volumes of sale from off-site outlets increase violence occurring at on-site outlets by: (i) increasing the prevalence of alcohol-impaired people arriving at on-site venues; (ii) increasing the level of intoxication among drinkers; or (iii) both. Although there have been a number of studies that describe pre-loading behaviour, evidence that off-site outlet alcohol sales may substantially influence violence that occurs at on-site outlets has been limited (Gruenewald *et al.* [23] showed densities of off-premise outlets but not bars to influence assaultive injuries at all locations but geocoded hospitalised patients to residence). It is noteworthy that a relatively recent report by the Scottish Executive quoted a health informant's observation that '... perhaps front loading was playing a role in antisocial behaviour outside on-sales, as with the increase of individuals drinking before going out, there is an increase of people in one location who are already drunk and "topping" up in on-sales which then spills out at the end of the night' ([24], p. 38).

If these findings are replicated, the implications may be substantial, as these data suggest that alcohol sold from one average additional off-site outlet may account for several times as many assaults occurring at licensed settings than the physical presence of one additional on-site outlet.

On-site outlets

The results from this study suggest that average volume of alcohol sales made by on-site outlets is a less important predictor of assault than actual numbers of on-site outlets. At least for these data, numbers of on-site outlets remained a significant predictor of assaults even after accounting for the average amount of alcohol sold by those premises. The implication is that unlike off-outlets that apparently influence violence primarily via alcohol availability (presumably more via economic than physical availability compared with on-site outlets) the effect that on-site outlets have on violence extends beyond changes to alcohol consumption per se with the major mechanism operating via changes to amenity rather than availability.

Hotels and other on-site outlets draw in drinkers from surrounding areas. Unlike off-site outlets where people are more likely to purchase their alcohol then depart, leaving consumption of the product to another time and place, on-site drinkers may remain at length, potentially growing in number and level of intoxication as the hours pass. The person-time and drinker-time

spent at on-site outlets and the entertainment districts in which they have a tendency to cluster is likely to be far greater than for off-site outlets. As Livingston *et al.* described, the very fact that on-site outlets tend to 'bunch' together provides a conduit for violence to occur: 'By virtue of their collective appeal, premises which are "bunched" together may apply a multiplicative pressure on violence and disorder as they draw large numbers of potential perpetrators and victims into close contact with one another... At a certain point, a growing bunch of outlets, particularly on-premise outlets such as hotels and bars, becomes fixed in people's mental maps as an entertainment district... attracting crowds above and beyond what would be attracted by the same number of outlets on their own...?' ([8], p. 562).

Implications

There are a number of implications to be drawn from the outcomes of this study, they relate to outlet density research in general as well as to directions for future focus on policy and strategies for controlling violence in the night-time economy.

With some recent notable exceptions (e.g. [25]) access to and application of licensed premise-specific sales data to outlet density research does not appear to be widely achievable, at least at present. Although the absence of alcohol sales data has rarely been directly pointed to (see [8]), it is a shortcoming of the outlet density research literature in general. The implication from this study is that for off-site outlets, count-based outlet density and violence studies—which force the assumption that such outlets are equivalent in their capacity to influence consumption—may only allow a weak proxy measure of the primary protagonist, that is, sale and consumption of alcohol. We argue that in cases where there is large variation in alcohol sales between off-site outlets, the diluting effect of counting outlets will exacerbate error and favour the null hypothesis. To illustrate, should the trend towards the establishment of large discount stores such as is currently occurring in Australia continue, leading to extreme variation in alcohol sales and capacity to influence consumption among outlets, then count-based studies of off-site outlets will underestimate effects and lead analysts to draw erroneous conclusions.

On the other hand, if the data presented here for Western Australia are at all representative of drinking cultures and liquor licensing regimes elsewhere, then it is probably the case that count-based studies of on-site outlets may well be superior to those that have solely focused on alcohol sales alone (e.g. [10,11]). Notably, the associations found between on-site outlet numbers

and assaults did not extend to residential settings and were strongest for violence occurring on licensed premises.

The support found here for amenity as opposed to availability as the main mechanism underlying the link between violence and on-site outlets suggests that efforts to improve situational characteristics (e.g. crowding) and movements of patrons in the night-time environment (e.g. discouraging bar-hopping, town planning to reduce numbers of on-site outlets within walking distance of each other) rather than a focus on alcoholic beverages purchased on-site (e.g. server training) may be a more efficient approach to curbing violence (see e.g. [26]).

Although on-site amenity effects are deserving of consideration, there may be much more wide-ranging and significant benefits from directing greater efforts at addressing the functions of off-site outlets. Off-site outlets appear to be major contributors to violence, which occurs not only at residential settings and elsewhere (e.g. street) but also at on-site outlets, such as hotels, nightclubs and restaurants. Indeed, the contribution of alcohol sales from one additional off-site outlet to violence occurring at hotels, nightclubs and restaurants is several times greater than one additional on-site outlet. Alcohol availability therefore rather than amenity appears to underlie the relation between off-site outlets and violence in a range of locations. We speculate that economic availability rather than physical availability is primarily at play here and that efforts to increase the average real price of alcohol sold at off-site outlets are required. Strategies, such as: establishing a minimum floor price for all alcoholic beverages (i.e. price posting); restricting discount sales and point of sale drinks promotions; limiting floor space; and taxation reform, may off-set a substantial proportion of the negative effects experienced in the night-time economy, which are encouraged and sustained by highly competitive pricing strategies engaged in by off-site outlets.

Limitations

The unit of analysis in this study was the population rather than the individual, so the qualifications applicable to an ecological study apply here. The data applied were unusually specific with regards to alcohol sales and location of offences, but we have not been able to identify the other individual differences among the outlets themselves, the individuals who patronise them or their movements in time and space. Unlike most off-site outlets, alcohol sale and consumption is but one of several activities and services, which on-site outlets provide (e.g. meals, entertainment) and which are provided in the broader night-time economy (e.g. food outlets) and these were not able to be documented. The

police data we relied upon are undoubtedly an underestimate of total levels of violence and the degree to which individual incidents involved alcohol was unknown. It is impossible to rule out unknown biases in the reporting of assaults by police; nevertheless, these data have been widely used in Australian and international studies of alcohol-related harms and outlet density (e.g. [27–29]).

The study was also cross-sectional, so it does not have the benefit of examining changes over time and concluding with confidence whether outlet density changes preceded changes in violence or vice versa. The observations made here arise from statistical associations but nevertheless show evidence for a substantial link between the two. Moreover, to an extent, the results of this study will reflect the cultural drinking practices and liquor licensing regime in Western Australia. For instance, it has been suggested that lingering and socialising outside of liquor stores where the surrounds are treated ‘as a kind of liquor store “patio”’ ([30], p. 619) potentially involving illegal activity, may partially explain observed links between liquor stores and violence in some communities (e.g. California, see [23]). However, such behaviour is not common in Western Australia and unlikely to act as a potential conduit for violence and illegal activity in the immediate vicinity of liquor stores.

Graham pointed to the ‘need to look closer at the relationship between violence and density of on-premise alcohol outlets to explore whether the relationship is related to the characteristics, and not simply the number, of the outlets’ ([30], p. 620). In keeping with most other studies in this domain, this study distinguished between on- and off-site outlets; however, there may be further variability within these classifications, which differentially influence outcomes (e.g. hotel vs. restaurant; standard vs. extended trading hours; run-down premises with permissive atmosphere vs. quality furnished and well-managed establishments) and this will be investigated in future work.

Several socioeconomic factors were also shown to significantly predict assaults, especially those that occurred at residential settings. Although the effects of off-site outlets remained after controlling for these factors it is possible that interaction effects may also exist. Unfortunately, the sample size (140 LGAs) precluded the reliable testing of interaction terms in this analysis.

Violence and public disorder represent a major focus for maintaining good order in the night-time economy, but there are many other forms of alcohol-related harm, which may be linked to drinking in this context, including road crashes, other non-intentional injuries (e.g. falls, burns), self-harm and even chronic disease (e.g. liver cirrhosis). There is evidence for associations

between outlet density and several of these harms, especially road crashes, and it is plausible the mechanisms that underlie those associations are not the same as for violence. For instance, on-site outlets may influence impaired driver road crashes primarily via availability and blood alcohol content reached rather than amenity, which appears to be an important mechanism for violence.

It is possible that our analyses may have been strengthened by use of smaller or more uniform neighbourhood-sized postcode regions rather than the larger LGAs. However, while spatial autocorrelation was not an issue for LGA regions it would almost certainly have been required to be adjusted for at a postcode level of analysis. The movement of drinkers among these smaller neighbourhoods (i.e. across boarders to out of neighbourhood drinking locations) would also have undermined the validity of population estimates as a proxy measure of actual drinking populations. Our future efforts with these data will test whether smaller postcode regions confer any additional analytical benefits over LGAs when volumes of alcohol sales are known.

Finally, a limitation of this and most studies of this nature is the degree to which residential population accurately reflects the actual drinking population (sometimes referred to as the service population). There is certain to be variation between numbers of residents in an area and the number of 'exposed' people (drinkers and those attending licensed outlets) in an area at any given time. The discrepancy between residents and the exposed population is likely to vary depending on size of the areas under consideration and whether or not it includes an entertainment precinct. To some extent this discrepancy was mitigated in our analyses by the exclusion of the Perth central business district as an outlier and the use of relatively large regions. In our analyses we also treated residential population as a confounder rather than a true exposure variable (most studies do the latter), which we argue is a more conservative approach (supported by post-hoc analyses).

Conclusion

The fundamental mechanisms by which on- and off-site outlets influence levels of violence appear to differ. We conclude that our findings support the notion that the link between on-site outlets and violence may be primarily underpinned by negative amenity effects, while the presence of off-site outlets alters alcohol availability in the surrounding area. Furthermore, we speculate that it is the economic availability of alcohol that is most influenced by liquor stores. Alcohol sales volumes from off-site outlets influence levels of violence, which

occur at both licensed and residential settings. In order to effectively address violence, strategies, interventions and policy need to be more pointedly focused on addressing the sales and marketing functions of off-sale outlets and the considerable role that they play in supporting the link between alcohol and violence. Whether or not the findings presented here accurately reflect the nature of the relationship between outlets and violence in other communities will only be possible to determine when detailed data on alcohol sales become more widely available and accessible to researchers. In the mean time, the judicious approach would be to recognise the potential for substantial and wide-ranging effects of liquor stores on alcohol-related harms, to acknowledge the possibility that their impact may well have been underestimated by both researchers and policy makers and to constructively work towards data collection, which will inform and improve our understanding.

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