The relationship between alcohol outlets and harm

A spatial panel analysis for New Zealand, 2007-2014

Version 2
January 2017

Cameron, M.P., Cochrane, W., and Livingston, M.
A report commissioned by the Health Promotion Agency

hpa health promotion agency

COMMENTS

The Health Promotion Agency (HPA) commissioned the University of Waikato to undertake this research as part of a HPA alcohol research investment round. The lead researchers involved in the project are Michael Cameron and William Cochrane (Waikato University) and Michael Livingston (La Trobe University).This research examines the relationship between alcohol outlets and social harm measured by Police activity and road traffic crashes. The analysis uses a longitudinal panel data set for the period 2007-2014 covering all of New Zealand.

HPA would like to acknowledge Cathy Bruce and Rhiannon Newcombe for their contribution to this project. The HPA commission was managed by Craig Gordon, Senior Researcher, HPA.

This version 2 report includes a small number of corrections to the original report released in November 2016. A list of the corrections is provided in Appendix VI.

This report has not undergone external peer review.

COPYRIGHT AND DISCLAIMER

The copyright owner of this publication is HPA. HPA permits the reproduction of material from this publication without prior notification, provided fair representation is made of the material and the authors are acknowledged as the research providers, and HPA as the commissioning agency.

This research has been carried out by independent parties under contract to HPA. The views, observations and analysis expressed in this report are those of the authors and are not to be attributed to HPA.

ISBN: 978-1-927303-89-4 (On-line)

Providers: Michael Cameron and William Cochrane (University of Waikato, New Zealand), and Michael Livingston (La Trobe University, Melbourne).

Citation: Cameron, M.P., Cochrane, W., & Livingston, M. (2016). *The relationship between alcohol outlets and harms: A spatial panel analysis for New Zealand, 2007-2014*. Wellington: Health Promotion Agency.

This document is available at http://www.hpa.org.nz/research-library.

For further information on the report contact Michael Cameron at mcam@waikato.ac.nz or HPA at enquiries@hpa.org.nz.

Health Promotion Agency
PO Box 2142
Wellington 6140
New Zealand

January 2017

THE UNIVERSITY OF
WAIKATO
Te Whare Wānanga o Waikato

The relationship between alcohol outlets and harm: A spatial panel analysis for New Zealand, 2007-2014

Michael P. Cameron [a,b]

William Cochrane [b,c]

Michael Livingston [d]

[a] Department of Economics, University of Waikato

[b] National Institute of Demographic and Economic Analysis, University of Waikato

[c] Faculty of Arts and Social Sciences, University of Waikato

[d] Centre for Alcohol Policy Research, La Trobe University

Commissioned Research Report

Prepared for the Health Promotion Agency

January 2017

The relationship between alcohol outlets and harm: A spatial panel analysis for New Zealand, 2007-2014

Any queries regarding this report should be addressed to:

Dr. Michael P. Cameron
Department of Economics
University of Waikato
Private Bag 3105
Hamilton 3240
E-mail: mcam@waikato.ac.nz
Phone: +64 7 858 5082.

Acknowledgements

This research was commissioned by the Health Promotion Agency (HPA). The authors would like to thank the many research assistants who helped with geo-coding and verification of the spatial data, and Francisca Simone for timely GIS assistance. We are also grateful to Craig Gordon, and Cathy Bruce of the HPA, and Rhiannon Newcombe, for their valuable input at key stages of the project.

Disclaimer

The views expressed in this report are those of the authors and do not reflect any official position on the part of the University of Waikato, or the Health Promotion Agency.

© 2016 Department of Economics
The University of Waikato
Private Bag 3105
Hamilton
New Zealand

Table of Contents

List of Figures

List of Tables

Executive Summary

- This research project was commissioned by the Health Promotion Agency (HPA) and has three overall objectives:
    1. To investigate the impacts of alcohol outlet density on police activity at the local (Census Area Unit) level across New Zealand;
    2. To evaluate how these impacts have changed between the period before passing of the Sale and Supply of Alcohol Act 2012 (SSAA) on 18 December 2012, and after; and
    3. To evaluate the direct and mediating effects of local alcohol policies (LAPs) on the relationships between alcohol outlet density and police activity.
- We use longitudinal panel data for the period 2007-2014 covering all of New Zealand to evaluate the relationships between alcohol outlets (by type) and both police events (by type) and motor vehicle accidents. The models are Poisson (count models) that use counts of police events and motor vehicle accidents as outcome variables, and counts of outlets as the key explanatory variables.
- Our results are broadly similar to, but smaller in magnitude than, those from the earlier literature.
- Despite the generally smaller coefficients than earlier research, there are a number of commonalities. In particular, off-licence outlets appear to have a number of positive relationships with alcohol-related social harms, while the relationships for on-licence outlets are more mixed. These relationships have generally been smaller in earlier New Zealand research, but in this work are demonstrably larger than the effects for other outlet types.
- Moreover, the relationship between outlets (by type) and social harm are mediated by population and social deprivation in a number of cases (i.e. the relationship in an area depends on population and/or social deprivation). For example, an increase in licensed clubs is significantly associated with violence in areas with low populations (i.e. rural areas) but not in areas with larger populations (i.e. urban areas). To generalise, social deprivation appears have more mediating influence on the relationships for licensed clubs and other on-licence outlets (primarily restaurants and cafés), while population (a proxy for rural or urban location) appears to have more mediating influence for bars and night clubs, and off-licence outlets.
- The short period of data available after the implementation of the SSAA and LAPs limited our ability to find robust changes in these relationships between the period before and the period after implementation of the SSAA or any LAPs.
- Despite the limitations, this research adds to the weight of evidence that links alcohol outlets and social harms.

1. Introduction

The Sale and Supply of Alcohol Act (SSAA) was passed on 18 December 2012, replacing the Sale of Liquor Act 1989. The SSAA was born out of a review conducted by the Law Commission (Law Commission, 2010), and aims to achieve safe and responsible sale, supply and consumption of alcohol, and to minimise harm from excessive and inappropriate use of alcohol. The changes in the SSAA have implications for licensing and licensing conditions, trading, social supply, promotions, community voice and amenity and good order.

The SSAA included a number of important changes in the way alcohol was sold in New Zealand, which came into force from 18 December 2013. Among those changes were new national maximum trading hours, and the ability for any local authority to adopt a Local Alcohol Policy (LAP) with provisions that differ from the generic provisions of the SSAA and that apply to their area. Specifically, Section 77 of the Act specifies that LAPs may include policies on any or all of the following matters relating to licensing (and no others):

a) location of licensed premises by reference to broad areas;
b) location of licensed premises by reference to proximity to premises of a particular kind or kinds;
c) location of licensed premises by reference to proximity to facilities of a particular kind or kinds;
d) whether further licences (or licences of a particular kind or kinds) should be issued for premises in the district concerned, or any stated part of the district;
e) maximum trading hours;
f) the issue of licences, or licences of a particular kind or kinds, subject to discretionary conditions; and
g) one-way door restrictions.

The impacts of alcohol outlet density are a key concern of community stakeholders (McNeill et al., 2012), particularly given that alcohol outlet density has been shown to be highest in poorer and more disadvantaged areas (Cameron et al., 2012b; 2013b; 2013c; Hay et al., 2009; Pearce et al., 2008). Past research in New Zealand (see Section 2 for further details) has demonstrated that alcohol outlet density and proximity to alcohol outlets are related to a range of indicators of harm, including problem drinking (Connor et al., 2011; Huckle et al., 2008), violent and other crime (Day et al., 2012; Cameron et al., 2012c; 2012d; 2013a; 2014a;

2014b), and motor vehicle accidents (Cameron et al., 2012c; 2012d; 2013a; Matheson, 2005). These results are similar to those reported internationally (Cameron et al., 2012a; Livingston et al., 2007; Popova et al., 2009).

Given the potential for change in outlet density as a result of the implementation of LAPs, this provides a timely opportunity to better understand these relationships in the local context in New Zealand. Where a local alcohol policy has restricted alcohol outlet density, this provides a natural experiment on the impacts of alcohol outlet density on associated harms (see Cameron et al. (2012a) for a discussion of natural experiments on alcohol outlet density).

This research project was commissioned by the Health Promotion Agency and has three overall objectives:

1. To investigate the impacts of alcohol outlet density on police activity at the local (Census Area Unit) level across New Zealand;
2. To evaluate how these impacts have changed between the period before implementation of the SSAA, and after; and
3. To evaluate the direct and mediating effects of local alcohol policies on the relationships between alcohol outlet density and police activity.

This research builds on previous work undertaken by members of the same research team in Manukau (Cameron et al., 2012c; 2012d) and the North Island of New Zealand (Cameron et al., 2013a; 2014a; 2014b). We extend the previous analyses by considering the entire country, and by considering the periods before and after the implementation of the SSAA. Unfortunately, due to the short period of data after the first LAPs became operative, we could not complete Objective 3. However, we do consider the mediating effects of social deprivation and population.

Moreover, previous analyses of the relationship between alcohol outlet density and social harm in New Zealand have used cross-sectional data, whereas we employ a panel dataset that is longitudinal. Using longitudinal data on alcohol outlet density and harms reveals the impact of alcohol outlet density in a cleaner way than past studies, because variable patterns over time in the data can be explicitly controlled for and because statistical power is much greater when analysing longitudinal data. There are benefits to this type of evaluation even when alcohol outlet density has not changed. Looking at the relationship when outlet density is effectively unchanged has the potential to reveal the mediating effects of other local

alcohol policy changes (and the SSAA more generally) on the relationship between alcohol outlet density and harms. For example, if a local alcohol policy specifies reduced opening hours for on-licence outlets, then the effect size of the relationship between on-licence outlet density and policy activity may decrease. A better understanding of the combination of these two effects (direct and mediating) will be important in terms of providing policy-relevant guidance on local alcohol policies in the future.

This report outlines the methodology and summarises the findings in terms of the relationships between alcohol outlet density and a few key outcome variables: different types of police events, and motor vehicle crashes. These particular indicators of social harm were selected mainly because of the availability of spatially-explicit data that lends itself to appropriate modelling. We note that these measures have been used in previous research (Cameron et al., 2012c; 2012d; 2013a; 2014a; 2014b). Alternative measures either have inappropriate spatial data recording (e.g. accident and emergency admission or hospitalisation data, where data are coded to the patient's home address, rather than the location where the harm occurred – see Cameron et al., 2012c), or are unavailable at this time (e.g. ambulance events, child abuse data).

The report is structured as follows:

- Section 2 briefly reviews the literature with specific relevance to New Zealand;
- Section 3 details the data and methodology;
- Section 4 presents and briefly discusses the results; and
- Section 5 concludes.

2. The relationships between alcohol outlets and social harm

Studies examining relationships between alcohol outlet density and social problems have consistently found significant and positive relationships (Cameron et al., 2012a; Livingston et al., 2007; Popova et al., 2009). There have been several recent reviews of the international literature, including Livingston et al., (2007), Popova et al., (2009), Cameron et al., (2012a), and Gmel et al., (2016). Across these studies, relationships between outlet density and social harm appear to vary significantly, both within and between studies, and depend on the type of outlet, category of crime, and the setting. For instance, studies in Australia have shown that the density of pubs is strongly associated with general assault rates, but that off-licence

outlets are more strongly associated with domestic violence rates (Livingston, 2008; 2011). Similarly, studies in the U.S. have found contrasting results, with some observing stronger associations between assault and off-licence outlets rather than bars (Gruenewald et al., 2006; Pridemore and Grubesic, 2013), while others have shown the opposite (Franklin et al., 2010). This has led some researchers to conclude that the number of outlets may matter less than the type of outlets that are present in a location and the characteristics of those outlets, following the critique of Lugo (2008). The setting appears to matter as well. Recent studies in Australia and the U.S. have demonstrated that density of alcohol outlets matters more in areas of already high outlet density, and in neighbourhoods with high levels of social deprivation (Livingston, 2008; Mair et al., 2013). Furthermore, the relationship between crime and alcohol outlet density may vary spatially and in non-systematic ways. For instance, Cameron et al. (2013a) demonstrated significant differences in the relationship between alcohol outlet density and police events, but the differences were not linked to observable differences between areas.

The New Zealand-specific literature on alcohol outlets generally finds similar effects to those reported in the international literature, in terms of their locations and relationships with consumption and social harms. That is, the relationships are generally positive but depend on context. A number of studies show that alcohol outlet density is positively associated with social deprivation in New Zealand (as measured by the New Zealand deprivation index). Pearce et al. (2008) examined spatial relationships between food and alcohol outlets and social deprivation at the meshblock level in main urban areas across New Zealand in 2004 and 2005. They found a positive association between the number of licensed alcohol outlets per 10,000 population and social deprivation (higher numbers of outlets were associated with more socially deprived areas). This pattern was also found for food outlets (supermarkets, convenience stores and fast food outlets). Hay et al. (2009) used data from 2001 to examine the relationship between distance from each meshblock to the nearest alcohol outlet with social deprivation. Their results show that overall social deprivation was positively associated with shorter distance to the nearest alcohol outlet (people have greater access to alcohol outlets when they live in more socially deprived areas). These associations however vary by outlet type, with restaurants having a different spatial profile, and with urban/rural status, where the pattern tended to be more marked for urban areas. Cameron et al. (2012b) describe the spatial characteristics of alcohol outlets in the Manukau City area in January 2009. They show that on-licence outlets were most dense in areas with good transport networks and that

off-licence outlet density was related to population density and with relative social deprivation (that is, higher population density and higher relative deprivation are associated with higher density of off-licence premises).

Some studies have found positive associations between alcohol outlet density and drinking patterns or negative social outcomes for specific populations or geographic areas. In an early study, Wagenaar and Langley (1995) used an interrupted multiple time-series design and nation-wide alcohol sales data from 1983 to 1993 to examine the effect of the Sale of Liquor Act 1989, which permitted grocery stores to begin selling table wine. They found that the number of alcohol outlets increased significantly following the law change, and that there was a 17 percent increase in wine sales between the period before and the period after the new Act came into effect. Kypri et al. (2008) looked at the association between alcohol outlet density (number of outlets within a given distance of the respondent's home) and survey measures of drinking patterns and alcohol-related harm in a sample of 2,550 tertiary students from six university campuses in 2005. They found overall a significant positive relationship between outlet density and the number of drinks per typical day, alcohol-related problems in relation to respondents' own drinking and second-hand effects (problems experienced from others' drinking). The observed effects were stronger for off-licence outlet density than for on-licence outlet density, and stronger for outlet density within a one kilometre radius than for outlet density within a three kilometre radius. Huckle et al. (2008) surveyed 1,179 12-17 year olds from the Auckland region in 2005 about drinking patterns and behaviour, and examined the relationships of these variables with alcohol outlet density. They found a significant positive relationship between outlet density (defined as the number of outlets within 10 minutes' drive of the respondent's home) and how much was consumed on a typical drinking occasion. No significant relationships were observed between outlet density and the frequency of drinking or the frequency of intoxication. A significant positive relationship was found between outlet density and social deprivation (as measured by the deprivation index). Connor et al. (2011) conducted a national survey of 1,925 18-70 year olds in 2007 looking at alcohol consumption and drinking consequences. Outlet density was defined as the number of alcohol outlets within one kilometre of each survey respondent's home address. Using a cross-sectional design, they found a significant positive association between binge drinking (defined as consuming more than five drinks on a single occasion once a month or more) and the density of off-licence outlets and bars and clubs, but not for

restaurants. No significant associations were found between outlet density and the average amount of alcohol consumed per year, or risky drinking.

Other New Zealand studies have focused more directly on the relationship between alcohol outlets and social harms. Matheson (2005) used geographically weighted regression to investigate the relationship between alcohol outlet type density and single-vehicle night-time crashes (between 2000 and 2004) and found that the relationship varied significantly between District Health Board areas in Auckland. Cameron et al. (2012c; 2012d), using spatial seemingly unrelated regression at the Census Area Unit level, found that alcohol outlet density was significantly positively associated with a range of social harm indicators (police incidents and motor vehicle crashes) in Manukau City in 2008-2009. Specific police incident categories such as violence or property damage were associated with different outlet types (see introduction for more detail). Day et al. (2012), using a cross-sectional ecological design, examined the association between serious violent crime recorded from 2005-2007 and alcohol outlet density. They found that areas with the greatest access (shortest travel distance) to alcohol outlets were associated with the highest incidence of serious violent crime. Off-licence premises were a significant predictor of area-level violent crime regardless of distance to alcohol outlets.

Most recently, Cameron et al. (2013a; 2016a; 2016b) used geographically weighted regression (GWR) to further explore the location-specific relationships between alcohol outlet density and both police events and motor vehicle accidents. They reported global (overall) models for the relationships based on average relationships for the measures of social harms and alcohol outlet densities in the North Island (which relies on a similar approach to other spatial models), as well as locally-specific parameter estimates (at the Census Area Unit level). In the global models, bar and night club density appeared to have the most robust and largest effects, being significantly positively associated with all categories of police events, and with motor vehicle accidents. Supermarket and grocery store density generally had statistically significant and positive effects on police events, but was significantly negatively related to motor vehicle accidents. Licensed club density and other on-licence density were significantly positively related to many of the categories of police events. The locally-specific (GWR) results demonstrated that global models potentially masked substantial local differences in the relationships between alcohol outlet density (by type) and social harms. All of the parameter estimates were demonstrated to vary greatly

across the North Island, and were statistically significant in some areas, and statistically insignificant in other areas.

Cameron et al. (2016a) further explored the locally-specific relationships between alcohol outlet density and violence, and found similar results to the earlier Cameron et al. (2013a). However, in both cases the spatial variation in the relationships appeared to be non-systematic. That is, there didn't appear to be other mediating factors that affected the locally-specific relationship between alcohol outlet density (by type) and social harms. This latter result may have been the result of the GWR framework that was applied, which is known to be sensitive to choices made during the modelling, among other limitations (Wheeler and Tiefelsdorf, 2005). Cameron et al. (2016b) concentrated on the relationships with property damage events and found that, after off-licence outlets were combined into a single category (rather than separating out supermarkets and grocery stores), alcohol outlet density of all types had statistically significant and positive relationships with property damage events, and that these relationships did not show significant spatial variation. Moreover, bars and night clubs had the largest marginal effects, along with licensed clubs.

Overall, the New Zealand and international literature demonstrates that there are generally positive correlations between alcohol outlets and social harms, but these correlations are not consistent across all studies. The different results across studies may be attributed to differences in study design such as the analysis techniques employed or the specification of the data, and/or contextual factors relevant to the location of the study, for example urban or rural, socio-demographic characteristics of the study area, and so on. All of the New Zealand literature to date on the relationships between alcohol outlet density and measures of social harm (and much of the international literature as well) is based on what are, essentially, cross-sectional ecological designs. As noted in the introduction, there are significant gains to be had by instead using a design that makes use of longitudinal or panel data. We outline our approach to this in the following section.

3. Data and Methods

3.1 Data

Lists of current liquor licences in New Zealand were obtained from the Ministry of Justice, covering quarterly intervals from 2005 to 2014. These lists included details on the name of

the licensee, the name of the premises, its address, and the type of liquor licence held.[1] Address data can often be geocoded to point locations using an address locator file in a suitable Geographic Information Systems software package. Unfortunately, many of the addresses in the lists were incomplete. To overcome this problem, we employed a manual process to geo-code the outlets to the Census Area Unit (CAU) level.

The manual geo-coding was performed by searching for each address using a combination of the Statistics New Zealand StatsMaps (http://www.stats.govt.nz/statsmaps/home.aspx) Google Maps (http://maps.google.com), and Google Street View (https://www.google.co.nz/maps/streetview/), to ensure triangulation and accurate geo-coding. All addresses were geocoded twice, by separate research assistants, and any inconsistencies were investigated and resolved by one of the researchers.[2] Ultimately, we achieved a 100 percent geo-coding success rate to the Census Area Unit level.

Following geo-coding, all of the quarterly cross-sectional lists of outlets were combined into a single longitudinal dataset. This dataset allows us to identify and follow individual outlets' status (licensed or not) over time. Using this dataset, duplicate outlets were more easily able to be identified and excluded, because in any time period there may be multiple outlets with the same name and/or the same address details. This exclusion of duplicates was generally able to be achieved even when outlets changed names or when the address details changed between periods.

Moreover, we were able to identify many instances where the same outlet initially appeared in the longitudinal dataset, then dropped out for one or more periods, before reappearing in a later period. These continuity problems could arise because of one of three reasons:

1. An outlet's licence genuinely lapsed for one or more periods before being renewed;
2. An outlet's licence appeared to the Ministry of Justice to have lapsed, but this is only because an application for licence renewal had (at the time the cross-sectional data was exported by the Ministry of Justice) not yet been decided by

[1] Special licences (licences granted for one-off events) are not included in this dataset, as they are not systematically reported to the Ministry of Justice, and are unlikely to have a long-term impact on social harms as would be observed in the quarterly data we use.
[2] The geo-coding success rate differed between research assistants, but overall was approximately 96 percent, leaving about 4 percent of cases that required resolution by the researchers.

the District Licensing Committee (under the SSAA; or the Liquor Licensing Authority under the Sale of Liquor Act 1989); [3] or

3. There was an error in the dataset.

Situations 2 and 3 must be corrected for in order to minimise measurement error in the outlet counts dataset. Where these continuity problems were four quarters (one year) or shorter, and where the outlet did not change names in the interim, we adjusted the data to include the outlet throughout the 'missing' period.[4] Outlet types (as noted in the Ministry of Justice data) that were clearly erroneous were also corrected at this stage.

Following some initial explorations of the data, it was observed that there were a number of issues with data quality in 2006, and after the middle of 2014. The issues with the early data suggested that there were a number of licences in the dataset that were not current, as an unusually large number of outlets disappeared in the first quarter of 2007. After 2014, a change in the way addresses were recorded in the dataset made matching much more difficult. We restricted our analysis to data on outlets between January 2007 and June 2014 (a total of 30 quarterly observations).

Following Cameron et al. (2013a), liquor licences were then classified by type, using the taxonomy described in Table 1 below. Some outlet types were excluded from consideration at this stage. Catering licences, auctioneers, mail order companies and conveyances were excluded because the location of the licence is likely to be largely unrelated to the location of drinking, which may occur far from the community in which the licence is located. Vineyards, hospitals, gift stores and florists were excluded because we expected any spatial relationship with drinking patterns and/or harm to be very weak for these outlet types. This follows the earlier approach adopted by Cameron et al. (2013a).

[3] We note that outlets that have applied for a renewal of their licence, but where the renewal has not yet been granted, are allowed to continue to trade under the previous license terms until the licensing decision has been made.

[4] We did not explicitly track the number of these adjustments that were made.

Table 1: Taxonomy of alcohol outlet types

Code	Main Types	Also includes…
01	Clubs	Off-licensed chartered clubs, off-licensed social clubs
02	Sports Clubs	
11	Bottle Stores	Off-licensed distilleries
12	Grocery Stores	On-licensed grocery stores
13	Supermarkets	
14	Off-licensed hotels	Off-licensed tourist houses
15	Off-licensed taverns	
19	Other off-licences	Off-licensed breweries, locational licences, complementary licences
21	Bars and night clubs	Adult entertainment venues, taverns, TABs, casinos
22	Restaurants and cafés	BYO restaurants, universities, airports
23	Accommodation and function centres	Conference venues, hotels, tourist houses
29	Other on-licences	Theatres, tasting only, gyms, music venues
31	Dual-licensed hotels	[Hotels and tourist-houses that hold both an on- and off-licence]
32	Dual-licensed bars	[Taverns, etc. that hold both an on- and off-licence]
33	Dual-licensed restaurants	[Restaurants, etc. that hold both an on- and off-licence]

While it is possible to analyse the data using the full taxonomy of alcohol outlet types shown in Table 1, this would pose a number of problems for the analysis. Most importantly, given that there are only small numbers of outlets of some types spread across the entire country, this would likely lead to spurious results in the statistical analysis. Having only a small number of some outlet types amplifies the effect of any measurement error, leading to overestimated standard errors and a bias towards statistical insignificance in the coefficients. Moreover, having a large number of likely-correlated variables in the analysis leads to problems of multicollinearity, which has a similar effect in terms of overestimated standard errors. We argue that there is little reason to believe that there are substantial differences between some of the outlet types, in terms of their effects on social harms, and reducing the number of outlet types is a standard approach applied in the international and New Zealand literature (e.g. see Cameron et al., 2013a).

Reducing the number of outlet types from Table 1 into categories for analysis necessarily involves a number of subjective decisions. First, as Gmel et al. (2015) note, off-licences and on-licences should be analysed separately. However, a further decomposition of outlet

categories is necessary, reflecting the fundamental difference in purpose between establishments (Cameron *et al.*, 2012c). Where drinking is one of the main activities (as in clubs and bars) the marginal effects are likely to be different to on-licence outlets where drinking is incidental to another activity (such as restaurants and cafés). Similar logic applies to off-licences, where the type of customer catered for by supermarkets and grocery stores may be different from that of other off-licence outlets. Previous research has shown that the relationships between alcohol outlets and social harms are different for different types of outlets (and hence, different licence types) (Cameron *et al.*, 2012c, 2012d).

Cameron et al. (2013a) aggregated the outlet types from Table 1 into five categories, including dual-licensed outlets in *both* the corresponding on-licence and off-licence categories. This approach leads to a double-counting of dual-licensed outlets. However, there is no generally accepted method of dealing with these outlets, in either the international or New Zealand literature. As these outlets involve both off-licence and on-licence sales, they are not easy to subcategorise and any choice about their categorisation is necessarily somewhat arbitrary. We opted instead to leave dual-licensed outlets as separate categories initially, and empirically test whether the relationship between these outlet types and measures of social harm were statistically significantly different from those of similar outlets (see Section 3.3 for further details).

We also note that Types 14 and 15 are unlikely to be observed in isolation. Most outlets that are initially coded as Type 14 (off-licensed hotel) should really be either Type 23 (accommodation and function centres) or Type 31 (dual-licensed hotels), while most outlets that are initially coded as Type 15 (off-licensed tavern) should really be either Type 11 (bottle stores) or Type 32 (dual-licensed tavern). All of the outlets categorised as Types 14 or 15 were carefully investigated by one of the researchers, before being recoded to a more appropriate type (leaving no outlets coded as Type 14 or Type 15).

Using the types in Table 1, outlet counts per CAU were initially aggregated into the following categories for analysis:

1. Clubs (Types 01 and 02);
2. Bottle stores (Type 11);
3. Other off-licences (Types 12, 13, and 19);
4. Bars and night clubs (Type 21);
5. Restaurants and cafés (Type 22);

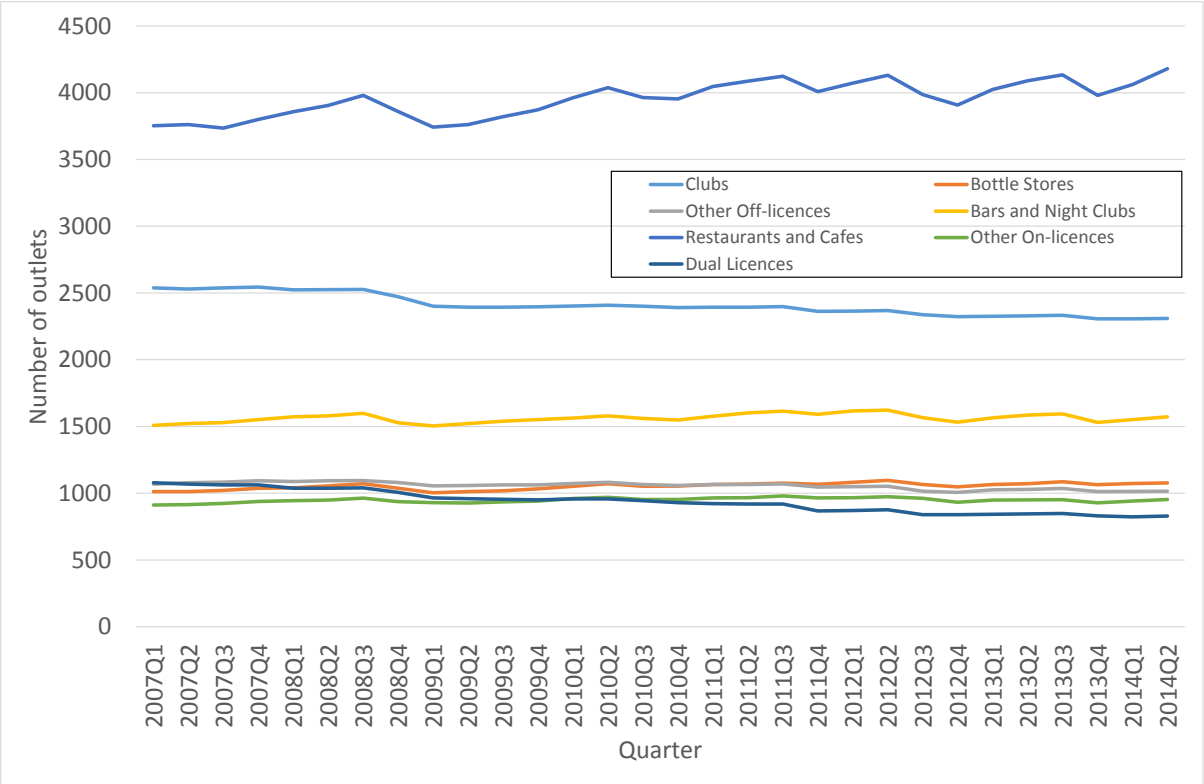
6. Other on-licences (Types 23 and 29);
7. Dual-licensed hotels (Type 31);
8. Dual-licensed taverns (Type 32); and
9. Dual-licensed restaurants (Type 33)

Counts for the number of outlets within each of the 1,862 Census Area Units across the country were obtained.[5] We used licence counts rather than calculating outlet density in relation to population size or geographic area or other similar measures. The reasons for this are outlined in detail in Section 3.2.

The total outlet count for each licence type from 2007Q1 to 2014Q2 is presented in Figure 1. Over this period, the total number of licences increased slightly, from 11,873 in 2007Q1 to 11,973 in 2014Q2. The peak number of total licences was 12,276 in 2008Q3, and the minimum was 11,587 in 2012Q4. Overall restaurants and cafés make up the highest proportion of outlets by type, followed by licensed clubs, and bars and night clubs. However, even though the total number of licences has not changed much over this period, the distribution of licences by type has changed substantially. In particular, the number of licensed restaurants and cafés has increased 11.4% (from 3,753 to 4,180) and the number of bottle stores has increased by 6.3% (from 1,013 to 1,077). The corresponding increase in the national population over that period was 7.3% (or 8.7% for the population aged 15 years and over), so only the increase in restaurant and café numbers has been faster than population growth. In contrast, dual licences have decreased by 23.2% (from 1,079 to 829) and licenced clubs by 9.0% (from 2,539 to 2,310). As noted by Cameron et al. (2013a), the global financial crisis does not appear to have caused a significant drop in the number of licences, but equally, there does not appear to have been a significant increase in the number of licences for the 2011 Rugby World Cup. It is possible that these two events offset each other, in terms of their effect on the aggregate number of licences.

[5] Islands, harbours, tidal flats and the like were excluded due to minimal populations. Fiordland was also excluded for the same reason. In all cases, 2013 Census Area Unit boundaries were used.

Figure 1: National alcohol outlet counts by type, 2007Q1 to 2014Q2



Data on police-attended motor vehicle accidents were obtained from the Ministry of Transport Crash Analysis System (CAS) database. Data on police events were obtained from the New Zealand Police Communications and Resource Deployment (CARD) database. Both datasets covered the period from 2007 to 2014, and each dataset was first cleaned to remove duplicate events or occurrences. Following Cameron et al. (2013a), the police data were then restricted to events that were coded to specific offences, and then broken down into seven categories (a more complete breakdown of the offences included in each category is given in Appendix I):

1. Antisocial behaviour offences
2. Dishonesty offences
3. Drug and alcohol offences
4. Property abuses
5. Property damage
6. Sexual offences
7. Violent offences (including family violence)

The data were geo-coded to the CAU level using an automated process in ArcGIS, then converted to counts per CAU per quarter.

In addition to the above data, three control variables were included: (1) Statistics New Zealand subnational population estimates for each CAU; and (2) New Zealand Deprivation Index (NZDep2013), a commonly used index of small area socioeconomic deprivation (Atkinson *et al*., 2014); and (3) the proportion of young men aged 15-24 years from the 2013 Census.[6] Population is included as an exposure variable, following Liang and Chikritzhs (2011) – where populations are higher we can expect to observe more police events and motor vehicle accidents. Social deprivation is expected to be related in particular to police events (Krivo and Peterson, 1996), and has proven to be an important variable in past analyses of New Zealand data (e.g. see Cameron et al., 2013a). Police events and motor vehicle accidents are both associated with young men more than other demographic groups, so we expect areas that have larger numbers of young men to have higher incidence of these events.

Summary statistics for the variables (across all quarters included in the dataset) are presented in Table 2. The number of observations is 55,860, being 1,862 Census Area Units each observed for 30 quarters. The mean number of violence events is 5.24 (in a quarter; equivalent to an annualised 21 events) with a median of three events. Dishonesty offence events and antisocial behaviour events are the most common (means of 18.75 and 10.48 respectively), while sexual offence events are the least common (mean of 0.46). Interestingly, with the exception of licensed clubs the median of all other outlet types is zero. This tells us that more than half of all observations (being 30 quarterly observations for each of the 1,862 Census Area Units) have zero outlets of each type (except licensed clubs). In other words, as noted in the final column of Table 1, there are a large number of Census Area Unit quarterly observations that have no outlets at all. This provides further support for the merging of different outlet categories discussed earlier in this section. Similarly, in terms of the dependent variables the median number of drug and alcohol offence events and sexual offence events is also zero – that is, for both of these types more than half of observations have zero events.

[6] While this variable does change over time, the change is slow and fairly linear so we use only one observation from the 2013 Census.

Table 2: CAU summary statistics across all quarters 2007Q1-2014Q2 (n=55,860)

Variable	Mean	Median	SD	Min	Max	Proportion of 'zeroes'
Dependent variables						
Violence events	5.24	3	8.12	0	170	21.7%
Antisocial behaviour events	10.48	4	20.00	0	439	20.7%
Dishonesty offence events	18.75	10	29.55	0	579	6.9%
Drug and alcohol offence events	1.22	0	5.54	0	297	60.4%
Property abuse events	2.88	1	4.58	0	94	30.5%
Property damage events	4.44	2	6.24	0	121	24.8%
Sexual offence events	0.46	0	1.31	0	19	75.6%
Motor vehicle accidents	1.76	1	2.75	0	48	45.3%
Outlet variables						
Licensed clubs	1.29	1	1.65	0	12	42.3%
Bars and night clubs	0.84	0	3.95	0	89	74.5%
Restaurants and cafés	2.12	0	6.67	0	141	52.0%
Other on-licence	0.51	0	1.57	0	27	75.8%
Bottle stores	0.57	0	1.16	0	21	67.4%
Other off-licence	0.57	0	0.98	0	18	62.5%
Dual-licensed hotels	0.22	0	0.58	0	7	86.8%
Dual-licensed taverns	0.26	0	0.64	0	11	80.9%
Dual-licensed restaurants	0.02	0	0.17	0	3	97.8%
Control variables						
Population (000s)	2.34	2.12	1.70	0	13.65	N/A
NZDep2013	995.1	975.5	80.2	850	1356	N/A
Proportion young males (%)	6.22	5.97	3.18	0	35.43	N/A

3.2 Outlet counts vs. outlet density

The focus of previous research into the relationship between alcohol outlets and social harms (such as that summarised in Section 2) has essentially been undertaken to determine whether an additional outlet (of a specific type) is associated with more social harms. From a policy or land use planning perspective, research into these relationships should inform whether adding an additional outlet (of a specific type) will increase social harms. Many previous studies have often used alcohol outlet *density*, measured as the number of outlets per unit of population, the number of outlets per unit of area, or the number of outlets per roadway mile, as the key variable of interest in the analysis. The hypothesis is that an increase in the

measure of accessibility (alcohol outlet density, however measured) is associated with increased social harms (however measured). However, despite the fact that we have used density measures (in terms of outlets per 10,000 population) in our own previous work (e.g. see Cameron et al., 2012c; 2012d; 2013a; 2016a), we argue that the focus on density measured in this way is theoretically flawed, and leads to measures that may not accurately capture the effects of an additional outlet on social harms.

For instance, take the number of outlets per 10,000 population (our preferred measure from earlier work) as a measure of accessibility. Now consider two areas (Area A and Area B), that both have the same land area and the same road accessibility (and the same socioeconomic characteristics, etc.). Now say that both areas have the same population, but that Area A has twice as many outlets as Area B. It would probably be reasonable to say that Area A has greater accessibility to alcohol. The measure of outlet density would reflect this, being twice as high for Area A than for Area B. People in Area A do not need to travel as far to obtain alcohol, as the nearest outlet would be closer to them. Outlets in Area A face more competition and as a result may open more hours, and charge lower prices. All of these effects lead to a lowering of the 'full cost' of alcohol for people living in Area A, relative to those in Area B. A lower full cost of alcohol should be associated with greater alcohol consumption, and consequently more alcohol-related harm.

Now consider an alternative scenario. Say that Area A and Area B still have the same land area, road accessibility, etc. *and* they both have the same number of outlets, but that Area A has half the population of Area B. Is it reasonable to suggest that Area A has more accessibility to alcohol now? Certainly, the measure of outlet density would still be twice as high for Area A than for Area B. But, people in Area A have to travel just as far to obtain alcohol as those in Area B, and outlets in Area A face the same level of competition as those in Area B. So, there isn't good reason to believe that there would be greater alcohol consumption, and consequently more alcohol-related harm, in Area A than in Area B. So while the measure of outlet density would be different in the two areas, the accessibility of alcohol would be no different between them.

This problem can easily lead to incorrect inferences about the relationship between alcohol outlets and outcome variables, and arises from the denominator in the outlet density measure – in the case of the example above, population. Areas with the same number of outlets (and the same in terms of their other characteristics) but different populations cannot be expected

to necessarily have differential accessibility to alcohol. Accessibility to alcohol is determined by the numerator (the number of outlets) not the denominator. This problem is similar for other denominators, including land area and roadway miles.

The 'denominator problem' of alcohol outlet density measures means that we need to re-think the approach to density. Overall, we are in agreement with Liang and Chikritzhs (2011), that alcohol outlets should be measured in terms of their absolute number and not in terms of density. However, we argue this for theoretical rather than pragmatic reasons.[7] Importantly, **we note that this does not necessarily mean that the concept of alcohol outlet density itself is flawed**. It only requires us to re-think the measurement of alcohol outlet density in terms of counts of outlets, rather than in terms of outlets per unit population (or area, or road miles).

Finally, we note that even if we were unconcerned about the 'denominator problem' noted above, we argue that adopting a model of counts rather than density is appropriate when using a fixed effects panel model (as we describe in the following section), because time-invariant or slowly changing variables typically present statistical problems for fixed effects panel models (where time-invariant variables are subsumed into the fixed effects).

3.3 Analysis method

Previous research by this research team has used two different methods to estimate the impact of alcohol outlet density: (1) aspatial and spatial models, including spatial error models, spatial Durbin models, and spatial seemingly unrelated regression models (Cameron et al., 2012c; 2012d); and (2) geographically-weighted regression (GWR) models (Cameron et al., 2013a; 2014a; 2014b). The latter models have the advantage that, in addition to accounting for spatial interdependency between locations, they allow for the estimation of effects at each locality (e.g. at each Census Area Unit). However, GWR models are sensitive to the presence of outliers, and interpretation of the reasons underlying differences in the locally-specific impacts of alcohol outlet density is difficult (Páez et al., 2011).

Given that the dependent variable is comprised of count data (i.e. the number police events of a given type, or the number of motor vehicle accidents), the appropriate class of models to

[7] Liang and Chikritzhs (2011) argue that outlet numbers should be used in order to mitigate problems of outliers in the measure density that arise in areas that have a small population.

apply in the analysis are Poisson models. However, as spatial modelling of count data is relatively new in the literature, there are currently no available routines for running spatial Poisson models that can fully accommodate panel data. Instead, we follow Figueiredo et al. (2014) in initially approximating spatial effects by clustering standard errors at the Territorial Authority level. We then include as explanatory variables not only the number of outlets by type (and other explanatory variables) in the area unit of interest, but also a weighted average of the number of outlets by type in neighbouring area units (essentially this is termed a 'spatial lag of X' (SLX) model). The combination of spatial lagged explanatory variables and clustering of standard errors can be expected to adjust for any spatial autocorrelation in the data (see Cameron et al. (2012c) for further discussions of spatial autocorrelation with specific application to alcohol outlet models).

Using a panel model, with 1,862 area units and 30 time periods provides 55,860 observations for the analysis. We run several model specifications for each dependent variable, each with different included explanatory variables. These models are summarised in Table 3 (page 20). The basic model (Model I) includes as explanatory variables only the direct effect of outlet counts (by type), population (in 000s) and the square of population. The square of population is included in order to capture any non-linear effects of population size, and is commonly used as a control in many applications. We cannot include social deprivation as a control variable at this stage, as the measure of social deprivation we are using (NZDep2013) is only updated following each Census; instead, the inclusion of Census Area Unit fixed effects will capture (for the most part) the relationship between social deprivation and the dependent variable (see below for further details). We initially included separate explanatory variables for all nine outlet types noted in Section 3.1, but statistical tests showed that the coefficients for some outlet types were not consistently statistically significantly different from each other; our final specification for Model I (and other models) includes as outlet types only four categories: (1) licensed clubs; (2) bars and night clubs (including dual-licensed taverns); (3) other on-licence outlets (including restaurants and cafés; accommodation and function centres; dual-licensed restaurants; and dual-licensed hotels); and (4) all off-licence outlets (including bottle stores; and supermarkets and grocery stores). We report the results of the tests of equality of coefficients for the different outlet types in Appendix II.

Model II adds a temporal lag of the dependent variable to the specification. This controls for serial autocorrelation – where the dependent variable is correlated with its own past and future values – which is a fairly common problem with longitudinal or panel data. Serial

correlation reflects that areas that have in the past experienced more violence events are likely to have more violence events in the future. This type of 'persistence' in the data leads to incorrect statistical inference, since the observations are not independent of each other. Including a temporal lag of the dependent variable reduces or eliminates this problem.

Model III adds to the specification interactions between the outlet counts (by type) and social deprivation, and interactions between the outlet counts (by type) and population. The inclusion of these interactions reflects that the relationship between outlets (by type) may be different in areas of high deprivation from the relationship in areas of low deprivation (and similarly, different between high population and low population areas). To reduce the problem of overfitting (where the number of explanatory variables becomes so large that the model starts to capture the effect of random noise, rather than the underlying relationships), we retain in the final Model III only the interactions that are statistically significant (at a level of $p<0.1$).[8]

Model IV adds a temporal lag of the total number of police events in the Census Area Unit to the specification. Under routine activity theory (Clarke and Felson, 1993; Cohen and Felson, 1979), crime occurs as a routine activity *in the absence of suitable guardians*. Research to date on the relationships between alcohol outlet and crime has not adequately controlled for the intensity of policing. Areas where police are more active (conducting more regular patrols, etc.) should be expected to have less crime. However, because of the likelihood of endogeneity (e.g. the number of violence events is part of the total number of police events in an area) we include the temporal lag of the total number of police events in an area. This captures the fact that, holding all else equal, we should expect that areas that see more regular police activity will experience less crime.

Finally, Model V adds to the specification spatial lags of the outlet counts (by type) and population. This captures the relationship between the number of outlets (or population) in *surrounding* areas on the dependent variable. The spatial lags were calculated as the inverse-squared-distance weighted average of the values of the variables in the nearest thirty surrounding Census Area Units. Because the weights are based on distance between the centroids of the Census Area Units, areas that are further apart contribute less to the average than areas that are closer to the Census Area Unit of interest.

[8] We choose the 10% level of significance here as an appropriate compromise between overfitting (by including more variables by using a cut-off level of significance) and potentially omitting important explanatory variables (by including fewer variables by using a higher cut-off level of significance).

Table 3: General model specifications

Included variables:	Model I	Model II	Model III	Model IV	Model V
Outlet counts (by type)	Yes	Yes	Yes	Yes	Yes
Population, and square of population	Yes	Yes	Yes	Yes	Yes
Temporal lag of dependent variable		Yes	Yes	Yes	Yes
Interactions between outlet counts (by type) and both social deprivation (NZDep2013) and population*			Yes	Yes	Yes
Temporal lag of total police events				Yes	Yes
Spatial lag of outlet counts (by type), and population†					Yes
Area unit fixed effects	Yes	Yes	Yes	Yes	Yes

* Only statistically significant (p<0.1) interactions are retained in the final Models III-V; † Only statistically significant (p<0.1) spatial lag variables are retained in the final Model V.

In addition to the five model specifications laid out in Table 3, we test three further specifications (the latter two of which we report only in Appendix V). In the first additional model (Model VI), we start with Model IV and then add interactions between the outlet counts (by type) and a dummy variable set equal to one for all periods after the introduction of the Sale and Supply of Alcohol Act (i.e. for all six periods after December 2012). This allows us to test whether the relationships *changed* following the passing of the Act.[9] In the

[9] Ideally, we would have liked to have tested whether the relationships changed following the full implementation of the Act on 18 December 2013. However, with only two periods of data available after that date, the statistical analysis using the implementation date (rather than the date the legislation was passed) was unsurprisingly unable to identify any statistically significant changes.

second additional model (Model VII), we again start with Model IV and then add the square of each outlet count (by type). This allows us to test for non-linear effects of the number of outlets on the dependent variable. Finally, in the third additional model (Model VIII), we again start with Model IV and then add dummy variables for each outlet type that are set to equal one when there are zero outlets of that type in the area. This allows us to test whether there are discontinuities in the relationship between outlets and each dependent variable for the first outlet, i.e. whether the first outlet in a particular area has an outsized effect on the dependent variable. Because of the risk of overfitting in these models that include many (and potentially closely related) explanatory variables, we report these additional models only in Appendix V, and offer a general comment on the overall results in Section 4.4.

One downside of using a panel model specification is that time-invariant variables will not be able to be included directly, and instead enter the model through the area unit fixed effects. In our case, this means that social deprivation (of which there is only one observation, at the 2013 Census) cannot be included in the model. However, we can evaluate the impact of social deprivation on the dependent variables by following a Hausman-Taylor approach (Hausman and Taylor, 1981). This involves a two-stage process. In the first stage the panel Poisson model is estimated, which includes estimation of all of the area unit specific fixed effects. The second stage involves regressing the area unit fixed effects (which are essentially the average effect of all time-invariant factors associated with the dependent variable) against the time-invariant variables, including social deprivation. This process allows us to estimate the relationship between the dependent variable and time-invariant variables, including social deprivation and land area. We report these second-stage results for each dependent variable at the end of the results for Model V.

4. Results and discussion

This section outlines and discusses the results of the statistical analysis. We consider the results with violence events in the most detail in Section 4.1, as this is the outcome variable most often considered in the international and New Zealand literature. We then summarise the key results for all other outcome variables in Section 4.2 (with additional detail on these models of other outcome variables provided in Appendix III). Section 4.3 looks at the extent to which these relationships have changed before and after the passing of the Sale and Supply of Alcohol Act on 18 December 2012. Finally, Section 4.4 briefly discusses the results of

other models that tested the effect of discontinuities around zero and non-linear effects of the number of alcohol outlets.

4.1 Violence events

The estimated regression equations for violence events (measured as the number of events per quarter in each CAU) are presented in Table 4 (page 25), including all five model specifications noted in the previous section. Note that each model includes two stages – the first stage includes as explanatory variables the counts of outlets (by type), population and its square, temporal lags of the dependent variable and total police events, and any significant interactions or spatial lags; and the second stage includes the time-invariant variables (land area, social deprivation, and the proportion of the population who are male aged 15-24 years). In the first stage regressions, the incidence rate ratios (IRRs) are reported, along with the standard errors on the coefficients.[10] The IRRs can be interpreted as the (multiplicative) increase in the incidence of violence events associated with a one unit increase in the explanatory variable. In the second stage regressions, the raw coefficients are reported, along with the standard errors on the coefficients. These coefficients are the linear (marginal) effect of a one-unit increase in the explanatory variable (land area or social deprivation) on the number of violence events.

In Model I, only bars and night clubs, and off-licence outlets are statistically significantly associated with greater levels of violence events, holding all else constant, though we note that off-licence outlets are only statistically significant at the 10% level of significance. An additional bar or night club is associated with 0.9 percent more violence events, and an additional off-licence is associated with 2.3 percent more violence events. In contrast, licensed clubs and other on-licence outlets (e.g. restaurants, cafés, and accommodation providers) show no statistically significant relationship with violence events. Population and its square are both highly statistically significant, demonstrating the significant non-linear relationship between resident population and violence. The coefficient on population is greater than one, and the coefficient on the square of population is less than one. This means that areas with larger populations have more violence events, but that the effect of additional population becomes smaller as the population of the CAU becomes larger.

[10] The coefficients can be obtained from the IRRs by taking the log of the IRRs.

Once serial correlation has been controlled for (Model II), no outlet types are statistically significant.[11] The temporal lag of violence events (the number of violence events in the previous quarter) is highly statistically significant, demonstrating that this control variable was necessary to account for serial correlation in the dependent variable.

Adding interactions between outlet types and social deprivation and population (Model III) changes the results somewhat. The direct effect of licensed clubs becomes statistically significant. However, the relationship between licensed clubs and violent events is not straightforward, because there is a significant interaction between the number of licensed clubs and social deprivation, as well as between the number of licensed clubs and population (we discuss the significant interactions in the discussion of Model V later in this section). The IRR for the interaction between licensed clubs and social deprivation is larger than one showing that holding population constant, while licensed clubs have an overall association with violence events that is positive, this association is largest in areas of low deprivation, and smallest in areas of high deprivation. The IRR for the interaction between licensed clubs and population is larger than one showing that holding social deprivation constant, while licensed clubs have an overall association with violence events that is positive, this association is largest in areas of low population, and smallest in areas of high population (see also the discussion of Model V below). In contrast to Model II, the coefficient on all off-licence outlets returns to statistical significance in Model III (at the 10% level of significance). In contrast, other on-licence outlets have an overall association with violent events that is negative and statistically significant, but this negative association is largest in areas of low deprivation, and becomes smaller in areas of high deprivation (see also discussion of Model V below). There are no significant interactions for bars and night clubs or off-licence outlets.

Model IV adds the temporal lag of police events (the number of police events in the previous quarter), which proves to be highly statistically significant and positive, but relatively small in magnitude. In other words, areas where police events have previously been recorded in larger numbers (which we argue is a proxy for areas where police target their resources and are therefore subject to a higher degree of guardianship), may be expected to have significantly more violence events.[12] This demonstrates that previous studies may suffer from an omitted variable bias because of the absence of this important control variable. We discuss

[11] As noted in Section 3.3, serial correlation reflects that areas that have in the past experienced more violence events are likely to have more violence events in the future.
[12] Though see Section 4.2 for more details on this.

the coefficient on the lag of police events in more detail in Section 4.2. In this model, licensed clubs become statistically insignificant as a predictor of violence events, while bars and night clubs return to (marginal) statistical significance. Other effects are similar in size and significance to Model III, with the exception of the interaction between social deprivation and licensed clubs, which becomes statistically insignificant.[13]

Finally, Model V adds spatial lags of the outlets (by type) and population.[14] Only licensed clubs and other on-licence outlets demonstrate statistically significant spatial lags. Both spatial lags are negative, suggesting that an additional licensed club or other on-licence outlet in surrounding areas is associated with significantly less violence. All other variables show effects that are similar in magnitude and statistical significance to the earlier models, except that the direct effect of licensed clubs returns to statistical significance and the effect of bars and night clubs becomes statistically insignificant. The statistically insignificant interaction between social deprivation and licensed clubs is dropped from this model.

The direct effects (where relationships are not mediated by interactions) in Model V can be interpreted easily. An additional off-licence outlet is associated with 1.2 percent greater incidence of violence events (see the following pages for the interpretation of effects for licensed clubs and other on-licence outlets, where the interaction effects are also statistically significant).

In the second stage of Model V, holding all other factors constant, larger Census Area Units have statistically significantly fewer violence events. This probably arises because land area of CAUs is a proxy for differences between rural (large CAUs) and urban (small CAUs) areas. In other words, this result demonstrates that, holding all else constant, violence events happen more frequently in urban areas. Social deprivation shows a statistically significant and positive relationship with violence events, demonstrating that holding all else constant, significantly more violence occurs in more deprived areas. Finally, a higher proportion of young males (aged 15-24) living in an area is associated with significantly more violence events.

[13] This is likely because the lag of police events captures the variation in violence events that was explained by this interaction in Models I-III.
[14] As noted in Section 3.3, spatial lags represent the number of outlets (or population) in *surrounding* areas, so these variables capture any relationship between violence events in one area, and the number of alcohol outlets (or population) in surrounding areas.

Table 4: Results – Violence events

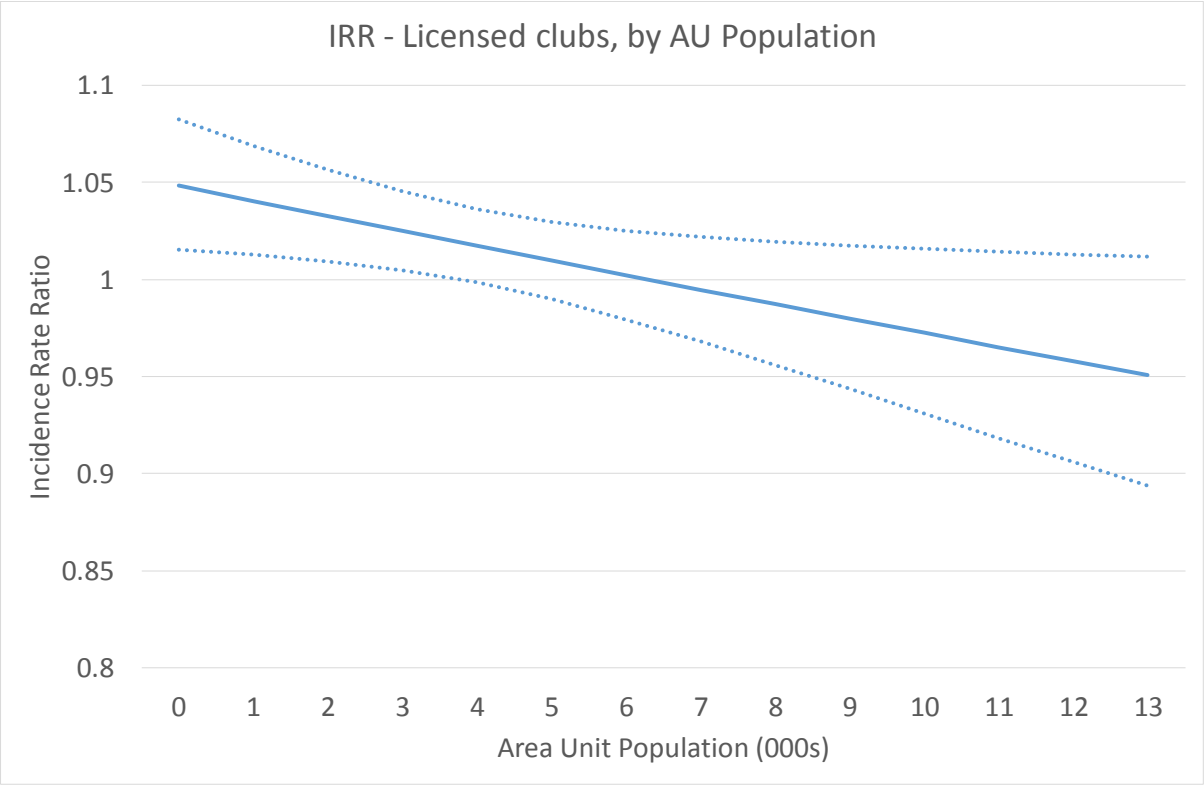
	Model I	Model II	Model III	Model IV	Model V
First stage:					
Licensed clubs	1.032 (0.023)	1.014 (0.011)	1.303** (0.109)	1.227 (0.130)	1.048*** (0.016)
Bars and night clubs	1.009** (0.003)	1.003 (0.002)	1.002 (0.002)	1.004* (0.002)	1.005 (0.003)
Other on-licence	0.999 (0.003)	0.999 (0.001)	0.954*** (0.016)	0.940*** (0.018)	0.948*** (0.018)
All off-licence	1.023* (0.014)	1.006 (0.006)	1.003* (0.005)	1.007* (0.004)	1.012*** (0.004)
Population (000s)	1.256*** (0.076)	1.192*** (0.052)	1.281*** (0.057)	1.287*** (0.054)	1.318*** (0.050)
Population squared	0.985*** (0.005)	0.991*** (0.003)	0.986*** (0.003)	0.984*** (0.003)	0.983*** (0.002)
Temporal lag of violence events	-	1.009*** (0.001)	1.008*** (0.001)	1.005*** (0.001)	1.005*** (0.001)
Social deprivation * Licensed clubs	-	-	0.9998* (<0.001)	0.9999 (<0.001)	-
Social deprivation * Other on-licence	-	-	1.00004*** (<0.001)	1.0001*** (<0.001)	1.00005*** (<0.001)
Population * Licensed clubs	-	-	0.991*** (0.003)	0.993** (0.004)	0.993*** (0.003)
Temporal lag of all police events	-	-	-	1.001*** (<0.001)	1.001*** (<0.001)
Spatial lag of licensed clubs	-	-	-	-	0.911** (0.042)
Spatial lag of other on-licence	-	-	-	-	0.982** (0.009)
Second stage:					
Area (sq. km)	-	-	-	-	-0.0002*** (<0.001)
Social deprivation	-	-	-	-	0.007*** (<0.001)
Proportion young (15-24) males	-	-	-	-	0.042*** (0.009)

*** p<0.01; ** p<0.05; * p<0.1; direct effects that are mediated by interactions are in shaded cells.

In Models III-V, the presence of statistically significant interaction terms makes interpreting the relationships less straightforward for licensed clubs and for other on-licence outlets. Instead, we need to consider how the relationship changes over the relevant range of social

deprivation (or population) values. Figure 2 displays the relationship between licensed clubs and violence events across the relevant range of population. The solid line is the point estimate of the relationship at each level of social deprivation, while the dotted lines represent the 95% confidence interval. Where the range between the dotted lines encompasses one, the relationship is statistically insignificant, while where the range between the dotted lines lies everywhere above (or below) one, the relationship is statistically significant.

Figure 2: Relationship between licensed clubs and violence events, by population

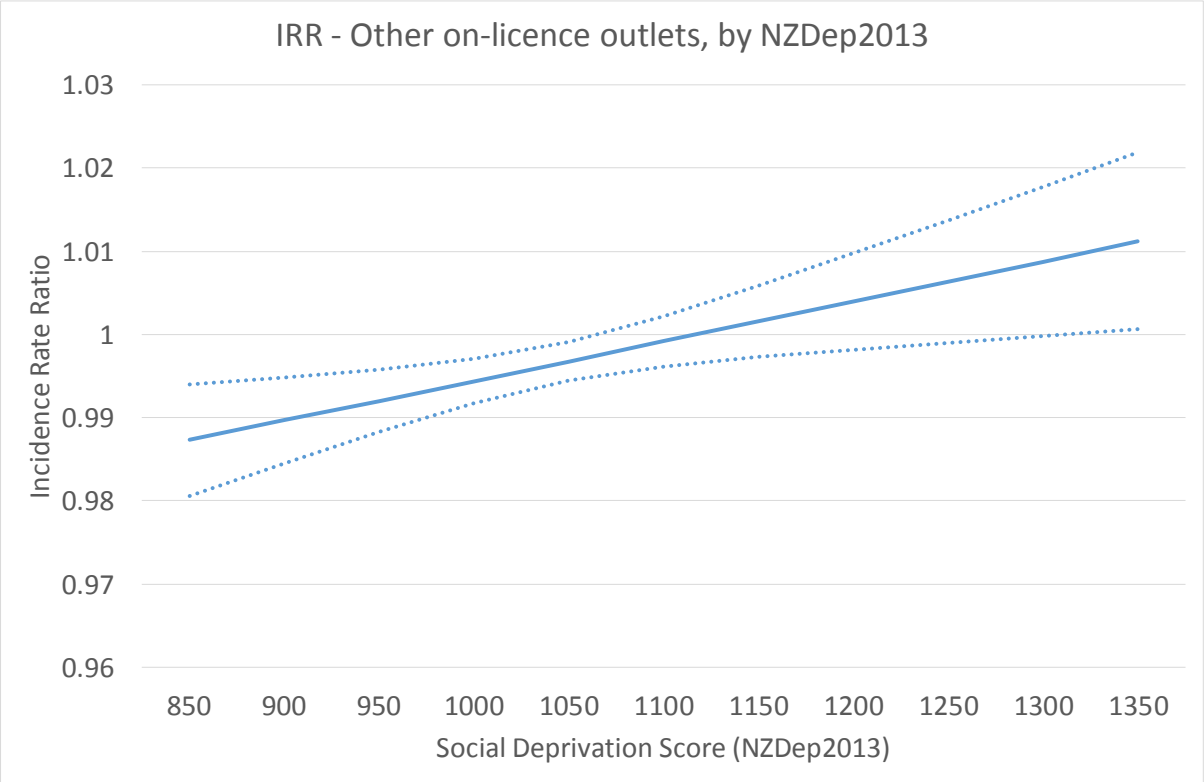


As shown in Figure 2, in Census Area Units with small populations the IRR is greater than one (more licensed clubs are associated with more violence), and this positive relationship is statistically significant (at the 5% level) up to populations of about 3000. Since the median population size is 2120 (refer to Table 2), this positive relationship is apparent for more than half of all Census Area Units, being those with the smallest populations (often rural areas and urban areas with low population density). In Census Area Units with populations greater than 3000, the IRR is not statistically significantly different from one, so the relationship between

licensed clubs and violence is only statistically significant for areas with small to average populations (though noting that this is apparent for the majority of Census Area Units).

Figure 3 displays the relationship between other on-licence outlets (restaurants, cafés, etc.) and violence events across the relevant range of social deprivation scores. At low levels of social deprivation, the IRR is less than one (more other on-licence outlets are associated with less violence), and this negative relationship is statistically significant (at the 5% level) up to a social deprivation score of more than 1050. Since the median social deprivation score is 976 and mean score 995 (refer to Table 2), this negative relationship is apparent for substantially more than half of all Census Area Units, being those with the lowest social deprivation levels (i.e. the 'richest' areas). At high levels of social deprivation, the IRR is greater than one (more other on-licence outlets are associated with more violence), but this positive relationship is only statistically significant (at the 5% level) at deprivation scores above about 1325, which includes only a handful of the most deprived areas in the country.

Figure 3: Relationship between other on-licence outlets and violence events, by social deprivation



4.2 Other outcome variables

In this section we present the results for other outcome variables. Rather than the detailed exposition of all Models I-V as in the previous section on violence events, we instead present only the results for Model V for each outcome variable. Interested readers can find the other model specifications (Models I-IV) for each outcome variable in Appendix III.

The estimated regression equations for other outcome variables (each corresponding to Model V) are presented in Table 5 (page 31). In terms of the control variables, the temporal lag of the dependent variable is statistically significant and positive in all models except for sexual offences and motor vehicle accidents. As with violence events in the previous section, this demonstrates that there is significant serial correlation in most models.[15]

The lag of police events is statistically significant and positive in all models except dishonesty offences, drug and alcohol offences, and motor vehicle accidents. As with violence events in the previous section, this demonstrates that policing intensity or guardianship is important to control for in these models. However, the sign of the coefficient on policing is positive (as it was for violence events in the previous section), which is not necessarily the expected sign. If the lag of police activity variable is picking up the presence of guardians (consistent with routine activity theory), then the IRR should be less than one. That is, more intensive policing should be associated with lower incidence of crime. However, when the relationship is statistically significant, the IRR is always larger than one, such that more intensive policing is associated with higher incidence of crime. However, we note that policing intensity serves two functions. First, the presence of police has a deterrent or preventive effect – greater police presence leads to less crime, as criminals are less likely to commit crime in relative proximity to police. Second, the presence of police leads to an intervention or apprehension effect – greater police presence leads to an increase in apprehensions, which would be recorded as additional police events in our data. Since, we cannot separate the deterrent and intervention effects with our data, we conclude that the second effect must be dominating.

Population and its square are significant for most outcome variables, showing a positive non-linear relationship between population and crime, as shown in the previous section for

[15] As noted in Section 3.3, serial correlation reflects that areas that have in the past experienced more harm events, such as violence events, are likely to have more harm events in the future.

violence events. In other words, areas with larger populations have higher levels of crime, but the crime increases with population at a decreasing rate.

Among the second stage variables, land area is statistically significant and negative in all models except for motor vehicle accidents, where it is statistically significant and positive, and property abuses, where it is statistically insignificant. This is consistent with most crime (except property abuses) being more likely to occur in urban areas, while motor vehicle accidents are more likely to occur in rural areas (after controlling for other variables), where there are more open roads with higher speeds. Social deprivation is positive and statistically significant in all models except for motor vehicle accidents, where it is statistically insignificant. This is consistent with socially deprived areas having more crime (as would be expected), but not more motor vehicle accidents. Finally, the proportion of young males in the population is positive and statistically significant in all models except sexual offences. Again, this is mostly consistent with what might be expected.

As for alcohol outlets, the relationships vary substantially between alcohol outlet types. Licensed clubs have no statistically significant un-mediated impacts on the outcome variables. As noted in the previous section, the relationship between licensed clubs and violence events is mediated by population (with a statistically significant relationship only observed for low-population areas). For dishonesty offences, the relationship with licensed clubs is mediated by social deprivation (shown in Figure 4, page 32). A statistically significant and positive relationship is observed between licensed clubs and dishonesty offences for low-deprivation areas (below a social deprivation score of about 1000), while in high deprivation areas (deprivation scores above about 1150) there is a statistically significant and negative relationship between licensed clubs and dishonesty offences. A similar mediated relationship is observed between licensed clubs and sexual offences (shown in Figure 5, page 32), where the relationship is significant and positive in very low-deprivation areas (below a social deprivation score of about 875), but significant and negative in high deprivation areas (deprivation scores above about 1100).

Bars and night clubs have a significant and positive un-mediated relationship with antisocial behaviour events, where an additional bar or night club in an area is associated with a 0.4 percent higher incidence of antisocial behaviour. Bars and night clubs have significant and negative un-mediated relationships with drug and alcohol offences, and sexual offences. For property abuses, the relationship with bars and night clubs is mediated by population (shown

in Figure 6, page 33). In low population areas (below a population of about 2500) the relationship is negative and statistically significant, but the relationship is positive and statistically significant in high population areas (above a population of about 5000). The mediated relationship between bars and night clubs and property damage is similar (shown in Figure 7, page 33). In low population areas (below a population of about 3500) the relationship is negative and statistically significant, but in higher population areas the relationship is statistically insignificant. These results are consistent with bars and night clubs in more urban areas being related to higher incidence of property crime, but bars and night clubs in more rural areas being related to lower incidence of property crime.

Other on-licence outlets (restaurants and cafés, etc.) have significant and negative un-mediated relationships with dishonesty offences and property damage events. For motor vehicle accidents, the relationship with other on-licence outlets is mediated by social deprivation (shown in Figure 8, page 34). A statistically significant and positive relationship is observed between other on-licence outlets and motor vehicle accidents only for high-deprivation areas (above a social deprivation score of about 1025), while in lower deprivation areas the relationship is statistically insignificant.

Finally, off-licence outlets have significant and positive un-mediated relationships with antisocial behaviour and sexual offences, where an additional off-licence outlet in an area is associated with a 1.3 percent higher incidence of antisocial behaviour and a 1.9 percent higher incidence of sexual offences. For drug and alcohol offences, the relationship with off-licence outlets is mediated by population (shown in Figure 9, page 34). In low population areas (below a population of about 7500) the relationship is positive and statistically significant, but the relationship is statistically insignificant in higher population areas. The relationship is similar for property damage events (shown in Figure 10, page 35), although despite the downward sloping relationship it is statistically insignificant for both low and high population areas. The relationship is also similar for motor vehicle accidents (shown in Figure 11, page 35), with the relationship being positive and statistically significant in low population areas (below a population of about 5000), but statistically insignificant in higher population areas. This is consistent with off-licence outlets in more rural areas being associated with these outcomes, but not outlets in more urban areas.

Table 5: Results – Other outcome variables (Model V)

Dependent variable	Antisocial behaviour	Dishonesty offences	Drug and alcohol offences	Property abuses	Property damage	Sexual offences	Motor vehicle accidents
First stage:							
Licensed clubs	0.995 (0.008)	1.400*** (0.132)	0.982 (0.030)	0.996 (0.015)	0.995 (0.009)	1.757** (0.246)	1.0005 (0.017)
Bars and night clubs	1.004*** (0.002)	0.999 (0.003)	0.977** (0.011)	0.992*** (0.003)	0.991*** (0.002)	0.987*** (0.004)	0.993 (0.008)
Other on-licence	0.997 (0.002)	0.997* (0.002)	1.005 (0.005)	0.999 (0.001)	0.997** (0.001)	1.002 (0.003)	0.918** (0.041)
All off-licence	1.013*** (0.003)	1.009 (0.007)	1.064*** (0.016)	1.006 (0.005)	1.015* (0.008)	1.019** (0.008)	1.026** (0.009)
Population (000s)	1.221*** (0.045)	1.158*** (0.036)	1.199** (0.087)	1.077 (0.051)	1.074 (0.044)	1.097 (0.129)	1.281*** (0.075)
Population squared	0.991*** (0.002)	0.992*** (0.002)	0.997 (0.007)	0.991*** (0.002)	0.999 (0.003)	0.994 (0.007)	0.992* (0.004)
Temporal lag of dependent variable	1.003*** (<0.001)	1.003*** (<0.001)	1.007*** (0.002)	1.007*** (0.002)	1.011*** (0.001)	1.002 (0.004)	0.999 (0.002)
Social deprivation * Licensed clubs	-	0.9997** (<0.001)	-	-	-	0.999** (<0.001)	-
Social deprivation * Other on-licence	-	-	-	-	-	-	1.0001** (<0.001)
Population * Bars & night clubs	-	-	-	1.002*** (0.001)	1.001** (0.001)	-	-
Population * All off-licence	-	-	0.995* (0.003)	-	0.998** (0.001)	-	0.997** (0.001)
Temporal lag of all police events	1.001*** (<0.001)	1.0002 (<0.001)	1.001 (0.001)	1.001*** (<0.001)	1.001*** (<0.001)	1.001** (<0.001)	1.0002 (<0.001)
Spatial lag of licensed clubs	0.908** (0.046)	1.082* (0.046)	0.798* (0.115)	-	-	0.787* (0.124)	-
Spatial lag of bars and night clubs	-	-	0.941*** (0.023)	0.970** (0.014)	-	0.899*** (0.039)	-
Spatial lag of other on-licence	-	0.963*** (0.013)	-	-	-	-	-
Spatial lag of off-licence	-	1.084* (0.045)	-	-	-	1.118** (0.049)	-
Spatial lag of population	0.670*** (0.118)	1.419** (0.162)	-	-	-	1.755** (0.277)	-
Spatial lag of population-squared	-	0.971** (0.015)	-	-	-	0.950* (0.028)	-
Second stage:							
Area (sq. km)	-0.001*** (<0.001)	-0.0002*** (<0.001)	-0.0001** (<0.001)	-0.0004 (<0.001)	-0.0003*** (<0.001)	-0.0003*** (<0.001)	0.001*** (<0.001)
Social deprivation	0.007*** (<0.001)	0.004*** (<0.001)	0.005*** (0.001)	0.006*** (<0.001)	0.005*** (<0.001)	0.004*** (<0.001)	-0.0003 (<0.001)
Proportion young (15-24) males	0.090*** (0.020)	0.071*** (0.015)	0.033** (0.017)	0.050*** (0.012)	0.047*** (0.012)	0.016 (0.017)	0.062*** (0.010)

*** $p<0.01$; ** $p<0.05$; * $p<0.1$; direct effects that are mediated by interactions are in shaded cells.

Figure 4: Relationship between licensed clubs and dishonesty offences, by social deprivation

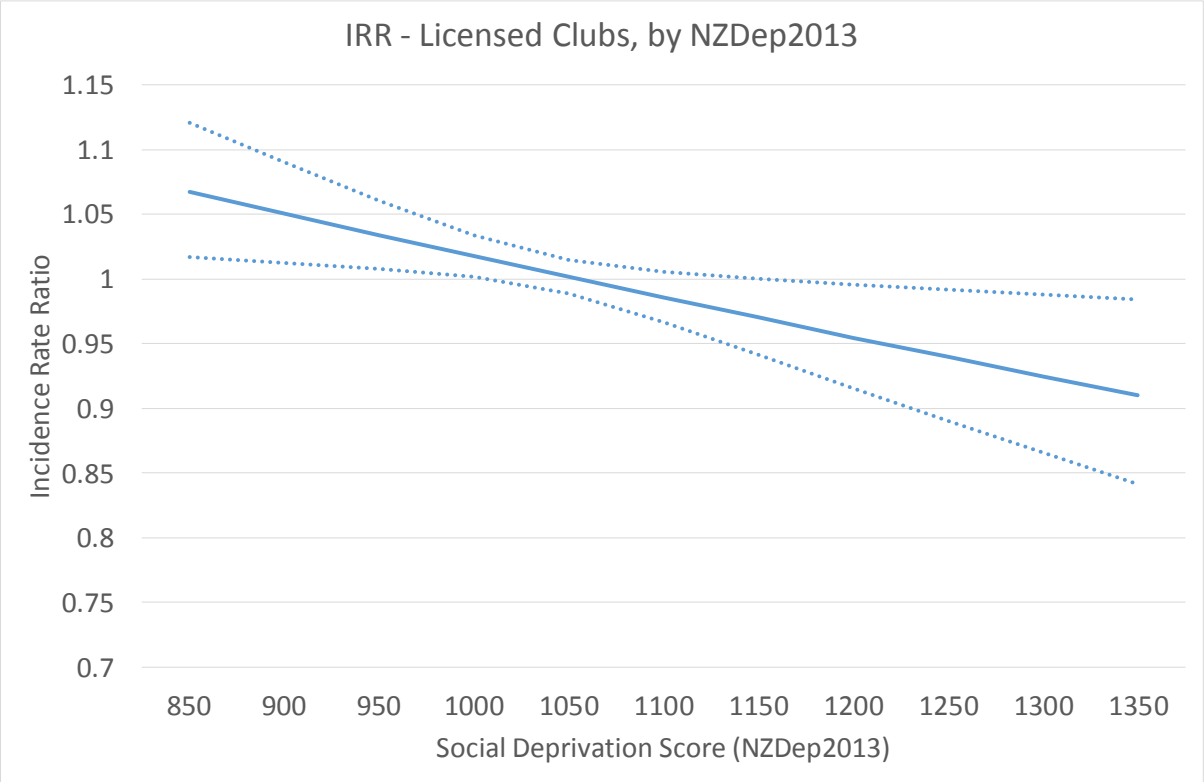


Figure 5: Relationship between licensed clubs and sexual offences, by social deprivation

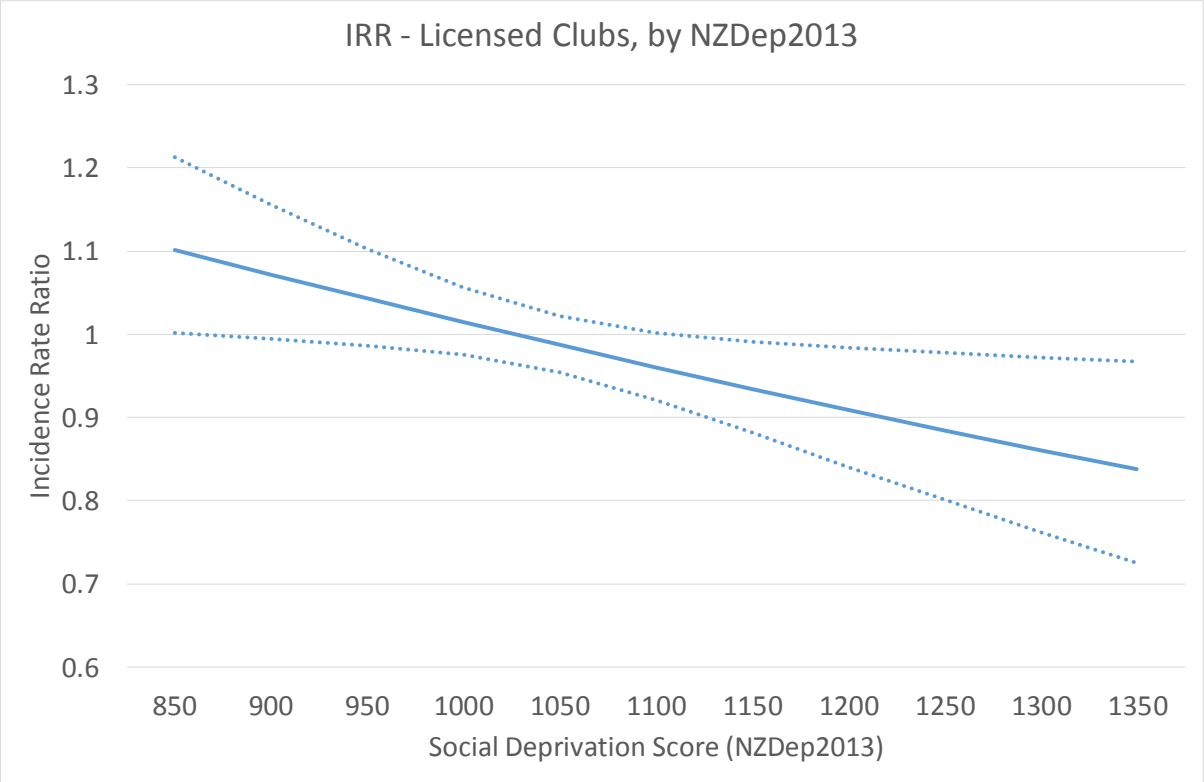


Figure 6: Relationship between bars and night clubs and property abuses, by population

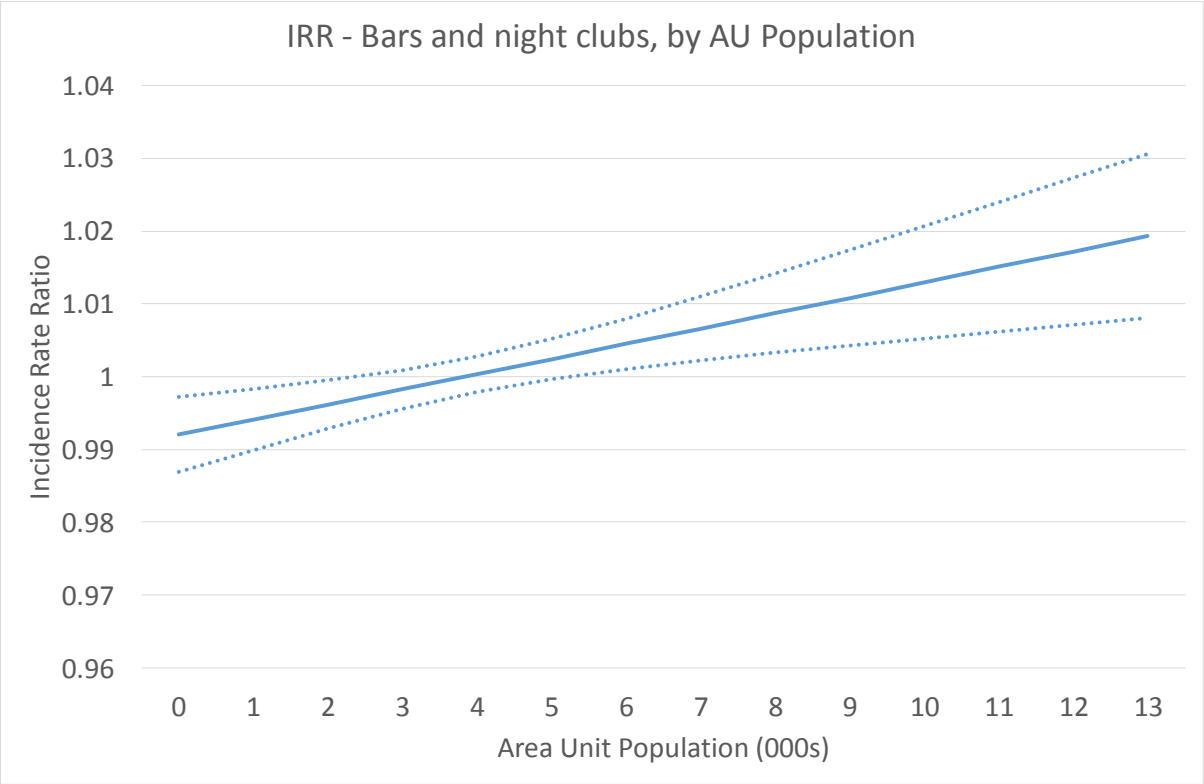


Figure 7: Relationship between bars and night clubs and property damage, by population

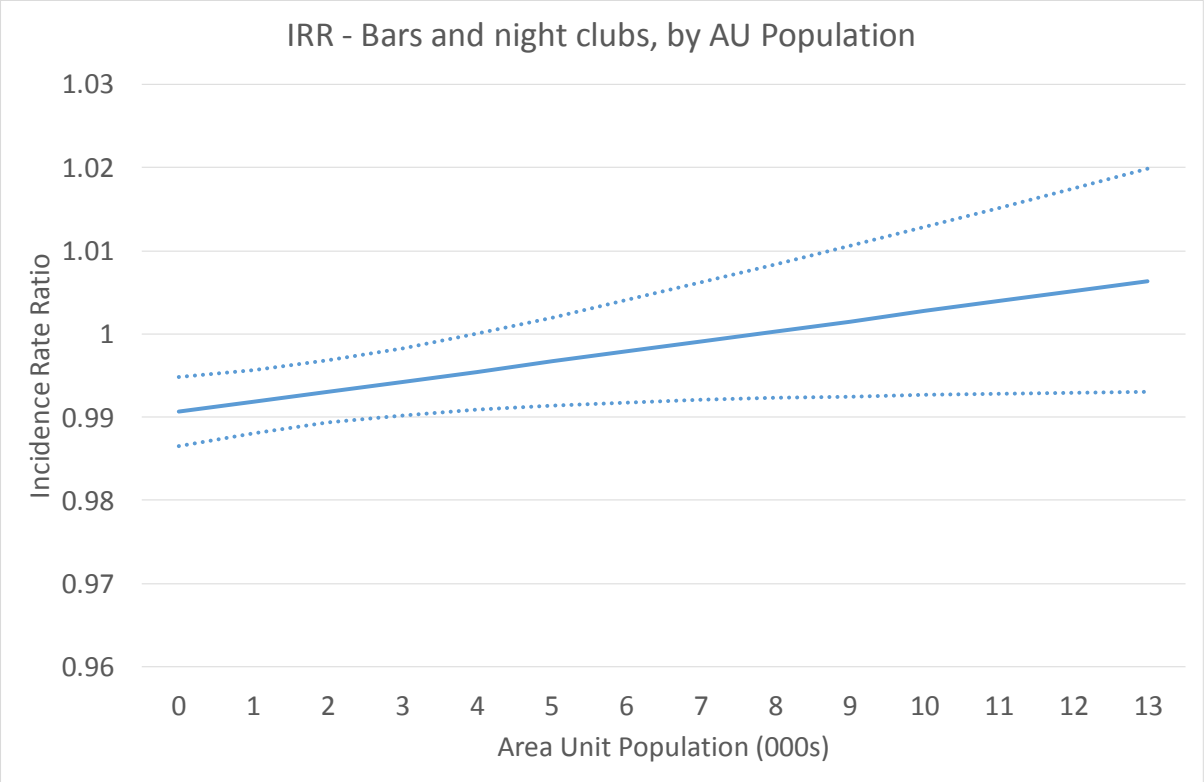


Figure 8: Relationship between other on-licence outlets and motor vehicle accidents, by social deprivation

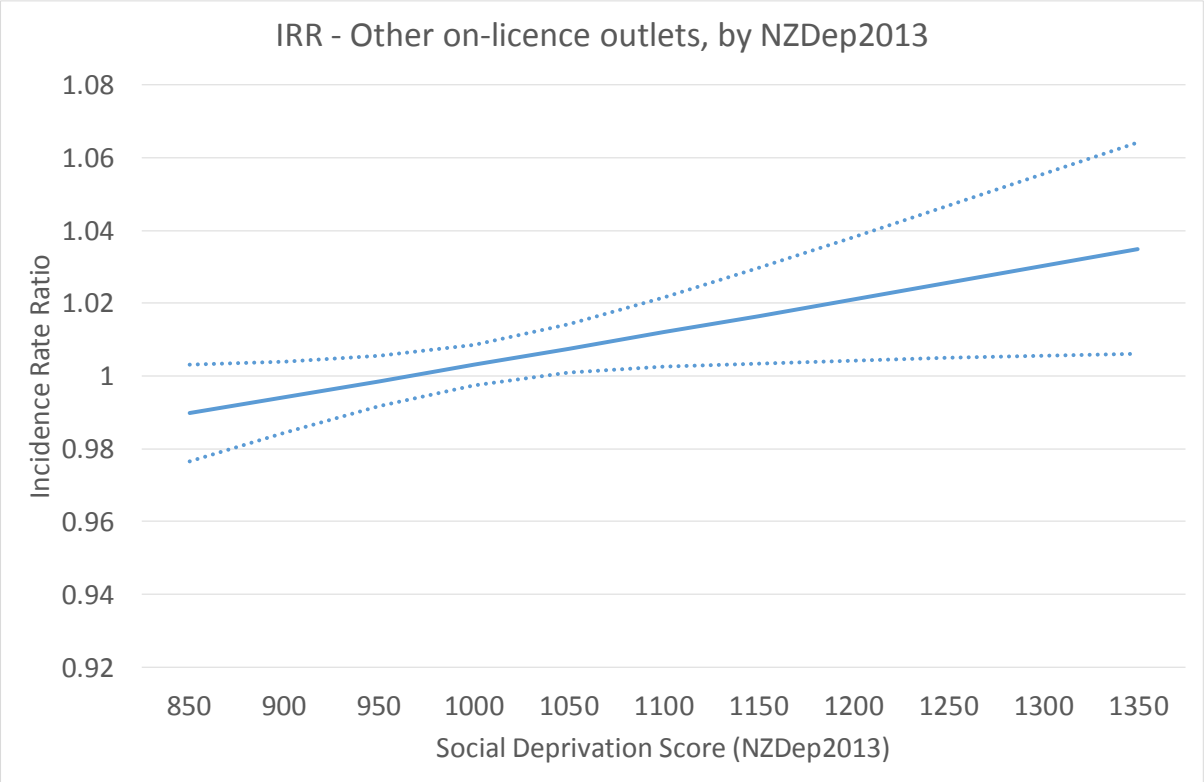


Figure 9: Relationship between off-licence outlets and drug and alcohol offences, by population

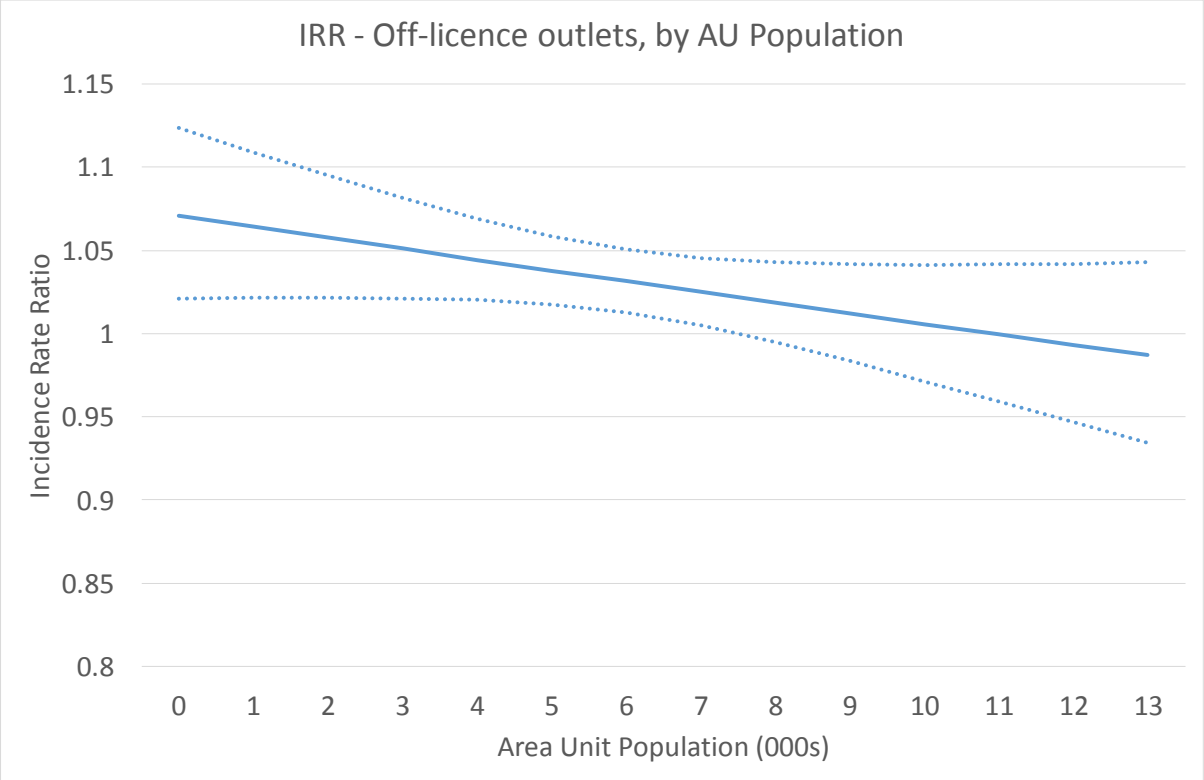


Figure 10: Relationship between off-licence outlets and property damage, by population

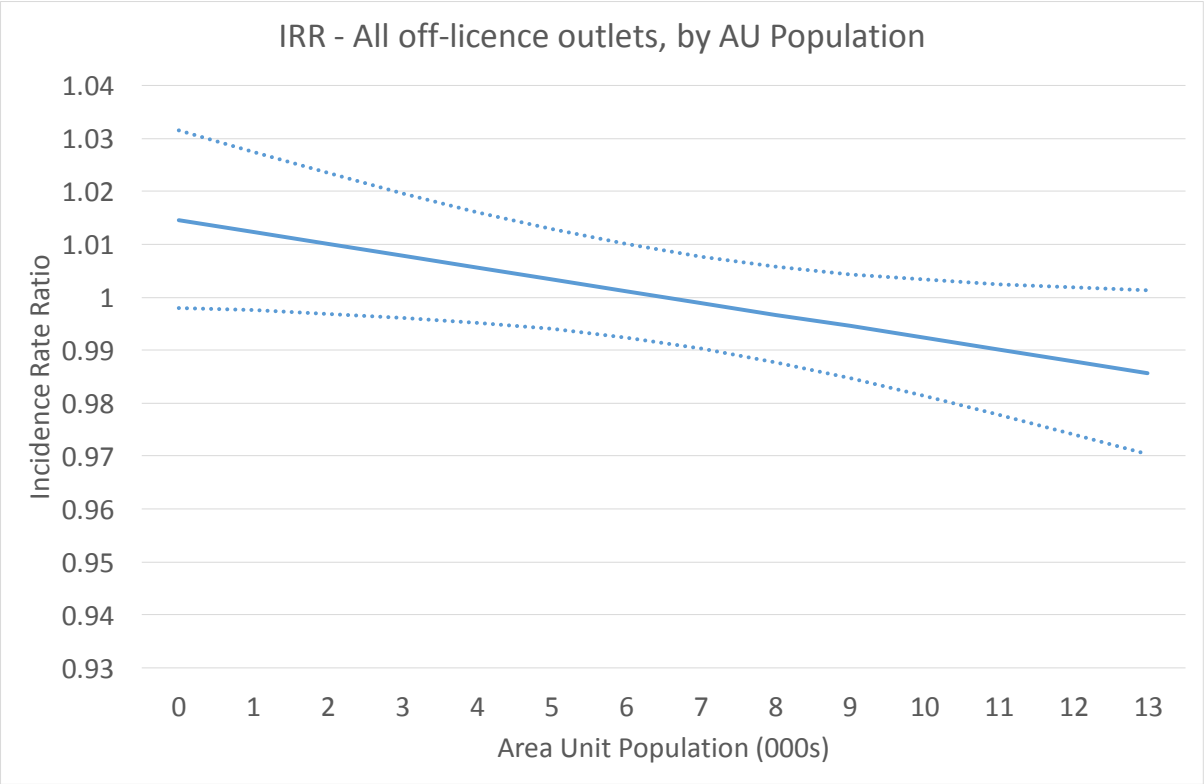


Figure 11: Relationship between off-licence outlets and motor vehicle accidents, by population

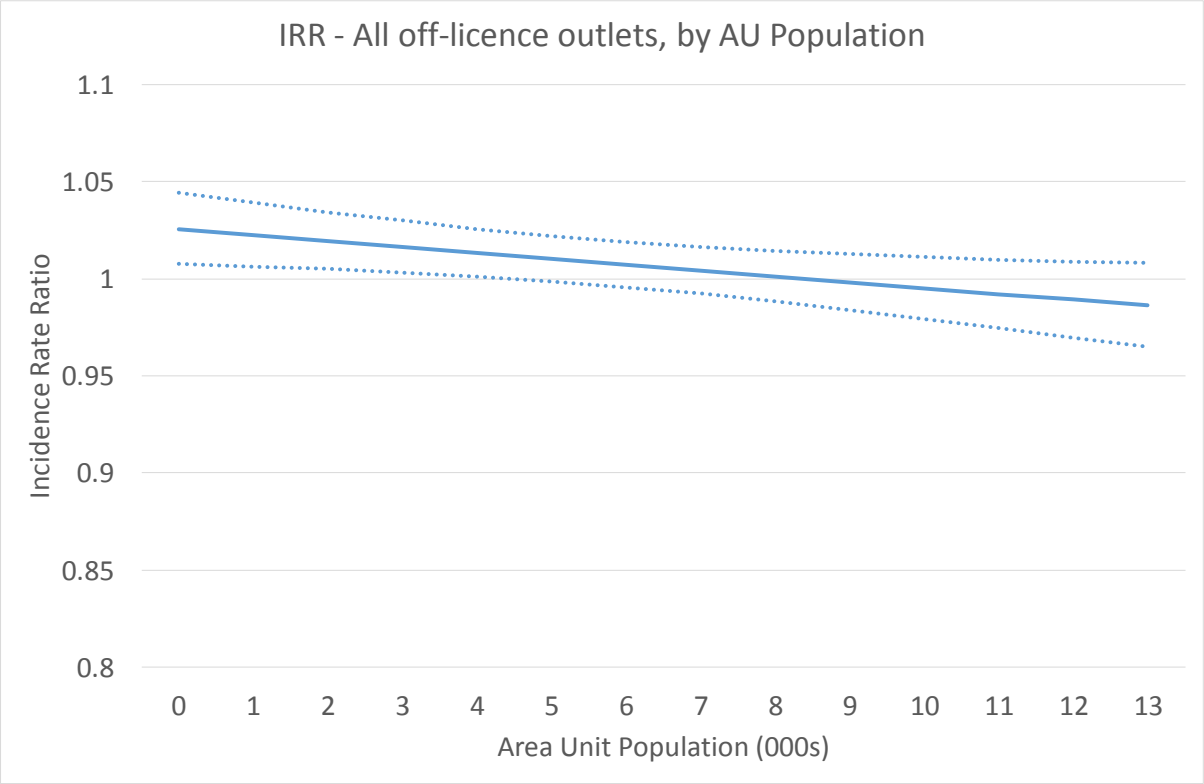


Table 6 summarises all of the relationships between the number of alcohol outlets (by type) and the number of police events or motor vehicle accidents (using the Model V results from Tables 4 and 5). To incorporate all of the mediated effects, we show the relationships for combinations of 'low' and 'high' population and 'low' and 'high' social deprivation. Where the relationship is positive and statistically significant, this is denoted "Positive"; where the relationship is negative and statistically significant, this is denoted "Negative"; and where the relationship is statistically insignificant, this is denoted "NS". We don't note the exact numerical relationships in this table – for those details, refer to Tables 4 and 5. In general, off-licence outlets have the most consistently positive relationships with police events and motor vehicle accidents, while the relationships for other outlet types are more mixed.

Table 6: Summary of results for alcohol outlets (by type) – Model V

Dependent variable	Population	Social deprivation	Licensed clubs	Bars and night clubs	Other on-licence	All off-licence
Violence events	Low	Low	**Positive**	NS	**Negative**	**Positive**
	Low	High	**Positive**	NS	**NS/Positive**	**Positive**
	High	Low	NS	NS	**Negative**	**Positive**
	High	High	NS	NS	**NS/Positive**	**Positive**
Antisocial behaviour	Low	Low	NS	**Positive**	NS	**Positive**
	Low	High	NS	**Positive**	NS	**Positive**
	High	Low	NS	**Positive**	NS	**Positive**
	High	High	NS	**Positive**	NS	**Positive**
Dishonesty offences	Low	Low	**Positive**	NS	**Negative**	NS
	Low	High	**Negative**	NS	**Negative**	NS
	High	Low	**Positive**	NS	**Negative**	NS
	High	High	**Negative**	NS	**Negative**	NS
Drug and alcohol offences	Low	Low	NS	**Negative**	NS	**Positive**
	Low	High	NS	**Negative**	NS	**Positive**
	High	Low	NS	**Negative**	NS	NS
	High	High	NS	**Negative**	NS	NS
Property abuses	Low	Low	NS	**Negative**	NS	NS
	Low	High	NS	**Negative**	NS	NS
	High	Low	NS	**Positive**	NS	NS
	High	High	NS	**Positive**	NS	NS
Property damage	Low	Low	NS	**Negative**	**Negative**	NS
	Low	High	NS	**Negative**	**Negative**	NS
	High	Low	NS	NS	**Negative**	NS
	High	High	NS	NS	**Negative**	NS
Sexual offences	Low	Low	**Positive**	**Negative**	NS	**Positive**
	Low	High	**Negative**	**Negative**	NS	**Positive**
	High	Low	**Positive**	**Negative**	NS	**Positive**
	High	High	**Negative**	**Negative**	NS	**Positive**
Motor vehicle accidents	Low	Low	NS	NS	NS	**Positive**
	Low	High	NS	NS	**Positive**	**Positive**
	High	Low	NS	NS	NS	NS
	High	High	NS	NS	**Positive**	NS

4.3 The Sale and Supply of Alcohol Act

In this section we present the results for models including interactions with the period of time following the passing of the Sale and Supply of Alcohol Act in December 2012. Additional models, showing interactions with the period of time following the implementation of the Act in December 2013 are included in Appendix IV.

The estimated regression equations (each corresponding to Model IV, plus statistically significant interactions) are presented in Table 7. The SSAA variable is a dummy variable set equal to one for the period from 2013Q1 onwards.[16] Models that included no statistically significant interactions with the SSAA variable are excluded from Table 7.

There are significant interactions for five of the eight outcome variables (dishonesty offences, drug and alcohol offences, property abuses, property damage, and motor vehicle accidents). In all five cases, there is a significant positive interaction between the SSAA dummy variable and the number of off-licence outlets in an area. This suggests that the relationship between the number of off-licence outlets and the outcome variables has become more positive since the passing of the SSAA. That is, off-licence outlets are now associated with *more* harm than they were in the period before the SSAA was passed. For instance, while an additional off-licence outlet in an area is associated with 0.6 percent higher incidence of dishonesty offences before the passing of the SSAA, after the passing of the SSAA an additional off-licence outlet is associated with 2.7 percent higher incidence of dishonesty offences (and this difference is statistically significant).[17]

In contrast, the other significant interactions are all negative, suggesting relationships between outlets and outcome variables that become less positive (or more negative) after the passing of the SSAA. This is the case for the relationship between dishonesty offences and other on-licence outlets; the relationship between drug and alcohol offences and bars and night clubs; and the relationship between property damage and licensed clubs.

[16] For simplicity, we present only first-stage estimates rather than the full model. Second stage estimates are very similar to those reported in Sections 4.1 and 4.2.

[17] The incidence rate ratio for the period after the passing of the SSAA can be approximated by adding the IRR for off-licence outlets with the IRR for the interaction term. This is not perfect, but is a useful approximation. However, care should be taken in interpreting the interactions where there are also significant interactions with other variables.

Table 7: Results – Sale and Supply of Alcohol Act (Model IV plus SSAA interactions)

Dependent variable	Dishonesty offences	Drug and alcohol offences	Property abuses	Property damage	Motor vehicle accidents
Licensed clubs	1.479*** (0.131)	0.980 (0.023)	0.999 (0.016)	0.996 (0.009)	1.003 (0.017)
Bars and night clubs	0.996* (0.002)	0.958*** (0.008)	0.993** (0.003)	0.991*** (0.002)	0.993 (0.008)
Other on-licence	0.999 (0.002)	1.012*** (0.003)	0.999 (0.002)	0.998 (0.002)	0.898*** (0.038)
All off-licence	1.006** (0.003)	1.070*** (0.026)	1.004 (0.009)	1.017** (0.008)	1.032*** (0.010)
Population (000s)	1.225*** (0.033)	1.045 (0.070)	1.072 (0.053)	1.071 (0.043)	1.284*** (0.081)
Population squared	0.984*** (0.001)	0.997 (0.007)	0.991*** (0.002)	0.9998 (0.003)	0.992 (0.005)
Temporal lag of dependent variable	1.003*** (<0.001)	1.006*** (0.002)	1.007*** (0.002)	1.011*** (0.001)	0.999 (0.002)
Social deprivation * Licensed clubs	0.9996** (<0.001)	-	-	-	-
Social deprivation * Other on-licence	-	-	-	-	1.0001** (<0.001)
Population * Bars & night clubs	-	1.005*** (0.001)	1.002*** (0.001)	1.001 (0.001)	-
Population * Other on-licence	-	0.999* (0.001)	-	-	-
Population * All off-licence	-	0.995** (0.003)	-	0.997*** (0.001)	0.997** (0.001)
Temporal lag of all police events	1.0002** (<0.001)	1.001* (0.001)	1.001*** (<0.001)	1.001*** (<0.001)	1.0002 (<0.001)
SSAA * Licensed clubs	-	-	-	0.986** (0.005)	-
SSAA * Bars & night clubs	-	0.994* (0.004)	-	-	-
SSAA * Other on-licence	0.998*** (0.001)	-	-	-	-
SSAA * All off-licence	1.021*** (0.003)	1.039*** (0.012)	1.007*** (0.002)	1.014*** (0.004)	1.010*** (0.003)

*** $p<0.01$; ** $p<0.05$; * $p<0.1$; direct effects that are mediated by interactions are in shaded cells.

The additional results (using the implementation date rather than the date of passing of the SSAA) provide similar evidence in terms of the changing relationships for off-licence outlets. However, they also provide suggestive evidence that the effect of bars and night clubs has become less positive (or more negative) after the implementation of the SSAA. However,

these results must be treated with some caution, as there are only two quarters of observations in the dataset occurring after the implementation of the SSAA.

4.4 Other models

As noted earlier, we ran a number of other models to test whether there were: (1) discontinuities in the relationship between outlets and each dependent variable for the first outlet, i.e. whether the first outlet in a particular area has an outsized effect on the dependent variable; and (2) non-linear (in this case, quadratic) effects of alcohol outlets. There were no generalised results, although there is suggestive evidence that the effects of other on-licence outlets (restaurants, cafés, etc.) may be non-linear. We report the results in Appendix V. We do not include these results in the main report because we are concerned about the risk of overfitting in these models due to the inclusion of many (and potentially closely related) explanatory variables.

The third objective of this project was to evaluate the direct and mediating effects of local alcohol policies on the relationships between alcohol outlet density and police activity. Unfortunately, due to a lack of data from the period after the first LAPs became operative (in 2014), we could not complete this evaluation.

5. Conclusions

This report investigated the relationships between alcohol outlets and social harms, using panel data for New Zealand for the period 2007-2014. Our approach in this report involves a number of advances over previous methods used to estimate these relationships. First, we make use of longitudinal panel data, which goes some way towards mitigating issues of spurious correlation. Second, we estimate models of counts rather than densities (per unit population, area, or road miles), which overcomes a theoretical issue that potentially undermines the robustness of earlier research. Third, we evaluate the mediating effects of population and social deprivation on the relationships. This provides a more defendable analysis of how the relationships between alcohol outlets and social harms vary spatially, since if the relationships vary by population and/or social deprivation, then their spatial variations can be more readily explained.

Our results are broadly similar to those from the earlier literature. However, the effects are generally much smaller in magnitude than those estimated in earlier research. For instance, Cameron et al. (2012d) estimated that an additional bar or night club was associated with 2.1 additional violence events in 2008/09 in Manukau City. This represented an increase of about 6 percent. Cameron et al. (2016a) found that an additional bar or night club was associated with an additional 5.3 violence events per year, using data from 2006-2011 for the entire North Island. However, in this report we find that an additional bar or night club is associated with a statistically insignificant 0.5 percent higher incidence of violence events. The smaller magnitude of effects arises because the panel data allows us to control for unobserved characteristics of the areas that are associated with both additional crime, and the location of alcohol outlets.

However, despite the generally smaller coefficients than earlier research, there are a number of commonalities. In particular, off-licence outlets appear to have a number of relationships with alcohol-related social harms. These relationships have generally been smaller in earlier New Zealand research, but in this work the coefficients are demonstrably larger for off-licence outlets than the for other outlet types. This may have arisen because of the shift from cross-sectional to longitudinal panel data (allowing the unobserved characteristics of areas to be controlled for in the model), or because of the inclusion of police activity within the model. In the case of the latter, the smaller coefficients on bars and night clubs may arise because police activity may concentrate in those areas, particularly at night and on weekends.

Moreover, the relationship between outlets and social harm are mediated by population and social deprivation in a number of cases. In other words, the relationship between outlets and social harm depends on the local context, and may differ between urban and rural areas, or between more-deprived and less-deprived areas. To generalise, social deprivation appears to be more of a mediating influence on the relationships for licensed clubs and other on-licence outlets (primarily restaurants and cafés), while population (a proxy for rural or urban location) appears to be more of a mediating influence on the relationships for bars and night clubs, and off-licence outlets. Further qualitative research may be necessary to understand why these mediating relationships exist.

This research project set out to evaluate whether the relationships changed between the period before the implementation of the SSAA, and after. Our results show some suggestive evidence that the relationships between off-licence outlets and social harms have become

larger (more positive) since the passing of the SSAA. However, the short period of data available after the implementation of the SSAA meant that the statistical tests were under-powered to identify substantial and robust changes in these relationships. Future research should extend the panel dataset used in this report to evaluate this question, now that additional periods of data are available.

It is worth noting some limitations of this research. While this report adds to the growing weight of literature in New Zealand showing significant relationships between alcohol outlets and measures of alcohol-related harm, and is among the first to apply panel data in this context, we are unable to definitively establish causality. Thus, we cannot say for certain that outlet density is the cause of the higher (or lower) numbers of police events or motor vehicle accidents in each CAU. Notwithstanding this concern, our results are broadly consistent with the past literature in that there are a number of statistically significant and positive relationships between alcohol outlets (of various types) and social harms. Our results are also consistent with a causal story that derives from availability theory, i.e. that greater availability of alcohol leads to increased consumption, which in turn leads to more social harms.

Despite the limitations, this research adds to the weight of evidence that links alcohol outlets and social harms. The evidence demonstrates that, almost regardless of the method and measures employed, that alcohol outlets are correlated with harm. The continuing finding of significant positive relationships between alcohol outlets and social harms, but with variations in the strength of the correlations and without being able to definitively attribute the findings as cause-and-effect, recalls the early findings in the literature on smoking and cancer. A. Bradford Hill (1965) defined a number of criteria that he argued suggested that cause-and-effect could be inferred from a large number of correlational studies. The most important of the criteria suggestive of causal relationships were the strength of the relationship (or effect size) and the consistency of findings across different studies in different populations (or samples). While none of the extant research on alcohol outlets and social harms definitively demonstrates a causal link, the increasing consistency of these findings is becoming more and more suggestive that the location of alcohol outlets are causing social harms.

References

Atkinson, J., Salmond, C., and Crampton, P. (2014). *NZDep2013 Index of Deprivation*. Wellington: Department of Public Health, University of Otago.

Cameron, M.P., Cochrane, W., Gordon, C., and Livingston, M. (2014a). *Global and locally-specific relationships between alcohol outlet density and property damage: Evidence from New Zealand*. Unpublished manuscript, Hamilton: University of Waikato.

Cameron, M.P., Cochrane, W., Gordon, C., and Livingston, M. (2014b). *Alcohol outlet density and violence: A geographically-weighted regression approach*. Unpublished manuscript, Hamilton: University of Waikato.

Cameron, M.P., Cochrane, W., Gordon, C., and Livingston, M. (2013a). *The Locally-Specific Impacts of Alcohol Outlet Density in the North Island of New Zealand, 2006-2011*, research report commissioned by the Health Promotion Agency, Hamilton: National Institute for Demographic and Economic Analysis, University of Waikato.

Cameron, M.P., Cochrane, W., Gordon, C., and Livingston, M. (2016a). Alcohol outlet density and violence: A geographically-weighted regression approach, *Drug and Alcohol Review*, 35(3), 280-288.

Cameron, M.P., Cochrane, W., Gordon, C., and Livingston, M. (2016b). *Global and locally-specific relationships between alcohol outlet density and property damage: Evidence from New Zealand*, unpublished manuscript. Hamilton: University of Waikato.

Cameron, M.P., Cochrane, W., McNeill, K., Melbourne, P., Morrison, S.L., and Robertson, N. (2012a). *A review of the international academic literature and New Zealand media reports: The impacts of liquor outlets in Manukau City Report No. 1*. Wellington: Alcohol Advisory Council of New Zealand.

Cameron, M.P., Cochrane, W., McNeill, K., Melbourne, P., Morrison, S.L., and Robertson, N. (2012b). *The spatial and other characteristics of liquor outlets in Manukau City: The impacts of liquor outlets in Manukau City Report No. 3*. Wellington: Alcohol Advisory Council of New Zealand.

Cameron, M.P., Cochrane, W., McNeill, K., Melbourne, P., Morrison, S.L., and Robertson, N. (2012c). *A spatial econometric analysis of selected impacts of liquor outlet density in*

Manukau City: The impacts of liquor outlets in Manukau City Report No. 4. Wellington: Alcohol Advisory Council of New Zealand.

Cameron, M.P., Cochrane, W., McNeill, K., Melbourne, P., Morrison, S.L., and Robertson, N. (2012d). Alcohol outlet density is related to police events and motor vehicle accidents in Manukau City, New Zealand. *Australian and New Zealand Journal of Public Health, 36, (6),* 537-542.

Cameron, M.P., Cochrane, W., and Simone, F. (2013b). *The Geography of Alcohol Availability in Hamilton City, January 2012*, research report commissioned by Hamilton City Council, Hamilton: National Institute for Demographic and Economic Analysis, University of Waikato.

Cameron, M.P., Cochrane, W., and Simone, F. (2013c). *The Geography of Alcohol Availability in Manukau City, January 2012*, research report commissioned by Auckland Council, Hamilton: National Institute for Demographic and Economic Analysis, University of Waikato.

Clarke, R.V., and Felson, M. (Eds). (1993). *Routine Activity and Rational Choice*. New Brunswick, NJ: Transaction Publishers.

Cohen, L.E., and Felson. M. (1979). Social change and crime rate trends: A routine activity approach. *American Sociological Review, 44*, 588-605.

Connor, J.L., Kypri, K., Bell, M.L., and Cousins, K. (2011). Alcohol outlet density, levels of drinking and alcohol-related harm in New Zealand: A national study. *Journal of Epidemiology and Community Health, 65*, 841-846.

Day, P., Breetzke, G., Kingham, S., and Campbell, M. (2012). Close proximity to alcohol outlets is associated with increased serious violent crime in New Zealand. *Australian and New Zealand Journal of Public Health, 36(1),* 48-54.

Figueiredo, O., Guimaraes, P., and Woodward, D. (2014). Industry localization, distance decay and knowledge spillovers: Following the patent paper trial, *FEP Working Paper No. 521*. Porto: University of Porto.

Franklin, F.A., LaVeist, T.A., Webster, D.W., and Pan, W.K. (2010). Alcohol outlets and violent crime in Washington D.C. *Western Journal of Emergency Medicine, 11*, 283–290.

Gmel, G., Holmes, J., and Studer, J. (2016). Are alcohol outlet densities strongly associated with alcohol-related outcomes? A critical review of recent evidence, *Drug and Alcohol Review*, 35(1), 40-54.

Gruenewald, P.J., Freisthler, B., Remer, L., LaScala, E.A., and Treno, A. (2006). Ecological models of alcohol outlets and violent assaults: Crime potentials and geospatial analysis, *Addiction, 101(5)*, 666-677.

Hausman, J.A., and Taylor, W.E. (1981). Panel data and unobservable individual effects, *Econometrica*, 43(6), 1377-1398.

Hay, G.C., Whingham, P.A., Kypri. K., and Langley, J.D. (2009). Neighbourhood deprivation and access to alcohol outlets: A national study. *Health and Place, 15*, 1086-1093.

Hill, A.B. (1965). The environment and disease: Association or causation?. *Proceedings of the Royal Society of Medicine*, 58(5), 295-300.

Huckle, T., Haukau, J., Sweetsur, P., Huisman, O., and Casswell, S. (2008). Density of alcohol outlets and teenage drinking: Living in an alcogenic environment is associated with higher consumption in a metropolitan setting. *Addiction, 103(10)*, 1614-1621.

Krivo, L.J., and Peterson, R.D. (1996). Extremely disadvantaged neighbourhoods and urban crime. *Social Forces*, 75(2), 619-650.

Kypri, K., Bell, M.L., Hay, G.C., and Baxter, J. (2008). Alcohol outlet density and university student drinking: A national study. *Addiction*, 103(7), 1131-1138.

Law Commission. (2010). *Alcohol in our lives: Curbing the harm – A report on the review of the regulatory framework for the sale and supply of liquor*. Law Commission Report No. 114. New Zealand: Law Commission.

Liang, W., and Chikritzhs, T. (2011). Revealing the link between licensed outlets and violence: Counting venues versus measuring alcohol availability, *Drug and Alcohol Review*, 30, 524-535.

Livingston, M. (2008). A longitudinal analysis of alcohol outlet density and assault, *Alcoholism: Clinical and Experimental Research, 32(6)*, 1074-1079.

Livingston, M. (2011). A longitudinal analysis of alcohol outlet density and domestic violence, *Addiction, 106(5),* 919-925.

Livingston, M., Chikritzhs, T., and Room, R. (2007). Changing the density of alcohol outlets to reduce alcohol-related problems. *Drug and Alcohol Review, 26(5),* 557-566.

Lugo, W. (2008). Alcohol and crime: Beyond density, *Security Journal, 21*, 229-245.

Mair, C., Gruenewald, P.J., Ponicki, W.R., and Remer, L. (2013). Varying impacts of alcohol outlet densities on violent assaults: explaining differences across neighborhoods. *Journal of Studies on Alcohol and Drugs, 74(1),* 50-58.

Matheson, A. (2005). *Alcohol in Auckland: Reducing associated harm*. Auckland: Auckland Regional Public Health Service.

McNeill, K., Cameron, M.P., Cochrane, W., Melbourne, P., Morrison, S.L., and Robertson, N. (2012). *Community stakeholder views on the impacts of liquor outlets in Manukau City: The impacts of liquor outlets in Manukau City Report No. 2*. Wellington: Alcohol Advisory Council of New Zealand.

Páez, A., Farber, S., and Wheeler, D. (2011). A simulation-based study of geographically weighted regression as a method for investigating spatially varying relationships. *Environment and Planning A, 43,* 2992-3010.

Pearce, J., Day, P., and Witten, K. (2008). Neighbourhood provision of food and alcohol retailing and social deprivation in urban New Zealand. *Urban Policy and Research, 26, (2),* 213-227.

Popova, S., Giesbrecht, N., Bekmuradov, D., and Patra, J. (2009). Hours and days of sale and density of alcohol outlets: Impacts on alcohol consumption and damage: A systematic review. *Alcohol and Alcoholism, 44, (5),* 500-516.

Pridemore, W.A., and Grubesic, T.H. (2013). Alcohol outlets and community levels of interpersonal violence: Spatial density, outlet type, and seriousness of assault. *Journal of Research in Crime and Delinquency, 50(1),* 132-159.

Wagenaar, A.C., and Langley, J.D. (1995). Alcohol licensing system changes and alcohol consumption: Introduction of wine into New Zealand grocery stores. *Addiction*, 90(6), 773-783.

Wheeler, D., and Tiefelsdorf, M. (2005). Multicollinearity and correlation among local regression coefficients in geographically weighted regression, *Journal of Geographical Systems*, 7, 161-187.

Appendix I – Police Event Categories

Antisocial behaviour offences – includes Disorder; and Gaming offences

Dishonesty offences – includes Burglary; Car conversion; Computer crime; Fraud; General Theft; Interference with cars; Receiving; Theft ex car; and Theft ex shop

Drug and alcohol offences – includes Breach of local council liquor ban; Drugs (cannabis only); Drugs (not cannabis); and Liquor offences

Property abuses – includes Animal cruelty; Firearms offences; Injures police dog; Littering; Postal/rail/fire service abuses; Telephone offenses; and Trespass

Property damage – includes Arson; Endangering/interfering; and Wilful damage

Sexual offences – includes Indecent videos; Rape; Sexual affronts; Sexual attacks; and Unlawful sex

Violent offences (including family violence) – includes Child abuse; Crimes against personal privacy; Domestic violence; Grievous assaults; Harassment; Homicide; Intimidation/threats; Kidnapping and abduction; Minor assaults; Robbery; Serious assaults; and Unlawful assembly

Note: The subcategories listed above are those that are used in the Police Communications and Resource Deployment (CARD) database.

Appendix II – Results of Tests of Equality of Coefficients between Alcohol Outlet Types (*p*-values)

Table A1: Results of tests of equality of coefficients between alcohol outlet types (p-values)

Test	Violence	Antisocial behaviour	Dishonesty offences	Drug and alcohol offences	Property abuses	Property damage	Sexual offences	Motor vehicle accidents
Dual-licensed taverns vs. Bars and night clubs	0.016**	0.001***	0.118	0.098*	0.258	0.221	0.750	0.987
Restaurants and cafés vs. Accommodation and function centres	0.420	0.353	0.026**	0.005***	0.364	0.169	0.404	0.391
Dual-licensed hotels vs. Accommodation and function centres	0.055*	0.269	0.002***	0.074*	0.007***	0.232	0.162	0.010**
Dual-licensed restaurants vs. Restaurants and cafés	0.025**	0.010**	0.125	0.109	0.843	0.122	0.415	0.077*
Bottle stores vs. supermarkets	0.138	0.230	0.223	0.009***	0.334	0.131	0.054	0.468

*** $p<0.01$; ** $p<0.05$; * $p<0.1$.

Appendix III – Full Model Results

Table A2: Results – Antisocial behaviour events

	Model I	Model II	Model III	Model IV	Model V
First stage:					
Licensed clubs	0.999 (0.024)	0.997 (0.011)	0.998 (0.010)	0.995 (0.009)	0.995 (0.008)
Bars and night clubs	1.004 (0.005)	1.001 (0.002)	0.995* (0.003)	0.997 (0.002)	1.004*** (0.002)
Other on-licence	1.004 (0.003)	0.9998 (0.001)	0.999 (0.001)	0.998 (0.001)	0.997 (0.002)
All off-licence	1.016 (0.011)	1.006 (0.004)	1.018*** (0.006)	1.012* (0.006)	1.013*** (0.003)
Population (000s)	1.076 (0.063)	1.109*** (0.028)	1.084*** (0.029)	1.081*** (0.027)	1.221*** (0.045)
Population squared	0.994 (0.005)	0.993*** (0.002)	0.991** (0.005)	0.990** (0.004)	0.991*** (0.002)
Temporal lag of antisocial behaviour events	-	1.005*** (0.001)	1.005*** (0.001)	1.004*** (0.001)	1.003*** (<0.001)
Population * Bars & night clubs	-	-	1.002** (0.001)	1.002** (0.001)	-
Population * All off-licence	-	-	0.998* (0.001)	0.999 (0.001)	-
Temporal lag of all police events	-	-	-	1.0005*** (<0.001)	1.001*** (<0.001)
Spatial lag of licensed clubs	-	-	-	-	0.908** (0.046)
Spatial lag of population	-	-	-	-	0.670*** (0.118)
Second stage:					
Area (sq. km)	-	-	-	-	-0.001*** (<0.001)
Social deprivation	-	-	-	-	0.007*** (<0.001)
Proportion young (15-24) males	-	-	-	-	0.090*** (0.020)

*** p<0.01; ** p<0.05; * p<0.1; direct effects that are mediated by interactions are in shaded cells.

Table A3: Results – Dishonesty offence events

	Model I	Model II	Model III	Model IV	Model V
First stage:					
Licensed clubs	1.009 (0.019)	1.004 (0.008)	1.514*** (0.136)	1.482*** (0.135)	1.400** (0.132)
Bars and night clubs	0.996 (0.006)	0.996 (0.002)	0.996** (0.002)	0.996** (0.002)	0.999 (0.003)
Other on-licence	1.002 (0.002)	0.998 (0.001)	0.998 (0.002)	0.997 (0.002)	0.997* (0.002)
All off-licence	1.011 (0.013)	1.014*** (0.004)	1.013*** (0.004)	1.012*** (0.004)	1.009 (0.007)
Population (000s)	1.239*** (0.062)	1.184*** (0.040)	1.197*** (0.037)	1.198*** (0.035)	1.158*** (0.036)
Population squared	0.990*** (0.003)	0.989*** (0.002)	0.988*** (0.002)	0.988*** (0.002)	0.992*** (0.002)
Temporal lag of antisocial behaviour events	-	1.004*** (<0.001)	1.004*** (<0.001)	1.003*** (<0.001)	1.003*** (<0.001)
Social deprivation * Licensed clubs	-	-	0.9996*** (<0.001)	0.9996*** (<0.001)	0.9997** (<0.001)
Temporal lag of all police events	-	-	-	1.0002*** (<0.001)	1.0002 (<0.001)
Spatial lag of licensed clubs	-	-	-	-	1.082* (0.046)
Spatial lag of other on-licence	-	-	-	-	0.963*** (0.013)
Spatial lag of all off-licence					1.084* (0.045)
Spatial lag of population	-	-	-	-	1.419** (0.162)
Spatial lag of population squared	-	-	-	-	0.971** (0.015)
Second stage:					
Area (sq. km)	-	-	-	-	-0.0002*** (<0.001)
Social deprivation	-	-	-	-	0.004*** (0.001)
Proportion young (15-24) males	-	-	-	-	0.071*** (0.015)

*** p<0.01; ** p<0.05; * p<0.1; direct effects that are mediated by interactions are in shaded cells.

Table A4: Results – Drug and alcohol offence events

	Model I	Model II	Model III	Model IV	Model V
First stage:					
Licensed clubs	1.059 (0.091)	1.006 (0.040)	0.984 (0.031)	0.974 (0.024)	0.982 (0.030)
Bars and night clubs	0.958* (0.025)	0.976** (0.011)	0.954*** (0.010)	0.949*** (0.007)	0.977** (0.011)
Other on-licence	1.031 (0.013)	1.008* (0.005)	1.011* (0.006)	1.016*** (0.004)	1.005 (0.005)
All off-licence	0.999 (0.017)	1.039* (0.022)	1.104*** (0.017)	1.063** (0.025)	1.064*** (0.016)
Population (000s)	1.588*** (0.124)	1.286*** (0.072)	1.012 (0.075)	1.038 (0.066)	1.199** (0.087)
Population squared	0.980*** (0.007)	0.984*** (0.006)	1.007 (0.007)	1.001 (0.006)	0.997 (0.007)
Temporal lag of antisocial behaviour events	-	1.009*** (0.001)	1.009*** (<0.001)	1.007*** (0.002)	1.007*** (0.002)
Population * Bars & night clubs	-	-	1.006*** (0.001)	1.007*** (0.001)	-
Population * Other on-licence	-	-	0.999* (0.001)	0.998*** (0.001)	-
Population * All off-licence	-	-	0.987*** (0.002)	0.992** (0.004)	0.995* (0.003)
Temporal lag of all police events	-	-	-	1.001* (0.001)	1.001 (0.001)
Spatial lag of Licensed clubs					0.798** (0.115)
Spatial lag of Bars & night clubs	-	-	-	-	0.941*** (0.023)
Second stage:					
Area (sq. km)	-	-	-	-	-0.0001** (<0.001)
Social deprivation	-	-	-	-	0.005*** (0.001)
Proportion young (15-24) males	-	-	-	-	0.033** (0.017)

*** p<0.01; ** p<0.05; * p<0.1; direct effects that are mediated by interactions are in shaded cells.

Table A5: Results – Property abuse events

	Model I	Model II	Model III	Model IV	Model V
First stage:					
Licensed clubs	1.006 (0.021)	0.997 (0.017)	0.998 (0.016)	0.997 (0.015)	0.996 (0.015)
Bars and night clubs	0.998 (0.003)	0.998 (0.003)	0.990*** (0.004)	0.992*** (0.003)	0.992*** (0.003)
Other on-licence	1.002 (0.002)	1.002 (0.003)	1.002 (0.002)	0.999 (0.001)	0.999 (0.001)
All off-licence	1.007 (0.007)	1.003 (0.005)	1.016** (0.008)	1.002 (0.009)	1.006 (0.005)
Population (000s)	1.071 (0.075)	1.055 (0.064)	1.048 (0.074)	1.075 (0.050)	1.077 (0.051)
Population squared	0.998 (0.004)	0.999 (0.003)	0.996 (0.004)	0.991*** (0.002)	0.991*** (0.002)
Temporal lag of antisocial behaviour events	-	1.010*** (0.002)	1.010*** (0.002)	1.007*** (0.002)	1.007*** (0.002)
Population * Bars & night clubs	-	-	1.002*** (0.001)	1.002*** (0.001)	1.002*** (0.001)
Population * All off-licence	-	-	0.998** (0.001)	1.0003 (0.001)	-
Temporal lag of all police events	-	-	-	1.001*** (<0.001)	1.001*** (<0.001)
Spatial lag of Bars & night clubs	-	-	-	-	0.970** (0.014)
Second stage:					
Area (sq. km)	-	-	-	-	-0.00004 (<0.001)
Social deprivation	-	-	-	-	0.006*** (0.001)
Proportion young (15-24) males	-	-	-	-	0.050*** (0.012)

*** p<0.01; ** p<0.05; * p<0.1; direct effects that are mediated by interactions are in shaded cells.

Table A6: Results – Property damage events

	Model I	Model II	Model III	Model IV	Model V
First stage:					
Licensed clubs	1.019 (0.015)	0.993 (0.009)	0.992 (0.008)	0.995 (0.009)	0.995 (0.009)
Bars and night clubs	0.994 (0.005)	0.996 (0.004)	0.991** (0.004)	0.991*** (0.002)	0.991*** (0.002)
Other on-licence	1.003 (0.002)	1.001 (0.001)	0.9998 (0.002)	0.997** (0.002)	0.997** (0.001)
All off-licence	1.019 (0.011)	1.005 (0.007)	1.025*** (0.009)	1.015* (0.008)	1.015* (0.008)
Population (000s)	1.163 (0.062)	1.089 (0.052)	1.048 (0.054)	1.074 (0.044)	1.074 (0.044)
Population squared	0.995 (0.004)	0.999 (0.003)	1.003 (0.004)	0.999 (0.003)	0.999 (0.003)
Temporal lag of antisocial behaviour events	-	1.014 (0.001)	1.014*** (0.001)	1.011*** (0.001)	1.011*** (0.001)
Population * Bars & night clubs	-	-	1.001*** (0.001)	1.001** (0.001)	1.001** (0.001)
Population * All off-licence	-	-	0.996*** (0.001)	0.998** (0.001)	0.998** (0.001)
Temporal lag of all police events	-	-	-	1.001*** (<0.001)	1.001*** (<0.001)
Second stage:					
Area (sq. km)	-	-	-	-	-0.0003*** (<0.001)
Social deprivation	-	-	-	-	0.005*** (0.001)
Proportion young (15-24) males	-	-	-	-	0.047*** (0.012)

*** p<0.01; ** p<0.05; * p<0.1; direct effects that are mediated by interactions are in shaded cells.

Table A7: Results – Sexual offence events

	Model I	Model II	Model III	Model IV	Model V
First stage:					
Licensed clubs	0.994 (0.019)	0.985 (0.019)	1.876*** (0.237)	1.593* (0.262)	1.757** (0.246)
Bars and night clubs	0.987*** (0.004)	0.987*** (0.004)	0.987*** (0.004)	0.988*** (0.003)	0.987*** (0.004)
Other on-licence	1.005 (0.004)	1.005 (0.004)	1.004 (0.004)	1.001 (0.004)	1.002 (0.003)
All off-licence	1.020 (0.013)	1.019 (0.013)	1.016 (0.012)	1.017* (0.009)	1.019** (0.008)
Population (000s)	1.133 (0.162)	1.137 (0.161)	1.145 (0.153)	1.127 (0.139)	1.097 (0.129)
Population squared	0.991 (0.009)	0.991 (0.009)	0.990 (0.008)	0.991 (0.007)	0.994 (0.007)
Temporal lag of antisocial behaviour events	-	1.008* (0.005)	1.008* (0.005)	1.002 (0.004)	1.002 (0.004)
Social deprivation * Licensed clubs	-	-	0.999*** (<0.001)	0.9995* (<0.001)	0.999** (<0.001)
Temporal lag of all police events	-	-	-	1.001** (<0.001)	1.001** (<0.001)
Spatial lag of Licensed clubs	-	-	-	-	0.787* (0.124)
Spatial lag of Bars & night clubs	-	-	-	-	0.899*** (0.039)
Spatial lag of All off-licence	-	-	-	-	1.118** (0.049)
Spatial lag of population	-	-	-	-	1.755** (0.277)
Spatial lag of population squared	-	-	-	-	0.950* (0.028)
Second stage:					
Area (sq. km)	-	-	-	-	-0.0003*** (<0.001)
Social deprivation	-	-	-	-	0.004*** (<0.001)
Proportion young (15-24) males	-	-	-	-	0.016 (0.017)

*** p<0.01; ** p<0.05; * p<0.1; direct effects that are mediated by interactions are in shaded cells.

Table A8: Results – Motor vehicle accidents

	Model I	Model II	Model III	Model IV	Model V
First stage:					
Licensed clubs	1.003 (0.018)	1.004 (0.018)	1.003 (0.019)	1.001 (0.017)	1.005 (0.017)
Bars and night clubs	0.992 (0.007)	0.992 (0.007)	0.992 (0.008)	0.993 (0.008)	0.993 (0.008)
Other on-licence	1.006*** (0.002)	1.006*** (0.002)	0.916** (0.039)	0.918** (0.041)	0.918** (0.041)
All off-licence	1.014** (0.006)	1.014** (0.006)	1.028*** (0.009)	1.026*** (0.009)	1.026*** (0.009)
Population (000s)	1.312*** (0.071)	1.313*** (0.072)	1.287*** (0.087)	1.281*** (0.075)	1.281*** (0.075)
Population squared	0.988*** (0.003)	0.988*** (0.003)	0.993 (0.005)	0.992* (0.004)	0.992* (0.004)
Temporal lag of antisocial behaviour events	-	0.999 (0.002)	0.999 (0.002)	0.999 (0.002)	0.999 (0.002)
Social deprivation * Other on-licence	-	-	1.0001** (<0.001)	1.0001** (<0.001)	1.0001** (<0.001)
Population * All off-licence	-	-	0.997*** (0.001)	0.997** (0.001)	0.997** (0.001)
Temporal lag of all police events	-	-	-	1.0002 (<0.001)	1.0002 (<0.001)
Second stage:					
Area (sq. km)	-	-	-	-	0.001*** (<0.001)
Social deprivation	-	-	-	-	-0.0003 (<0.001)
Proportion young (15-24) males	-	-	-	-	0.062*** (0.010)

*** $p<0.01$; ** $p<0.05$; * $p<0.1$; direct effects that are mediated by interactions are in shaded cells.

Appendix IV – Additional Model Results

Table A9: Results – Sale and Supply of Alcohol Act implementation (Model IV plus SSAA interactions)

Dependent variable	Dishonesty offences	Drug and alcohol offences	Property damage	Motor vehicle accidents
Licensed clubs	1.433*** (0.133)	0.964 (0.025)	0.992 (0.009)	0.999 (0.016)
Bars and night clubs	0.997* (0.002)	0.949*** (0.009)	0.989*** (0.002)	0.993 (0.008)
Other on-licence	0.998 (0.002)	1.016*** (0.004)	0.997** (0.001)	0.926* (0.044)
All off-licence	1.010* (0.005)	1.069*** (0.023)	1.015* (0.008)	1.022** (0.009)
Population (000s)	1.192*** (0.035)	1.066 (0.070)	1.074 (0.044)	1.273*** (0.072)
Population squared	0.989*** (0.001)	0.995 (0.007)	0.999 (0.003)	0.993 (0.004)
Temporal lag of dependent variable	1.003*** (<0.001)	1.007*** (0.002)	1.010*** (0.001)	0.999 (0.002)
Social deprivation * Licensed clubs	0.9997** (<0.001)	-	-	-
Social deprivation * Other on-licence	-	-	-	1.0001* (<0.001)
Population * Bars & night clubs	-	1.007*** (0.001)	1.002*** (0.001)	-
Population * Other on-licence	-	0.998*** (0.001)	-	-
Population * All off-licence	-	0.990** (0.004)	0.997** (0.001)	0.998* (0.001)
Temporal lag of all police events	1.0003** (<0.001)	1.001* (0.001)	1.001*** (<0.001)	1.0002 (<0.001)
SSAA13 * Licensed clubs	-	-	-	-
SSAA13 * Bars & night clubs	0.994*** (0.001)	0.990* (0.005)	0.994** (0.003)	0.996*** (0.001)
SSAA13 * Other on-licence	-	-	-	-
SSAA13 * All off-licence	1.011*** (0.003)	1.041*** (0.016)	1.017** (0.007)	-

*** $p<0.01$; ** $p<0.05$; * $p<0.1$; 'SSAA13' is a dummy variable equal to one for quarters starting after 18 December 2013; direct effects that are mediated by interactions are in shaded cells.

Appendix V – Additional Model Results

Table A10: Results – Models including discontinuities for the first outlet of a given type (Model IV plus interactions)

Dependent variable	Dishonesty offences	Drug and alcohol offences	Property abuses	Sexual offences
Licensed clubs	1.473*** (0.136)	0.974 (0.024)	0.997 (0.015)	1.613* (0.267)
Bars and night clubs	0.996** (0.002)	0.949*** (0.007)	0.993*** (0.003)	0.989*** (0.003)
Other on-licence	0.997 (0.002)	1.017*** (0.004)	0.999 (0.001)	1.001 (0.004)
All off-licence	1.013*** (0.005)	1.062** (0.025)	0.998 (0.008)	1.017* (0.009)
Population (000s)	1.202*** (0.035)	1.042 (0.066)	1.077 (0.050)	1.136 (0.137)
Population squared	0.988*** (0.002)	1.001 (0.006)	0.990*** (0.002)	0.990 (0.007)
Temporal lag of dependent variable	1.003*** (<0.001)	1.007*** (0.002)	1.007*** (0.002)	1.002 (0.004)
Social deprivation * Licensed clubs	0.9996*** (<0.001)	-	-	0.9995** (<0.001)
Population * Bars & night clubs	-	1.007*** (0.001)	1.002*** (<0.001)	-
Population * Other on-licence	-	0.997*** (0.001)	-	-
Population * All off-licence	-	0.992** (0.004)	1.001 (0.001)	-
Temporal lag of all police events	1.0002** (<0.001)	1.001* (0.001)	1.001*** (<0.001)	1.001** (<0.001)
Zero * Bars & night clubs	-	-	-	1.091* (0.051)
Zero * Other on-licence	-	1.114** (0.044)	1.048** (0.022)	-
Zero * All off-licence	1.030* (0.017)	-	0.951** (0.020)	-

*** $p<0.01$; ** $p<0.05$; * $p<0.1$; 'Zero' is a dummy variable equal to one if there are no outlets of a given type in the CAU; direct effects that are mediated by interactions are in shaded cells.

Table A11: Results – Models including non-linearities for outlet variables (Model IV plus quadratic terms)

Dependent variable	Violent offences	Dishonesty offences	Property damage	Sexual offences	Motor vehicle accidents
Licensed clubs	1.237 (0.130)	1.509*** (0.130)	0.998 (0.010)	1.595* (0.270)	1.0001 (0.016)
Bars and night clubs	1.005* (0.002)	0.997** (0.001)	0.990*** (0.003)	0.989*** (0.003)	1.014 (0.013)
Bars and night clubs squared	-	-	-	-	0.9998** (<0.001)
Other on-licence	0.946*** (0.016)	1.003 (0.003)	1.008*** (0.003)	1.008 (0.006)	0.917** (0.040)
Other on-licence squared	0.99998* (<0.001)	0.99997** (<0.001)	0.9999*** (<0.001)	0.99996* (<0.001)	-
All off-licence	1.007* (0.004)	1.013** (0.005)	1.022** (0.009)	1.017* (0.009)	1.033*** (0.009)
Population (000s)	1.285*** (0.054)	1.198*** (0.034)	1.071 (0.045)	1.123 (0.134)	1.237*** (0.067)
Population squared	0.984*** (0.003)	0.988*** (0.002)	0.999 (0.003)	0.991 (0.007)	0.995 (0.004)
Temporal lag of dependent variable	1.005*** (0.001)	1.003*** (<0.001)	1.010*** (0.001)	1.002 (0.004)	0.999 (0.002)
Social deprivation * Licensed clubs	-	0.9996*** (<0.001)	-	0.9995* (<0.001)	0.999** (<0.001)
Social deprivation * Other on-licence	-	-	-	-	1.0001** (<0.001)
Population * Licensed clubs	0.993* (0.004)	-	-	-	-
Population * Bars & night clubs	-	-	1.002** (0.001)	-	-
Population * All off-licence	-	0.995** (0.003)	0.997*** (0.001)	-	0.996*** (0.001)
Temporal lag of all police events	1.001*** (<0.001)	1.0003** (<0.001)	1.001*** (<0.001)	1.001** (<0.001)	1.0002 (<0.001)

*** $p<0.01$; ** $p<0.05$; * $p<0.1$; 'Zero' is a dummy variable equal to one if there are no outlets of a given type in the CAU; direct effects that are mediated by interactions are in shaded cells.

Appendix VI – List of Errata

Corrections to text

- Added some page numbers when referring to some tables or figures in text.
- Pg 21, corrected reference to section 4.3 to 4.4.
- Pg 22, 2nd paragraph, corrected 'other off-licence outlets' and 'other off-licence outlets (e.g supermarkets and grocery stores)' to 'off-licence outlets'.
- Changed Footnote 15 (pg 28).
- Pg 30, 2nd paragraph, corrected 'below' social deprivation score of 1025 to 'above'.
- Pg 30, 3rd paragraph, corrected text referring to Figure 10 to '… although despite downward sloping relationships it is statistically insignificant for both low and high population areas'.

Corrections to Tables

- Table 1 (pg 10), corrected misspelling of licenced and licensed.
- Corrected Table 6 (pg 36), 4th column (headed Licensed clubs) for sexual offences to 'Positive, Negative, Positive, Negative' from 'NS, NS, Negative, Negative'.
- Minor corrections to some of the model V numbers so they are consistent between Table 5 (pg 31) and Appendix III Tables A2-A8 (pg 49-55). There were also two instances in Table 5 where the level of statistical significance was incorrectly reported as $p<0.05$ rather than $p<0.10$ (Drug and alcohol offences, population*all off-licences; Dishonesty offences, spatial lag of licensed clubs) and one instance where a result in Appendix III Table A4 (Drug and alcohol offences, population*all off-licence) was incorrectly indicated as not statistically significant.