Socioeconomic Determinants of Exposure to Alcohol Outlets

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ABSTRACT. Objective: Alcohol outlets tend to be located in lower income areas, exposing lower income populations to excess risks associated with alcohol sales through these establishments. The objective of this study was to test two hypotheses about the etiology of these differential exposures based on theories of the economic geography of retail markets: (a) outlets will locate within or near areas of high alcohol demand, and (b) outlets will be excluded from areas with high land and structure rents. **Method:** Data from the 2010 National Drug Strategy Household Survey were used to develop a surrogate for alcohol demand (i.e., market potential) at two census geographies for the city of Melbourne, Australia. Bayesian conditional autoregressive Poisson models estimated multilevel spatial relationships between counts of bars, restaurants, and off-premise outlets and market potential, income,

and zoning ordinances (Level 1: $n = 8,914$). **Results:** Market potentials were greatest in areas with larger older age, male, English-speaking, high-income populations. Independent of zoning characteristics, greater numbers of outlets appeared in areas with greater market potentials and the immediately surrounding areas. Greater income excluded outlets in local and surrounding areas. **Conclusions:** These findings are consistent with the hypothesis that alcohol outlets are located in areas with high demand and are excluded from high-income areas. These processes appear to take place at relatively small geographic scales, encourage the concentration of outlets in specific low-income areas, and represent a very general economic process likely to take place in communities throughout the world. (*J. Stud. Alcohol Drugs*, 76, 439–446, 2015)

GREATER EXPOSURE TO ALCOHOL OUTLETS in a neighborhood appears to be related to greater alcohol use (Gruenewald, 2011) and related problems such as violent assaults (Gruenewald & Remer, 2006; Livingston, 2008; Mair et al., 2013; Toomey et al., 2012), motor vehicle collisions (McMillan et al., 2007; Ponicki et al., 2013), child abuse and neglect (Freisthler & Weiss, 2008; Freisthler et al., 2007), and intimate partner violence (Cunradi et al., 2012; Livingston, 2011). Alcohol outlets also tend to be concentrated in lower income areas (Gorman & Speer, 1997; Hay et al., 2009; Pearce et al., 2008; Romley et al., 2007), presumably exposing lower income populations to increased risks related to having these retail establishments in their neighborhoods. In this study, we considered some of the social and economic processes by which excess exposure to alcohol outlets in lower income populations might arise.

One explanation for the tendency of outlets to concentrate in low-income areas would be that these are locations with greater demand; alcohol outlets would open in areas with greatest demand to minimize travel costs to consumers and maximize profits. However, it is clear that alcohol consumption is lower in neighborhoods with lower incomes (Pollack et al., 2005), so the greater concentration of out-

lets in these areas would not appear to be explained by this simple supply–demand relationship. Economic theories of the geography of retail outlets suggest that alternate causal mechanisms may explain the distribution of alcohol outlets across neighborhood areas within communities. Retail businesses choose locations that maximize market share by locating near customers with high demand while minimizing operating costs (Aoyama et al., 2011; Hanson, 2005; Harris, 1954). Because total alcohol consumption (reflecting demand) is greater in neighborhoods with greater population and income, alcohol outlets will be more likely to open in or near these areas. However, locating in neighborhoods with high incomes may also raise business costs, as these areas will have higher land and structure rents and may also have greater ability to exclude businesses associated with public nuisance and health problems (DiPasquale & Wheaton, 1992; Skogan, 1990). Furthermore, wholesale transportation costs may be minimized by locating close to similar businesses (agglomeration), and competition (Hotelling, 1929) and zoning effects may also lead to clustering.

Using data from the city of Melbourne, Australia, we investigated the specific hypotheses that greater concentrations of alcohol outlets will be found in areas that have greater demand for alcohol, have lower income (and therefore lower land and structure rents), and are adjacent to areas with higher income populations (with greater demand, a spatial lag effect). Because a direct measure of the demand for alcohol was not available, we developed survey-based estimates of the “market potential” for alcohol sales using Australian national data and then applied these to estimate demand across areas of Melbourne, a common method applied in market

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analyses and location planning (see Aoyama et al., 2011; Hanson, 2005; Harris, 1954). This approach allowed us to distinguish the hypothesized attractive effects of increased incomes (through greater market potentials for alcohol sales) from the essentially repellant effect of increased incomes related to greater land and structure rents. Importantly, the scale at which these dynamics operate and the appropriate spatial resolution at which to investigate their effects is unclear (Flowerdew et al., 2008); therefore, we conducted our analyses using two census geographies.

Method

We conducted this study in stages. First, we used person-level data from a national epidemiological survey to estimate per capita annual ethanol consumption according to demographic characteristics. Second, we used census data to approximate the market potential for alcohol within geographic units in Melbourne. Last, we investigated the location of alcohol outlets within these units according to market potential, income, and relevant zoning ordinances. This study was approved by the Monash University Human Research Ethics Committee.

Data sources

Survey data. We accessed person-level responses to the 2010 National Drug Strategy Household Survey (NDSHS) through the Australian Data Archive (Australian Institute for Health and Welfare, 2011). Residential information was available only to the state level, so we included responses from all Victorian participants.

The dependent variable was an estimate of annual alcohol consumption, computed as drinking occasions per year multiplied by typical drinks per occasion. Categorical data were available for both the frequency (every day, 5–6 days/week, 3–4 days/week, 1–2 days/week, 2–3 days/month, about 1 day/month, less often, and no longer drink) and quantity (20 or more drinks, 16–19 drinks, 13–15 drinks, 11–12 drinks, 9–10 drinks, 7–8 drinks, 5–6 drinks, 3–4 drinks, 2 drinks, 1 drink, half a drink) of the respondents' typical consumption of Australian standard drinks (10 g pure ethanol). The distribution of both variables was right skewed; therefore, we used the lower bound of the categories for each variable. We then multiplied these numeric quantity and frequency values to produce a minimum estimate of total ethanol consumption (converted to liters/year) for each respondent.

The independent variables were demographic data recorded in the NDSHS that had directly corresponding data in the 2011 census. Available variables were sex (male vs. female), age (30–44 years, 45–59 years, 60–74 years, ≥75 years vs. 15–29 years), education (diploma/degree vs. no diploma/degree), employment (full- or part-time employed, unemployed, current student vs. retired/homemaker/unable to

work), marital status (widowed, separated or divorced, never married vs. married/cohabiting), language spoken at home (English vs. not English), and weekly household income in Australian dollars (\$400–\$1,000, \$1,000–\$2,000, >\$2,000 vs. <\$400). All categorical data were dummy coded.

Spatial unit data. We obtained census 2011 data from the Australian Bureau of Statistics (ABS) at both the Statistical Area 1 (SA1) and Statistical Area 2 (SA2) levels. SA1 regions are the smallest spatial scale for which census data are available and are wholly nested within SA2 regions. Statewide, SA1 regions have a mean population of 401.0 ($SD = 194.3$), and SA2 regions have a mean population of 12,345.8 ($SD = 6,905.3$).

SA2 regions eligible for inclusion had an internal centroid within the ABS Major Cities of Australia region of Melbourne. The Major Cities of Australia are defined using a score for SA1 regions according to the roadway distance to five classes of service center (ABS, 2013b). To create a convex hull, we omitted one noncontiguous SA2 region (Melton West) and included one SA2 region (Morrington) that was wholly surrounded by included regions and the waterfront. In total, there were 256 SA2 regions included in the study. SA1 regions eligible for inclusion ($n = 8,914$) were nested within the selected SA2 regions.

Demographic data extracted from the 2011 census for the included SA1 and SA2 regions were population, sex, age, education, employment status, marital status, language spoken at home, and median household income. Spatially lagged income and estimated demand were calculated as the average median household income and summed market potential (described below) for adjacent regions.

Other sources. Alcohol outlet data from 2011 were obtained from the Victorian Commission for Gambling and Liquor Regulation; 99.7% were geocoded based on street address and number. The dependent variable was a count of alcohol outlets within each census region, categorized according to license type. Bars were defined as all addresses with a General, Late Night (General), or Late Night (On Premises) license; restaurants had a Restaurant and Café license; and off-premise outlets had a Packaged or a Late Night (Packaged) license.

Two administrative units were also included as covariates: retail zones and dry zones. For the former, planning and zoning data were obtained from VicMap, the Victorian State government mapping authority. We calculated the proportion of land area within each census region zoned for business (B1Z, B2Z, B3Z, B4Z, B5Z) or capital city use (CCZ1, CCZ2). Regarding the latter, a local ordinance prohibits on-premise alcohol sales in a 55.1 km² region of the inner eastern suburbs. However, establishment owners can seek a restaurant and café license through a local plebiscite, so that area is not entirely without on-premise licensees. All 328 SA1 and 9 SA2 regions with a centroid inside that boundary were classified as dry zones.

Statistical analysis

Alcohol demand. Using the person-level data, we conducted a censored regression model (Tobin, 1958) predicting estimated total ethanol consumption (liters/year) based on the NDSHS demographic items. The model accounted for left censoring because ethanol consumption must be at least 0 L/year. From the 5,467 Victorian responses to the survey, 1,354 (24.8%) missing only income information received an indicator dummy. The 502 responses with other missing data were deleted list-wise, leaving 4,965 (90.8%) cases.

The market potential for alcohol was estimated using the method by which we have previously investigated Californian marijuana markets (Morrison et al., 2014). The coefficients from the censored regression model were multiplied by the proportion of the population within each census region with that characteristic. The sum of these demographic-specific estimates and the intercept from the Tobit model provided the estimated annual per capita ethanol consumption (liters/year) for current drinkers within each region. The proportion with predicted consumption greater than zero liters per year was interpreted as a region-specific estimate of the proportion of the population who were current drinkers. The product of this proportion, the region population, and the estimated ethanol consumption for drinkers provided the region-level estimate of total ethanol consumption (i.e., the market potential).

Spatial models. We constructed Bayesian conditional autoregressive (CAR) Poisson models relating counts of alcohol outlets to market potential and relevant covariates. Spatial autocorrelation of model residuals is common in geographically aggregated data and has the potential to violate the assumption of unit independence in standard regression models (Griffith, 1987). Models included a CAR random effect that controls for similarity between adjacent spatial units (Waller & Gotway, 2004) as well as overdispersion of the count data (Lord et al., 2005). We also included a nonspatial random effect to estimate residual variation. We used the mean number of outlets per spatial unit as the expectancies for the Poisson models.

Multilevel models estimated local counts of bars (Model 1), restaurants (Model 2), and off-premise outlets (Model 3) in SA1 units nested within SA2 units, with random effects for SA2 units. Independent variables were the local and lagged market potential within SA1 units, local and lagged SA1 income, dry and retail zoning, and SA2 market potential and income. The spatial units are not of uniform size, so all models also controlled for land area (logged km²) (Hilbe, 2011). We specified uninformed priors for all random effects and allowed a Markov Chain Monte Carlo burn-in of 300,000 iterations before sampling 50,000 iterations to provide a 95% credible interval (which can be interpreted similarly to a confidence interval from a regular

regression model). Two chains initialized with different starting values had converged in all three models before sampling.

Last, we conducted sensitivity analyses using single-level models estimating local counts of bars, restaurants, and off-premise outlets according to local and lagged market potential, income, and zoning characteristics within SA1 and SA2 units. The censored regression models and geo-processing were performed using STATA Version 10.1 (StataCorp LP, College Station, TX) and ArcGIS Version 10.1 (Environmental Systems Research Institute, 2011) respectively. The Bayesian models were estimated using WinBUGS Version 4.3.1 (Lunn et al., 2000).

Results

Mean annual ethanol consumption was 3.3 L ($SD = 6.0$) for the 4,965 Victorian respondents to the 2011 NDSHS who had no missing data (apart from income). Results of the censored regression model predicting this person-level estimate are shown in Table 1. Relative to the comparison respondents (i.e., females, ages 15–29, no degree/diploma, retired/homemaker/unable to work, married, English not spoken at home, and income <\$400 week), significant predictors of increased consumption were being male, age 60–74, separated/divorced or never married, speaking English at home, and having income greater than \$1,000 per week. Being a current student was associated with lower alcohol consumption. A low McFadden pseudo- R^2 (.018) indicated that the model explained very little of the observed variance in alcohol consumption per person.

Descriptive statistics for the spatial units are presented in Table 2. The 8,914 SA1 regions had a mean land area of 0.5 km² ($SD = 2.2$), a population of 415.1 ($SD = 207.1$), and mean aggregated alcohol consumption of 1,371.1 L ($SD = 693.7$) per year. The 256 SA2 regions had a mean area of 15.5 km² ($SD = 27.0$), population of 14,452.2 ($SD = 6,736.5$), and estimated alcohol consumption of 47,742.3 L ($SD = 23,022.6$) per year. On average, there were 0.1 ($SD = 0.9$) bars, 0.3 ($SD = 1.5$) restaurants, and 0.1 ($SD = 0.5$) off-premise outlets per SA1 region.

Table 3 presents the results of the multilevel Bayesian Poisson models. Model 1, predicting the count of bars, did not detect a relationship for local market potential, but a 1,000 L per year increase in lagged market potential was associated with a 1.3-fold increase in bars (incidence rate ratio [IRR] = 1.33; 95% CI [1.08, 1.64]). A \$10,000 increase in median household income was marginally associated with fewer bars, although the credible interval included the possibility of no relationship (IRR = 0.97; 95% CI [0.94, 1.00]). A \$10,000 increase in lagged median household income was associated with 10% fewer bars (IRR = 0.90; 95% CI [0.84, 0.97]). Dry zones had fewer bars, and retail zones had more bars. There was no evidence of an association between the

TABLE 1. Censored regression model for estimated ethanol consumption (liters/year) according to demographic characteristics ($n = 4,957$)

Variable	<i>b</i>	<i>SE</i>	[95% CI]
Age, in years			
15–29 (ref.)	1.000		
30–44	0.322	0.334	[-0.334, 0.977]
45–59	0.529	0.349	[-0.156, 1.214]
60–74	0.883	0.390	[0.119, 1.647]
≥75	-0.231	0.519	[-1.248, 0.787]
Sex			
Female (ref.)	1.000		
Male	2.805	0.201	[2.411, 3.198]
Education			
No degree/diploma (ref.)	1.000		
Degree/diploma	0.302	0.206	[-0.102, 0.705]
Employment status			
Employed	0.095	0.271	[-0.436, 0.626]
Unemployed	-0.328	0.553	[-1.412, 0.757]
Current student	-1.472	0.511	[-2.475, -0.470]
Retired/homemaker/unable to work (ref.)	1.000		
Marital status			
Married (ref.)	1.000		
Widowed	0.096	0.458	[-0.802, 0.994]
Separated/divorced	0.927	0.325	[0.290, 1.563]
Never married	1.505	0.296	[0.924, 2.086]
Language spoken at home			
English	4.638	0.371	[3.911, 5.366]
Not English (ref.)	1.000		
Median household weekly income, Aus. \$			
<\$400 (ref.)	1.000		
\$400–\$1,000	0.633	0.398	[-0.148, 1.413]
\$1,000–\$2,000	1.468	0.415	[0.654, 2.283]
>\$2,000	1.655	0.445	[0.782, 2.527]
Missing	0.047	0.383	[-0.705, 0.798]
Constant	-5.064	0.599	[-6.238, -3.890]
Sigma	6.524	0.073	[6.380, 6.668]
Model pseudo R^2	0.018		
Model χ^2 (17 <i>df</i>)	505.540		

Notes: **Bolded** estimates have $p < .05$. Ref. = reference; Aus. \$ = Australian dollars.

number of bars in SA1 units and the market potential or income of the SA2 level in which they were nested. Models 2 and 3 found similar associations for the number of restaurants and off-premise outlets, except that increased market potential and lower income in local SA1 regions were associated with a greater IRR of restaurants and off-premise licenses, and dry zones were positively associated with more off-premise outlets.

We used the posteriors from the spatial random effects to calculate global Moran coefficients for all three license types. Coefficients in all three models indicate this CAR term was highly spatially auto-correlated ($I \geq 0.819$), violating the standard assumption of unit independence and suggesting a high likelihood of type I errors in uncorrected analyses. The single-level SA1 models (not shown) had very similar results to the SA1 level estimates in the multilevel models. However, unlike the multilevel models, the single-level SA2 models supported a positive relationship between all outlets and local market potential and a negative relationship between bars and off-premise outlets and greater income.

Discussion

Our data are consistent with theory that explains excess exposure of low-income groups to risk associated with alcohol outlets as a product of the geographical economic dynamics of retail markets. Supporting the hypothesis that local supply will be related to demand, we found a relationship between estimated alcohol consumption and the number of outlets in an area. Supporting the hypothesis that outlets will be excluded from high-income areas (by high land and structure rents as well as resistance from local residents), we found that alcohol outlets are more abundant in areas with lower income. These observations combine to suggest that residents of lower income areas are exposed to risk related to the presence of alcohol outlets that service demand from surrounding areas.

The observed negative relationships for income suggest that wealthier populations exclude outlets up to at least the neighboring SA1 units. Our use of a market potential estimate effectively absorbed the hypothesized attractive effect of higher income (because of increased consumption),

TABLE 2. Characteristics of census SA1 and SA2 regions

Variable	SA1 (<i>n</i> = 8,914) <i>M</i> (<i>SD</i>)	SA2 (<i>n</i> = 256) <i>M</i> (<i>SD</i>)
Area, km ²	0.45 (2.18)	15.53 (26.99)
Population	415.12 (207.13)	14,452.23 (6,736.51)
Age, in years		
Median	37.12 (8.40)	36.96 (5.06)
Sex (%)		
Male	49.31 (5.19)	49.19 (1.32)
Education (%)		
Tertiary	42.65 (11.57)	43.21 (10.02)
Employment status (%)		
Employed	48.23 (9.93)	48.81 (7.25)
Unemployed	2.77 (2.16)	2.8 (1.04)
Current student	12.19 (5.59)	12.61 (5.36)
Marital status (%)		
Married/de facto	52.16 (10.72)	52.16 (8.36)
Widowed	5.21 (4.86)	5.06 (1.86)
Separated/divorced	10.22 (5.27)	9.95 (2.64)
Never married	35.53 (11.11)	36.44 (10.66)
Language spoken at home (%)		
English	65.58 (20.41)	65.72 (18.02)
Annual median household income, Aus. \$		
Local	73,042.10 (27,236.52)	71,730.03 (19,798.55)
Adjacent	72,256.88 (20,155.59)	71,444.93 (12,169.28)
Market potential		
Total liters ethanol/year	1,371.11 (693.70)	47,742.31 (23,022.56)
Retail zone (%)	3.08 (10.62)	3.88 (7.67)
Alcohol outlets		
Bars	0.14 (0.89)	4.71 (18.49)
Restaurants	0.30 (1.48)	10.57 (26.86)
Off-premise	0.13 (0.46)	4.66 (3.69)

Notes: SA1 = Statistical Area 1; SA2 = Statistical Area 2; Aus. \$ = Australian dollars.

allowing for a cleaner interpretation of the local and lagged income variables than if we had used only resident population to represent demand. To further clarify this finding, we used the posterior estimates from Model 3 to estimate the

combined effect of local and lagged income on the IRR for counts of off-premise outlets within individual SA1 areas. Figure 1 demonstrates that outlets (Figure 1.1) are generally aligned with market potential (Figure 1.2); however,

TABLE 3. Multilevel Bayesian conditionally autoregressive Poisson models for alcohol outlets in 8,914 SA1 nested within 256 SA2 regions

Variable	Model 1: Bars		Model 2: Restaurants		Model 3: Off-premise	
	IRR	[95% CI]	IRR	[95% CI]	IRR	[95% CI]
SA1 level						
Area, logged km ²						
Local	1.980	[1.765, 2.222]	1.548	[1.377, 1.740]	1.150	[1.046, 1.261]
Market potential, ×1,000 L/year						
Local	1.067	[0.959, 1.175]	1.166	[1.048, 1.287]	1.131	[1.034, 1.230]
Lagged	1.329	[1.075, 1.640]	1.653	[1.316, 2.075]	1.768	[1.455, 2.135]
Household income, ×\$10,000/year						
Local	0.971	[0.939, 1.004]	0.944	[0.914, 0.975]	0.927	[0.896, 0.958]
Lagged	0.900	[0.836, 0.970]	0.894	[0.834, 0.963]	0.919	[0.864, 0.979]
Zoning						
Dry	0.124	[0.016, 0.535]	0.365	[0.151, 0.870]	1.625	[1.008, 2.602]
Retail	1.042	[1.037, 1.047]	1.074	[1.068, 1.080]	1.049	[1.044, 1.054]
SA2 level						
Market potential (×1,000 L/year)	1.411	[0.802, 2.549]	0.778	[0.432, 1.401]	0.855	[0.573, 1.261]
Household income local (×Aus. \$10,000/year)	1.006	[0.927, 1.096]	1.075	[0.976, 1.180]	1.044	[0.973, 1.119]
Global Moran's <i>I</i> of spatial random effect	0.894		0.819		0.923	

Notes: β intercept suppressed from table. **Bolded** IRRs denote a 95% credible interval that does not include 1.00, thereby indicating support of a significant association between the corresponding independent variable and the count of alcohol outlets. SA1 = Statistical Area 1; SA2 = Statistical Area 2; IRR = incidence rate ratio; CI = confidence interval; Aus. \$ = Australian dollars.

FIGURE 1. Density of off-premise outlets (Figure 1.1), market potential per km² (1.2), and the contribution of local and lagged income to the incidence rate ratio for exposure to off-premise outlets (1.3) within SA1 regions of inner eastern Melbourne.

lower local and lagged income among areas of the north and southeast contribute to greater exposure to outlets for those residents (Figure 1.3).

The multilevel models (Table 3) showed that market potential was related to bar density in lagged but not local SA1 units. The guiding theory from economic geography explains this finding. Where populations are mobile and travel costs are low, outlets will respond to increased demand over large areas (Aoyama et al., 2011), but local increases in demand may not be sufficient to support greater supply in a neighborhood. Importantly, the relationship between market potential and bars, restaurants, and off-premise outlets within SA1 areas did not extend to the SA2 level. This suggests, on average, that consumers travel to outlets in at least the 4.2 km² area around their residences (i.e., the SA1 area plus the lagged SA1 area) with sufficient frequency to support greater supply, but not as far as the 15.5 km² SA2 area. This geographic bounding is counter to observations from urban economics that people tend to use resources in the space available to them (O'Sullivan, 2007). Future analyses will examine these dynamics within multiple cities, allowing assessment of the extent to which residents may travel over entire metropolitan areas to access outlets, rather than just the census units we investigated here.

Bars were related to market potential differently compared with restaurants and off-premise outlets. This finding is also consistent with the motivating theory. Off-premise outlets sell roughly equivalent products for similar prices,

limiting the extent to which consumers will prefer one outlet over another (Treno et al., 2000). The primary concern is therefore convenience, leading to the geographic distribution of outlets over the city that generally corresponds to market potential, constrained to retail zones and subject to local agglomerative processes (Figure 1). By comparison, individual bars offer vastly different products from one another. Consumers are willing to trade convenience for amenity value in order to access particular outlets (Treno et al., 2000). Agglomerated within entertainment districts, bars tend to be related to alcohol demand over larger rather than smaller areas. Relationships between restaurants and market potential appear more similar to off-premise outlets than bars. The relative abundance of restaurants may enable consumers to prioritize convenience.

Our finding that low income was not associated with outlet location in the SA2 level is at odds with prior studies conducted using similarly sized or larger spatial units (Berke et al., 2010; Duncan et al., 2002; Gorman & Speer, 1997; Hay et al., 2009; LaVeist & Wallace, Jr., 2000; Pearce et al., 2008; Romley et al., 2007). Comparing our single-level sensitivity analyses with our multilevel models helps explain this difference. Our single-level SA2 models found a relationship between market potential and outlet density; however, in the multilevel models, no additional information for predicting the density of outlets in SA1 units was found at the SA2 level. This suggests that our single-level SA2 models are subject to aggregation bias.

The mutually correcting processes of supply and demand do not act over a uniform geographic extent and are not confined within arbitrary administrative boundaries such as census areas. Using larger spatial units leads to more averaging, combining the positive local and/or lagged effects with dispersed neutral effects. Smaller spatial units are therefore a more appropriate scale at which to study these relationships than larger areas. Our results also differed slightly from another study in metropolitan Melbourne, which used the smallest units from the 2006 census (similar to SA1 regions), finding that lower socioeconomic status areas had more off-premise outlets but fewer bars and restaurants (Livingston, 2012). We found evidence of substantial autocorrelation of the spatially structured heterogeneity, but neither that study nor the other prior studies controlled for its effects. Had we not done so, there was a high likelihood that we would have erroneously detected spatial relationships.

Our study was limited by our use of market potential as a proxy for demand, rather than aggregated real alcohol consumption. Quantity–frequency estimates typically underestimate per-person consumption (Midanik, 1982; Rehm, 1998), and our estimate accounts for only 32.8% of per capita alcohol compared with sales by ethanol volume (ABS, 2013a). Alternative constructions (e.g., graduated-frequency estimates) did not improve estimates. In addition, using a cross-sectional design to test hypotheses related to market dynamics requires an assumption of equilibrium, potentially introducing endogeneity between the indicators of demand and supply. A time-series analyses would enable observation of the extent to which changes in outlet density precede changes in per capita alcohol consumption, and to which changes in overall consumption (i.e., because of population density and per capita consumption) precede changes in outlet density. The underlying theory suggests that both processes occur simultaneously.

This study demonstrates that the spatial distribution of alcohol outlets in one urban area is consistent with predictions from economic geography regarding the shaping of retail markets and that smaller spatial units (in this case containing approximately 400 residents) are more appropriate for identifying these relationships than larger spatial units. Unimpeded, these dynamic processes contribute to the development and perpetuation of pockets of disadvantage in which lower income people are disproportionately exposed to risk related to the presence of alcohol outlets. That we found fewer on-premise outlets and more off-premise outlets in dry zones demonstrates the power of such regulatory mechanisms to shape alcohol markets. Similar policy approaches, such as establishing alcohol-free zones, introducing density limits, or capping current outlet counts within areas of urban growth, may be effective strategies to reduce income-related health disparities attributable to differential exposure to alcohol outlets.

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