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RESEARCH REPORT

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The relationship between alcohol outlets and crime is not an artefact of retail geography

Michael P. Cameron[1,2]

[1]School of Accounting, Finance and Economics, University of Waikato, Hamilton

[2]Te Ngira—Institute for Population Research, University of Waikato, Hamilton

Correspondence
Michael P. Cameron, School of Accounting, Finance and Economics, University of Waikato, Private Bag 3105, Hamilton, 3240, New Zealand.
Email: mcam@waikato.ac.nz

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Abstract

Background and Aims: In previous research, the spatial distribution of alcohol outlets has been shown to be related to the spatial distribution of crime. However, the spatial distribution of alcohol outlets is also related to the spatial distribution of other retail (and non-retail) activities. We measured whether a residual relationship between alcohol outlets and crime remains statistically significant after controlling for retail density.

Design and setting: A cross-sectional analysis of area unit data for Hamilton, New Zealand.

Measurements: We constructed index measures of retail density using principal component analysis, based on counts of retail outlets (non-alcohol outlets alone and all outlets in total). We estimated the relationship between outlets and police calls-for-service using negative binomial regression, controlling for social deprivation, population and demographics. In our primary analysis, we employed a two-stage process that first accounted for the correlation between calls-for-service and retail density in a negative binomial regression model, then tested for correlation between alcohol outlet counts and the first-stage residuals.

Findings: The spatial distributions of retail outlets of all types were highly correlated with each other, and all types of retail outlets (alcohol and non-alcohol) were correlated with crime, after controlling for social deprivation, population and demographics. After controlling for index measures of retail density and other controls, statistically significant semipartial correlations remained with counts of alcohol outlets of all types. For example, in our preferred specification, which controlled for non-alcohol retail density in the first stage, an additional off-licence alcohol outlet was associated with 97.34 (95% confidence interval = 36.66–158.0) additional police calls-for service.

Conclusions: There is a positive relationship between the spatial distribution of alcohol outlets and the spatial distribution of crime that appears to persist even after controlling for non-alcohol retail density. The relationship between alcohol outlets and crime is not simply an artefact of retail geography.

KEYWORDS
Alcohol outlets, crime, density, New Zealand, retail density, retail geography

INTRODUCTION

A large and growing research literature has developed, linking alcohol outlets with crime (including violent crime, domestic violence, and property crime) and alcohol-related harm more generally (for systematic reviews, see [1–3]). However, despite this extensive literature, a generalized and consistent relationship linking alcohol outlets with various measures of harm remains elusive. Results and conclusions vary across (and sometimes within) studies, leading some to conclude that the relationships may be context-sensitive [4–7], or that the focus on alcohol outlets may be misplaced [2].

Part of the issue with interpreting the multiplicity of results is a variety of competing (and sometimes complementary) theories. Availability theory [8, 9] posits that greater availability of alcohol (either spatially or temporally) reduces the 'full cost' of alcohol and leads to increased alcohol consumption which, in turn, leads to more alcohol-related harm. This theory can be applied to both off-licence (take-away) outlets and on-licence outlets such as bars or restaurants. In contrast, niche theory/assortative drinking [10] asserts that increased density of on-licence outlets leads to greater market segmentation, with some outlets catering to patrons who are more predisposed to creating alcohol-related harms. Under routine activity theory [11, 12], crime occurs as a routine activity when motivated offenders interact with potential victims in the absence of suitable guardians. Alcohol may act as a 'chemical facilitator', reducing inhibitions of offenders or impairing potential victims [13]. The co-location of outlets, such as in entertainment precincts with good transport links, may encourage drinkers to drink more [14], but will also co-locate a greater number of motivated offenders and potential victims, increasing the potential for alcohol-related harm even if alcohol consumption is not affected. This is related to the theory of amenity effects [15], wherein alcohol outlets change the nature of the surrounding area which affects the spatial location of alcohol-related harms. Alternatively, the businesses in the area around an alcohol outlet might put pressure on the alcohol outlet and its business practices, reducing alcohol-related harm [16]. Finally, crime potential theory (or crime pattern theory) [17, 18] explains the spatial distribution of crime by reference to crime generators (places that attract large numbers of people) and crime attractors (places that are attractive to motivated offenders, having attractive crime targets or many impaired potential victims).

The spatial pattern of alcohol outlets is, in all cases, not random. The location of alcohol outlets is restricted by zoning regulations [19], the availability of suitable premises (or land for development), the pattern of roadways [20], public transport links and available car-parking and the distribution of resident and ambient populations [21], among other factors. The non-random spatial distribution of alcohol outlets, and the similarly non-random spatial distribution of other retail outlets, creates a potential problem for studies attempting to estimate the relationship between alcohol outlets and measures of alcohol-related harm. This is because the spatial distribution of alcohol outlets is correlated with the spatial distribution of retail outlets of other types [22], as well as correlated with the spatial distribution of other land uses [7]. Various land uses have been shown to be correlated with measures of harm, including abandoned buildings [23], public parks [24, 25], commercial businesses [26], motels and hotels [27], industrial areas [24], payday lenders [28] and fast-food restaurants [29] (see also [30] for a review of land use and violent crime). If other land uses are correlated with alcohol-related harm (however measured), and these other land uses are not included in the empirical model, an omitted variable bias will arise. If excluded land uses are positively (negatively) correlated with alcohol-related harm, then the measured relationship between alcohol outlets and harm will be biased upwards (downwards).

Despite this concern, to date few studies of alcohol outlets and harm have explicitly included measures of other land uses or tested for bias from omitting these measures [31–33]. In particular, the effect of including retail density (variously measured) on the statistical significance of alcohol outlet density as a correlate of harms has rarely been explicitly tested. However, a number of studies have included measures of retail density as control variables [7, 16, 33], but with little consistency in terms of the statistical significance of these measures.

A common issue for most studies that include both the number or density of alcohol outlets, and the number or density of retail outlets of other types, is multicollinearity. This may explain the inconsistent findings of statistical significance in the studies outlined above. Alternative measures of retail density could be used that might be less correlated with the number of alcohol outlets, and some studies have adopted this approach [34–36]. In this study, we adopt an alternative approach to controlling for retail density, both in terms of its measurement and of the structure of the statistical model, and apply this to cross-sectional data from Hamilton, New Zealand. We hypothesize that a statistically significant residual relationship between alcohol outlets and crime will persist after controlling for retail density.

METHODS

Setting

Our analysis is based on cross-sectional data for Hamilton, New Zealand (population 153 200) for the first quarter of 2014. Hamilton was chosen for convenience (proximity to the researcher's institution) and to limit fieldwork costs. Hamilton consists of 46 area units (non-administrative areas similar in size to a suburb), which are our unit of analysis, with an average estimated resident population of 3311 (range = 157–8403).

Procedure

Data on the location of alcohol outlets were derived from a list of current alcohol licences from the Ministry of Justice. Because the address field in the data set was incomplete or sometimes incorrect the outlets were manually geocoded to the area unit level, as described in Cameron *et al*. [4]. The manual geocoding process achieved a 100%

geocoding success rate, after which duplicate outlets were identified and removed. Following previous research [4], catering licences, auctioneers, mail order companies and conveyances were excluded, as were vineyards, hospitals, gift stores and florists. Outlet counts for each area unit were then derived for four types of outlet: (1) licensed clubs (e.g. sports clubs, working-men's clubs, etc.); (2) bars and night clubs; (3) other on-licensed outlets (e.g. restaurants and cafés, function centres, etc.); and (4) off-licensed outlets (e.g. bottle stores, grocery stores, supermarkets, etc.). Analysis at the national level has previously established that off-licence outlets of all types have similar effects [4], so we did not disaggregate those outlets further.

We manually located and geocoded retail outlets of four other types: (1) bakeries and lunch bars; (2) hairdressers and salons; (3) service stations; and (4) take-away food outlets. These retail outlet types were selected because, other than being representative of the general retail geography of the city, they are unlikely to have a meaningful theoretical relationship with crime (although see [29]). The manual location process was conducted by first consulting Hamilton City Council planning maps and identifying every location categorized as a commercial business zone (because of zoning restrictions, no retail activities of the five types are located outside these zones). Each commercial zone was then physically visited by the researcher or a research assistant. On the visit, each street segment was viewed and retail outlets of the five types were noted. As with alcohol outlets, these five outlet types were geolocated to the area unit level and summarized by counts.

Using the data on counts of outlets (alcohol and general retail), we constructed two alternative measures of retail density. First, we used principal components analysis (PCA) using data on the counts of outlets of all eight outlet types (four alcohol outlet types and four non-alcohol retail outlet types) to create an index of retail density at the area unit level (the PCA results are included in the Supporting information, Table S1). The first principal component had an eigenvalue of 6.17 and explains 77.2% of the covariance, and the Kaiser–Meyer–Olkin measure of sampling adequacy confirmed that sampling was adequate (KMO = 0.88). We took predicted values from the first principal component as our index of retail density. We then repeated the exercise, excluding the four alcohol outlet types. In this case, the first principal component had an eigenvalue of 3.27 and explained 81.8% of the covariance, and the Kaiser–Meyer–Olkin measure of sampling adequacy again confirms that sampling is adequate (KMO = 0.74).

Data on police calls-for-service were obtained from the New Zealand Police Communications and Resource Deployment (CARD) database. The data set was cleaned to remove duplicate events or occurrences and then restricted to events that were coded to specific offences, broken down into seven categories: (1) antisocial behaviour offences; (2) dishonesty offences; (3) drug and alcohol offences; (4) property abuses; (5) property damage; (6) sexual offences; and (7) violent offences. The data were geocoded to the area unit level using an automated process in ArcGIS, then summarized by counts. The analysis was not pre-registered, so the results should be considered exploratory.

Analysis

The purpose of the analysis is not to determine an 'optimal' model specification, nor to precisely estimate the marginal effect of an additional outlet of a particular type. Instead, we seek to determine whether there remains some residual explanatory power of alcohol outlets on police calls-for-service, after controlling for retail density in a cross-sectional analysis. In other words, we test the discriminant validity of alcohol outlets in explaining crime, over and above the effect of retail density more generally. This approach relies upon the identifying assumption that there is some variation in alcohol outlets that is not wholly explained by retail density. This assumption is probably valid, because alcohol outlet locations are determined by licensing decisions made by the local authority, and not simply by the retail geography of the city.

We use negative binomial regression as our primary regression specification, as the dependent variable (calls-for-service) is count data. As robustness checks, we also run Poisson regression models and ordinary least squares (OLS) linear regression. In all models we find qualitatively similar results, so we only report the negative binomial regression results (other results are available on request from the author). The data are also spatially explicit, so we expect significant spatial autocorrelation. However, somewhat surprisingly, Moran's I tests confirm no statistically significant spatial interactions in any of our regression models. We therefore do not make any adjustment for spatially correlated errors.

Our models focus upon two dependent variables that are the most commonly used in the extant literature: (1) total police calls-for-service; and (2) police calls-for-service for violent offences. The key explanatory variables are counts of retail outlets (by type). Each model also controls for the estimated resident population of the area unit as an exposure variable [37], the proportion of the population that is male and aged 15–24 years, the proportion of the population who are Māori (the indigenous ethnic group in New Zealand) and the New Zealand Deprivation Index (NZDep13; a commonly used index of small area socio-economic deprivation) [38, 39]. Summary statistics for all of the variables used in the analysis are included in the Supporting information, Table S2.

For each dependent variable, we first confirm that many of the types of retail outlets are significantly correlated with police calls-for-service, while controlling for population, demographics, and social deprivation. We do this by including the counts of each outlet type in separate regression models. We then move to our main analysis, which aims to confirm that alcohol outlets are correlated with police calls-for-service even after controlling for retail density and other control variables. A key problem here is that the counts of retail outlets are highly correlated, leading to problems of multicollinearity, as noted in the introduction section. We avoid the multicollinearity problem in two ways. First, we run each model (total police calls-for-service, and police calls-for-service for violent offences) with the overall retail density index measure and control variables as explanatory variables, and extract the residuals from the model. We then use the residuals as the dependent variable in second stage models, with the count of each

type of alcohol outlet as the sole explanatory variable. This semipartial correlation analysis will reveal whether alcohol outlets (by type) are independently correlated with police calls-for-service, over and above any effects of retail density and other controls. Because the residuals from the first stage are no longer expressed as counts, we use OLS regression in the second stage. We do not include all alcohol outlet counts in a single second stage model because of the likelihood of multicollinearity issues between these outlet variables, which would prevent us from identifying statistically significant semipartial correlations.

RESULTS

Table 1 presents the correlation matrix for the counts of alcohol outlets (by type) and non-alcohol retail outlets. All the correlations are highly statistically significant and positive, demonstrating the high potential for multicollinearity problems when counts of many different outlet types are included in the same regression model. Of particular note, off-licence alcohol outlets, hairdressers and service stations all have correlations of 0.6 or higher with every other retail outlet type. In contrast, bakeries have correlations less than 0.5 with licensed clubs, bars and night clubs and other on-licensed alcohol outlets.

Table 2 presents the incidence-rate ratios from negative binomial regression models, where each model includes the count of one of the outlet types as an explanatory variable (in addition to the control variables). Table 2, panel A presents the results with total police calls-for-service as the dependent variable. Population and social deprivation are consistently statistically significant, with coefficients in the expected direction, but the demographic control variables are less precisely estimated and only the proportion of Māori is statistically significant). All retail outlet variables (both alcohol outlets and non-alcohol outlets) are statistically significant in their individual models. The largest incidence-rate ratios are for service stations, off-licence alcohol outlets and bakeries. Table 2, panel B presents the results with police calls-for-service for violent offences as the dependent variable. The results are largely similar, with service stations having the largest incidence-rate ratio.

Table 3 presents the results of the second-stage analysis for each alcohol outlet type, after controlling for retail outlet density and other controls. There are two sets of columns. The first set of columns shows our preferred results, using as a dependent variable the residuals of first-stage models of non-alcohol retail density and control variables. The second set of columns shows the results from similar models as a robustness check, except that the measure of retail density is based on all retail outlets (including both alcohol outlets and non-alcohol outlets). Again, Table 2, panel A presents the results for total police calls-for-service, and panel B presents the results for police calls-for-service for violent offences. In all first-stage models, the retail index variables (as well as social deprivation and population) were statistically significant and in the expected direction (see Supporting information, Table S3). In every second stage regression, the count of alcohol outlets is statistically significant and positively correlated with the residual from the first stage. That is, over and above the effect of retail density and other controls, the count of alcohol outlets (of each type) is correlated with police calls-for-service. This is apparent for both total calls-for-service and calls-for-service for violent offences.

DISCUSSION

The spatial pattern of retail activity is not random. Retail outlets are generally restricted to areas that are specifically zoned for commercial activities. That gives rise to multicollinearity between the spatial distribution of alcohol outlets and the spatial distribution of other retail outlets, which may be problematic for studies of the relationship between alcohol outlets and measures of harm. The statistically significant correlations in Table 1 support the view that multicollinearity may be an issue. Our results demonstrate that, in our context of Hamilton City in New Zealand, alcohol outlets and non-alcohol retail outlets tend to be co-located, and the counts of these outlets are highly correlated. High correlations are not just apparent within the alcohol and non-alcohol retail segments, but across the retail segments as well. It is unlikely that this result is a specific feature of the retail geography of Hamilton City—this is more probably a general feature of the retail geography of all cities.

The retail geography of an area might be a key contributor to the total amount of crime and its spatial distribution. Both routine activity theory and crime potential theory do not pre-suppose that the spatial

TABLE 1 Correlation matrix

Outlet counts	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
Licensed clubs (A)	1.000							
Bars and night clubs (B)	0.8675	1.000						
Other on-licences (C)	0.8732	0.9950	1.000					
Off-licences (D)	0.6637	0.7753	0.7653	1.000				
Bakeries (E)	0.3425	0.4892	0.4722	0.7566	1.000			
Hairdressers (F)	0.8110	0.9214	0.9196	0.8392	0.6105	1.000		
Service stations (G)	0.6028	0.6763	0.6667	0.7584	0.7778	0.7126	1.000	
Take-away food outlets (H)	0.5415	0.6978	0.6829	0.9156	0.8681	0.7828	0.7851	1.000

TABLE 2 Negative binomial regression results

Variable	(1)	(2)	(3)	(4)
A: Total calls-for-service				
Licensed clubs	1.223 (1.141–1.310)			
Bars and night clubs		1.061 (1.032–1.091)		
Other on-licences			1.038 (1.022–1.054)	
Off-licences				1.308 (1.216–1.408)
Bakeries				
Hairdressers				
Service stations				
Take-away food outlets				
Social deprivation index	1.013 (1.009–1.018)	1.013 (1.009–1.018)	1.013 (1.009–1.018)	1.010 (1.007–1.018)
Population (000s)	1.284 (1.060–1.556)	1.325 (1.103–1.592)	1.318 (1.094–1.588)	1.317 (1.107–1.566)
Proportion male 15–24 years	0.152 (0.000–64.22)	0.050 (0.000–14.31)	0.061 (0.000–18.04)	1.086 (0.012–97.31)
Population Māori	0.024 (0.002–0.278)	0.029 (0.003–0.276)	0.028 (0.003–0.268)	0.098 (0.017–0.577)
Sample size	46	46	46	46
B: Violence calls-for-service				
Licensed clubs	1.213 (1.147–1.282)			
Bars and night clubs		1.048 (1.042–1.054)		
Other on-licences			1.031 (1.027–1.035)	
Off-licences				1.225 (1.144–1.311)
Bakeries				
Hairdressers				
Service stations				
Take-away food outlets				
Social deprivation index	1.009 (1.005–1.013)	1.009 (1.005–1.013)	1.009 (1.005–1.013)	1.008 (1.004–1.012)
Population (000 s)	1.310 (1.167–1.469)	1.332 (1.181–1.502)	1.326 (1.175–1.498)	1.293 (1.132–1.476)
Proportion male 15–24 years	0.745 (0.023–24.38)	0.243 (0.008–7.232)	0.283 (0.010–8.133)	1.309 (0.041–42.30)
Population Māori	0.489 (0.058–4.104)	0.473 (0.065–3.426)	0.505 (0.068–3.768)	0.696 (0.079–6.126)
Sample size	46	46	46	46

Results are reported as incidence-rate ratios, with heteroscedasticity-robust 95% confidence intervals in parentheses.

TABLE 2 (Continued)

Variable	(5)	(6)	(7)	(8)
A: Total calls-for-service				
Licensed clubs				
Bars and night clubs				
Other on-licences				
Off-licences				
Bakeries	1.282 (1.160–1.417)			
Hairdressers		1.161 (1.092–1.234)		
Service stations			1.476 (1.302–1.674)	
Take-away food outlets				1.130 (1.098–1.163)
Social deprivation index	1.009 (1.006–1.012)	1.013 (1.008–1.017)	1.010 (1.007–1.013)	1.009 (1.006–1.012)
Population (000s)	1.415 (1.199–1.670)	1.306 (1.103–1.548)	1.363 (1.121–1.657)	1.308 (1.113–1.538)
Proportion male 15–24 years	1.197 (0.007–200.1)	0.094 (0.000–30.44)	2.585 (0.023–284.8)	0.874 (0.022–34.64)
Population Māori	0.158 (0.030–0.830)	0.035 (0.003–0.400)	0.118 (0.021–0.666)	0.214 (0.033–1.359)
Sample size	46	46	46	46
B: Violence calls-for-service				
Licensed clubs				
Bars and night clubs				
Other on-licences				
Off-licences				
Bakeries	1.191 (1.055–1.344)			
Hairdressers		1.125 (1.107–1.145)		
Service stations			1.325 (1.155–1.521)	
Take-away food outlets				1.096 (1.055–1.138)
Social deprivation index	1.008 (1.004–1.012)	1.009 (1.005–1.012)	1.008 (1.004–1.013)	1.008 (1.003–1.012)
Population (000 s)	1.374 (1.208–1.564)	1.315 (1.173–1.474)	1.324 (1.161–1.511)	1.284 (1.127–1.463)
Proportion male 15–24 years	0.826 (0.001–608.4)	0.366 (0.019–6.986)	3.857 (0.073–203.9)	0.757 (0.011–52.17)
Population Māori	0.566 (0.066–4.883)	0.684 (0.101–4.626)	0.669 (0.075–6.003)	0.155 (0.087–15.39)
Sample size	46	46	46	46

Results are reported as incidence-rate ratios, with heteroscedasticity-robust 95% confidence intervals in parentheses.

distribution of crime is determined only, or predominantly, by the location of alcohol outlets separate from the location of other retail activities. We find support for the general nature of the relationship between retail geography and crime. As shown in Table 2, retail outlets of all types (both alcohol and non-alcohol) are correlated with police calls-for-service, while controlling for social deprivation, resident population and demographics.

These results should give pause to researchers who find a statistically significant relationship between alcohol outlets and crime: is the observed relationship demonstrating a real underlying effect, or is it merely an artefact of the retail geography of the study area? Fortunately, our results provide some comfort in relation to this question. After controlling for retail geography, a statistically significant positive residual cross-sectional relationship between the number of alcohol outlets and police calls-for-service remains. This suggests a robustness to this relationship, and that the observed relationship does not merely arise due to the correlation between the spatial distribution of alcohol outlets and the spatial distribution of retail activity more generally. Moreover, as our results are similar when alcohol outlets are included in the measure of retail density, this indicates that the relationship between alcohol outlets and crime is not occurring only through the mechanism of retail density.

A key implication of our results is not that retail geography can be ignored because the relationships are robust to its inclusion. Quite the contrary—the extant literature on the relationship between crime and alcohol outlets that does not control for retail density may suffer from an omitted variable bias. To the extent that retail activities other than alcohol outlets are positively correlated with measures of crime, the omitted variable bias will lead to a positive bias in the coefficients on alcohol outlets. This would lead to an overestimation of the negative effects of alcohol outlets on crime. Measures of retail density should be included in order to avoid this omitted variable bias (as in many of the studies outlined in the introduction), or at the very least measures of retail density should be tested as to whether they are statistically significant in the analysis (e.g. [40]).

Of course, our analysis is not without limitations. We use cross-sectional data, whereas longitudinal or panel data are preferred and may lead to different results. However, there is no strong theoretical reason why the association between retail density and police calls-for-service, and the residual relationship between alcohol outlets and calls-for-service, should not be apparent in a panel setting. The cross-sectional relationship between alcohol outlets and crime is observed across many studies, as well as in longitudinal studies (e.g. [40]). The apparent context-dependent relationships between alcohol outlets and crime may well be better and more consistently explained if appropriate measures of retail density are included in analyses. We did not test the relative contribution of different alcohol outlet types to crime due to multicollinearity between the counts of alcohol outlets, but further research can explore this issue. We aggregated outlets of the same type together, despite evidence that there may be heterogeneous effects between outlets of the same type (e.g. [41, 42]). We used a retail density index derived from principal

TABLE 3 Second-stage (residual) regression results

	First stage includes non-alcohol retail density index			
Variable	(1)	(2)	(3)	(4)
A: Total calls-for-service				
Licensed clubs	108.7 (61.45–156.0)			
Bars and night clubs		28.73 (27.38–30.09)		
Other on-licences			18.76 (17.90–19.63)	
Off-licences				97.34 (36.66–158.0)
Sample size	46	46	46	46
B: Violence calls-for-service				
Licensed clubs	4.611 (2.916–6.305)			
Bars and night clubs		1.183 (1.051–1.314)		
Other on-licences			0.774 (0.685–0.862)	
Off-licences				4.615 (2.340–6.890)
Sample size	46	46	46	46

Results are reported as linear model coefficients, with heteroscedasticity-robust 95% confidence intervals in parentheses.

TABLE 3 (Continued)

Variable	First stage includes total retail density index (5)	(6)	(7)	(8)
A: Total calls-for-service				
Licensed clubs	284.2 (152.1–416.3)			
Bars and night clubs		74.14 (71.50–76.79)		
Other on-licences			48.54 (46.82–50.26)	
Off-licences				218.9 (23.99–413.9)
Sample size	46	46	46	46
B: Violence calls-for-service				
Licensed clubs	8.111 (5.065–11.16)			
Bars and night clubs		2.042 (1.948–2.137)		
Other on-licences			1.339 (1.271–1.407)	
Off-licences				6.771 (1.954–11.59)
Sample size	46	46	46	46

Results are reported as linear model coefficients, with heteroscedasticity-robust 95% confidence intervals in parentheses.

component analysis. This measure has the advantage of endogenously determining the weighting applied to the counts of retail outlets of different types, such that the proportion of the covariance explained by the index is maximized. Alternative measures of retail density include simple counts of outlets in total, or density measured in terms of customer or traffic flows, total retail sales volume or employment (e.g. [43]). Future research should explore the robustness of the alcohol outlets–crime relationship to alternative measures of retail density.

Our results may also be specific to the particular setting and to the particular timing of the research (first quarter of 2014). Previous research in New Zealand has demonstrated that the relationships between alcohol outlets and police calls-for-service may vary spatially [44], and that crime rates [45] and alcohol consumption [46] both exhibit strong seasonal effects. Further research in different settings and at different times of the year, in addition to incorporating longitudinal data and testing alternative measures, would help to further test the robustness of the relationship between alcohol outlets and crime to the inclusion of measures of retail density. Finally, our results do not imply a causal relationship between retail or alcohol outlets and crime. Nevertheless, our results are useful for more clearly understanding the limitations of the extant literature on the relationship between alcohol outlets and alcohol-related harm, and crime in particular.

CONCLUSIONS

Many studies have identified statistically significant relationships between alcohol outlets and alcohol-related harm. However, the number and spatial distribution of alcohol outlets is not random, and closely related to the number and spatial distribution of retail outlets more generally. We have demonstrated the potential for problems of multicollinearity, and shown that the relationship between the number of alcohol outlets and police calls-for-service is robust to controlling for retail density. We can conclude, therefore, that the relationship between alcohol outlets and crime is not simply an artefact of retail geography.

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AUTHOR CONTRIBUTIONS

Michael P. Cameron: Conceptualization; data curation; formal analysis; methodology.

DECLARATION OF INTERESTS

M.P.C. is a District Licensing Committee member and commissioner in New Zealand, and has acted as an unpaid expert witness for local authorities before the Alcohol Regulatory and Licensing Authority.

ORCID

Michael P. Cameron https://orcid.org/0000-0002-4296-3775

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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