

The Locally Specific Impacts of Alcohol Outlet Density in the North Island of New Zealand 2006-2011

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COMMISSIONING CONTACT'S COMMENTS:

The Health Promotion Agency (HPA) contract was managed by Margaret Chartres (Senior Researcher) and Cathy Bruce, (Principal Advisor, Local Government).

The HPA, formerly the Alcohol Advisory Council of New Zealand, is interested in improving our understanding of the relationships between alcohol outlet density and social harm in New Zealand. As part of this work programme, the HPA has published a series of reports on a research programme undertaken by the National Institute of Demographic and Economic Analysis at the University of Waikato (NIDEA) examining the impacts of alcohol outlet density focused on a specific region, Manukau City (<http://www.hpa.org.nz/research-library/research-publications/impacts-liquor-outlets-manukau-city-summary-report-revised>). International and New Zealand research however suggests that these relationships can be context-specific or vary across regions.

In March 2012, the HPA commissioned NIDEA to undertake research into the geographically-specific relationships between alcohol outlet density (by type of outlet) and social harms (specifically different types of police events, and motor vehicle crashes) in the North Island of New Zealand between 2006 and 2011. This project expands and extends the earlier Manukau research on alcohol outlet density to cover a larger geographic area and a longer timeframe in order to better understand context-specific issues. A final report from the authors, Michael Cameron, William Cochrane, Craig Gordon and Michael Livingston, was received in May 2013.

This report presents a series of overall model estimates for the North Island on the relationship between alcohol outlet density (by outlet types) and eight social harm measures (different police events and motor vehicle crashes) and the New Zealand deprivation index and population density. In addition, geographically weighted regressions are used to develop locally-specific estimates for these relationships in the North Island at the census area unit level (CAU, roughly equivalent to a suburb). Detailed results summarising these relationships at the CAU level using thematic maps are presented for two of the social harm measures, violence and motor vehicle crashes.

The research findings show that the nature of the relationships between alcohol outlet density and social harms varies by geographic location throughout the North Island and by outlet type. The report indicates whether these relationships are statistically significant and provides information on the strength and direction of these associations between outlet density (or outlet proximity) and measures of social harm. The relationships presented however, do not establish cause.

REVIEW

The report has not undergone external peer review.

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Also, the views expressed in this report are those of the authors and do not reflect any official position on the part of NIDEA, the University of Waikato.

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EXECUTIVE SUMMARY

- This report summarises the results of research (commissioned by the Alcohol Advisory Council of New Zealand, now part of the Health Promotion Agency) into the geographically specific relationships between alcohol outlet density (by type of outlet) and social harms (specifically different types of police event, and motor vehicle accidents) in the North Island of New Zealand, between 2006 and 2011.
- As well as developing global (overall) models for the relationships, the research used geographically weighted regression analysis to develop locally specific parameter estimates (at the Census Area Unit level) for the relationships between the measures of social harm and alcohol outlet densities in the North Island.
- In the global models, bar and nightclub density appears to have the most robust and largest effects, being significantly positively associated with all categories of police event and with motor vehicle accidents. Supermarket and grocery store density generally has statistically significant and positive effects on police events, but is significantly negatively related to motor vehicle accidents. Licensed club density and other on-licence density are significantly positively related to many of the categories of police event.
- The global models potentially mask substantial local differences in the relationships between alcohol outlet density (by type) and social harms. All of the parameter estimates vary greatly across the North Island, and are statistically significant in some areas and statistically insignificant in other areas.
- The variability in parameter estimates is best demonstrated by mapping the parameter estimates, as demonstrated by the two case studies presented in this report (violent offences and motor vehicle accidents).
- The substantial variability in relationships demonstrates the need for locally specific policy development, such as the local alcohol policies currently under development by many local authorities in New Zealand.
- Future studies should make increasing use of locally specific models such as geographically weighted regression, both to account for the variability in relationships across space and to provide adequate evidence for local policy development.

INTRODUCTION

The Sale and Supply of Alcohol Act 2012 became law in December 2012 and superseded the Sale of Liquor Act 1989. During the development of the new Act, significant debate on the impacts of alcohol outlets on communities in New Zealand occurred. The Sale of Liquor Act 1989 allowed for the first time the sale of wine in supermarkets and grocery outlets, and this change was associated with a substantial increase in the number of outlets supplying alcohol (Law Commission, 2010). As part of the ongoing debate, discussion has occurred about the effects of alcohol outlet density on alcohol-related harm in New Zealand, and whether the number of liquor licences should be more tightly controlled by local or central government.

In 2008, the Alcohol Advisory Council of New Zealand (ALAC, now part of the Health Promotion Agency [HPA]) commissioned the University of Waikato to undertake a programme of research exploring the relationships between alcohol outlet density and alcohol-related harm in Manukau City. McNeill *et al.* (2012) reported that community stakeholders were particularly concerned about alcohol outlet density and its social impacts. Following this, Cameron *et al.* (2012b) described the spatial characteristics of alcohol outlets at the Census Area Unit (CAU) level in the Manukau City area in January 2009. Key findings included that on-licence outlets were most dense in areas with good transport networks; off-licence outlet density was related to population density and relative social deprivation (as measured by the New Zealand Deprivation Index); off-licence outlets tended to be distributed throughout an area rather than in clusters; and the price and availability of alcohol at off-licence outlets appeared to be related to off-licence outlet density.

Finally, detailed spatial econometric modelling by Cameron *et al.* (2012c, 2012d) demonstrated that alcohol outlet density was significantly associated with a range of social harm indicators in Manukau City. Key findings included that off-licence density was significantly positively associated with violent offences, sexual offences and drug and alcohol offences, and significantly negatively associated with family violence.¹ The density of clubs and bars was significantly positively associated with violent offences, drug and alcohol offences, property damage, property abuses, antisocial behaviour, dishonesty offences and traffic offences. The density of restaurants and cafés was significantly positively associated with violent offences, family violence, property damage, property abuses, antisocial behaviour, dishonesty offences, traffic offences and motor vehicle crashes.

International and New Zealand research on outlet density and alcohol-related harm suggests that these relationships are context specific (Cameron *et al.* 2012a, 2012c; Livingston *et al.*, 2007; Popova *et al.*, 2009). That is, the observed relationships between alcohol outlet density and harms depend on the types of outlet density considered, such as off-licence density and on-licence density, the types of outcome variable considered, and the nature of the location in terms of its socioeconomic and other characteristics. Furthermore, the relationships may vary over time.

¹ In the Manukau research, the 'family violence' category included police events coded as child abuse, domestic violence and domestic dispute. That is, events such as intimidation and threats, and assaults, were not included and instead formed part of a 'violent offences' category. It should be noted that the definition of family violence used in that research does not necessarily match up with the definition of family violence used by service agencies. For further details, see Cameron *et al.* (2012c).

This research project was commissioned by ALAC in March 2012 and aims to extend substantially the geographic and temporal scopes of the spatial modelling approach undertaken by Cameron *et al.* (2012b, 2012c) for Manukau City. The geographic scope of the research covers the entire North Island of New Zealand, and the temporal scope covers a six-year period, from 2006 to 2011. Furthermore, the methods employed are extended to encompass geographically weighted regression (GWR), such that the relationships between outlet density and outcome variables are able to vary across space. This report presents the methodology and summarises the findings of this modelling for the whole of the North Island, in terms of the impacts on a few key indicator variables: different types of police event, and motor vehicle crashes. These particular indicators of alcohol-related harm were selected mainly because of the availability of spatially explicit data that lend themselves to appropriate modelling. Alternative measures either have inappropriate spatial data recording (e.g. accident and emergency admission and 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 outline is as follows. The next section briefly outlines relevant international and New Zealand evidence on the impacts of alcohol outlet density. The data and methods employed in this research project are then presented, followed by the modelling results, including two case studies supported by mapped results. The final section further discusses the results and concludes the report.

ALCOHOL OUTLET DENSITY AND ALCOHOL-RELATED HARM

The theoretical underpinnings of the research that has established links between alcohol outlet density and alcohol-related harms are complex and varied. In the simplest case, researchers have used 'availability theory', wherein negative social outcomes are linked directly or indirectly to the availability of alcohol (Stockwell and Gruenewald, 2004). This approach relies on a causal chain where a greater availability of alcohol (such as through a higher density of alcohol outlets) leads to a greater consumption of alcohol, which leads to negative social outcomes. This relies on basic economics: increasing the number of alcohol outlets will reduce the 'full price' of alcohol by reducing the effort required to locate and travel to an outlet (and potentially by decreasing the actual price of alcohol via increased competition [Cameron *et al.*, 2012b]).

This basic theoretical framework has been somewhat undermined by the inconsistent results of studies that have examined the links between alcohol outlet density and alcohol consumption (Stockwell *et al.*, 2009; Picone *et al.*, 2010; Pollack *et al.*, 2005). For example, at the aggregate level, outlet numbers in Victoria, Australia have more than doubled in recent years, while consumption levels have remained steady or are declining (Livingston *et al.*, 2010). In contrast, studies examining alcohol outlet density and alcohol problems, particularly violence, have consistently found significant relationships (Cameron *et al.*, 2012a; Livingston *et al.*, 2007; Popova *et al.*, 2009). In explaining these findings, researchers have relied on theories from criminology, arguing that outlet density can increase problems from drinking even without greatly affecting the amount of alcohol consumed. These effects, broadly described as 'amenity effects' by Livingston *et al.* (2007), rely on areas of high outlet density increasing the opportunity for negative social outcomes. For instance, crimes and other alcohol-related harms are more likely to occur where large numbers of potentially alcohol-impaired victims and alcohol-influenced offenders congregate (Roncek and Maier, 1991). Such an effect is consistent with 'routine activities theory', which suggests that crime increases where the opportunities available for criminal activity are higher (Clarke and Felson, 1993). Amenity effects could also occur if alcohol outlet density changes the distribution of 'routine drinking activities', such as encouraging more drinkers to drink in bars as opposed to at home, or encouraging drinkers to drink more (Stockwell and Gruenewald, 2004), or where drinkers pre-load and become intoxicated at home (or elsewhere) before going to locations with alcohol outlets (Forsyth, 2010).

Importantly, the relationship between outlet density and harm will vary by outlet type, harm type and setting. For example, Australian studies have identified a strong link between the density of pubs and general assault rates, while finding that off-licence outlets are strongly associated with rates of domestic violence (Livingston, 2008; 2011). Similarly, studies in the United States have shown that different types of outlet have distinct effects on different types of child maltreatment (Freisthler *et al.*, 2004). Furthermore, it's clear that different harms will have different associations with outlet density. Most obviously, some researchers have argued that high outlet density may be protective for motor vehicle accidents, by reducing travel times to outlets and thus lowering the risk of crashes (Meliker *et al.*, 2004), although this argument is contested (Gruenewald and Johnson, 2010). Finally, there is

growing evidence that even the association between a particular type of outlet and a specific harm will vary by setting. Studies in Australia and the United States have found suggestive evidence that outlet density matters more in areas with high pre-existing outlet numbers and in areas of high neighbourhood social deprivation (Livingston, 2008; Mair *et al.*, 2013). This reflects the different characteristics and uses of outlets in different parts of the community, and is a critical consideration for policy-makers.

Thus, the research literature paints a complex and diverse picture: alcohol outlet density is generally associated with alcohol-related problems, but there are substantial variations depending on the type of outcome, the outlet type and the context. For these reasons, this study aims to provide the most comprehensive evidence possible for policy-makers, by exploring a detailed array of outlet types and a range of outcomes, and using sophisticated modelling to develop location-specific findings.

NEW ZEALAND RESEARCH ON OUTLET DENSITY

New Zealand-specific literature on the impacts of alcohol outlets is limited but growing (Cameron *et al.*, 2012a). A few studies and reports have looked at the effects of law changes on liquor licences and outlets. A Law Commission (2010) report presented information on the effects on outlets of the Sale of Liquor Act 1989, which relaxed the criteria for granting licences. Between 1990 and 2010 the number of licences granted for alcohol outlets more than doubled, with licences to sell liquor on premises more than trebling and off-licence licences more than doubling. This report also presented information showing that while supermarkets were only a small proportion of the total number of licences (3 percent in 2008), they were estimated to have sold 33 percent of all beer and 58 percent of all wine available for consumption in 2008, and that the supermarket share of alcohol sales had increased since 2000. Wagenaar and Langley (1995), using an interrupted multiple time-series design, examined nationwide alcohol sales data from 1983 to 1993 to examine the effects of the Sale of Liquor Act 1989, which permitted grocery stores to sell table wine. They found that the number of alcohol outlets had increased, and that there had been a 17 percent increase in wine sales associated with the change.

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. 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 showed 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, varied 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) described the spatial characteristics of alcohol outlets in the Manukau City area in January 2009. They showed 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 were 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. Kypri *et al.* (2008) looked at the association between alcohol outlet density (number of outlets within a given distance of a respondent's home) and survey measures of drinking patterns and alcohol-related harm in a sample of 2550 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 1179 12- to 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) 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 New Zealand Deprivation Index). Connor *et al.* (2011) conducted a national survey of 1925 18- to 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 restaurants. No significant associations were found between outlet density and the average amount of alcohol consumed per year, or risky drinking.

Matheson (2005), using GWR, found that the relationship between alcohol outlet type density and single-vehicle night-time crashes (between 2000 and 2004) varied significantly between District Health Board areas in Auckland. Cameron *et al.* (2012c, 2012d), using spatial seemingly unrelated regression at the CAU 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 and property damage were associated with different outlet types (see the introduction for more detail). Day *et al.* (2012), using a cross-sectional ecological design, examined the association between serious violent crime recorded from 2005 to 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.

Thus, the New Zealand research shows positive associations between outlet density and some measures of drinking behaviour and a range of negative social outcome measures. As with the international literature (Cameron *et al.*, 2012a; Livingston *et al.*, 2007; Popova *et al.*, 2009), the

associations appear to vary with a number of factors such as the type of alcohol outlet, the environment (i.e. rural versus urban) and proximity to alcohol outlets. The relationships may also vary depending on neighbourhood characteristics (Mair *et al.*, 2013; Livingston, 2008). However, there appears to be a consistent finding for a positive association between outlet density and social deprivation (more outlets tend to occur in socially deprived areas).

DATA AND METHODS

This research aims to address gaps in the New Zealand literature by examining population-level effects on selected harm measures (police events and motor vehicle crashes), for the entire North Island, in the six-year period 2006-2011, rather than a snapshot (i.e. a single year). Furthermore, this research uses sophisticated modelling techniques that allow the relationships between outlet density and outcomes to vary spatially, providing results that are more directly relevant for local policy development.

Quarterly liquor licensing data were obtained from the Ministry of Justice, covering all licensed outlets in New Zealand in the period 2005-2011. As the address data for many licences were incomplete, the licence data for the North Island were geo-coded to the CAU level manually. The geo-coding was performed by searching for each address using a combination of the Statistics New Zealand Interactive Boundary Map, Google Maps and Google Street View, to ensure triangulation and accurate geo-coding. A sample of 10 percent of the geo-coded addresses was verified by a second separate geo-coding, and compared with the dataset to ensure accuracy.

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 a 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 relationships with drinking patterns and/or harm to be very weak for these outlet types.

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 nightclubs	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 on- and off-licences)
32	Dual-licensed bars	(Taverns, etc. that hold both on- and off-licences)
33	Dual-licensed restaurants	(Restaurants, etc. that hold both on- and off-licences)

Outlet counts per CAU were then aggregated into five categories for analysis:

1. Clubs (Types 01 and 02)
2. Bars and nightclubs (Types 21 and 32)
3. Other on-licences (Types 22, 23, 29, 31 and 33)
4. Supermarkets and grocery stores (Types 12 and 13)
5. Other off-licences (Types 11, 14, 15, 19, 31, 32 and 33).

Total on-licence and off-licence outlet categories were not used. The split of on-licences into two categories reflects 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 different from those in on-licence outlets where drinking is incidental to other activities (such as

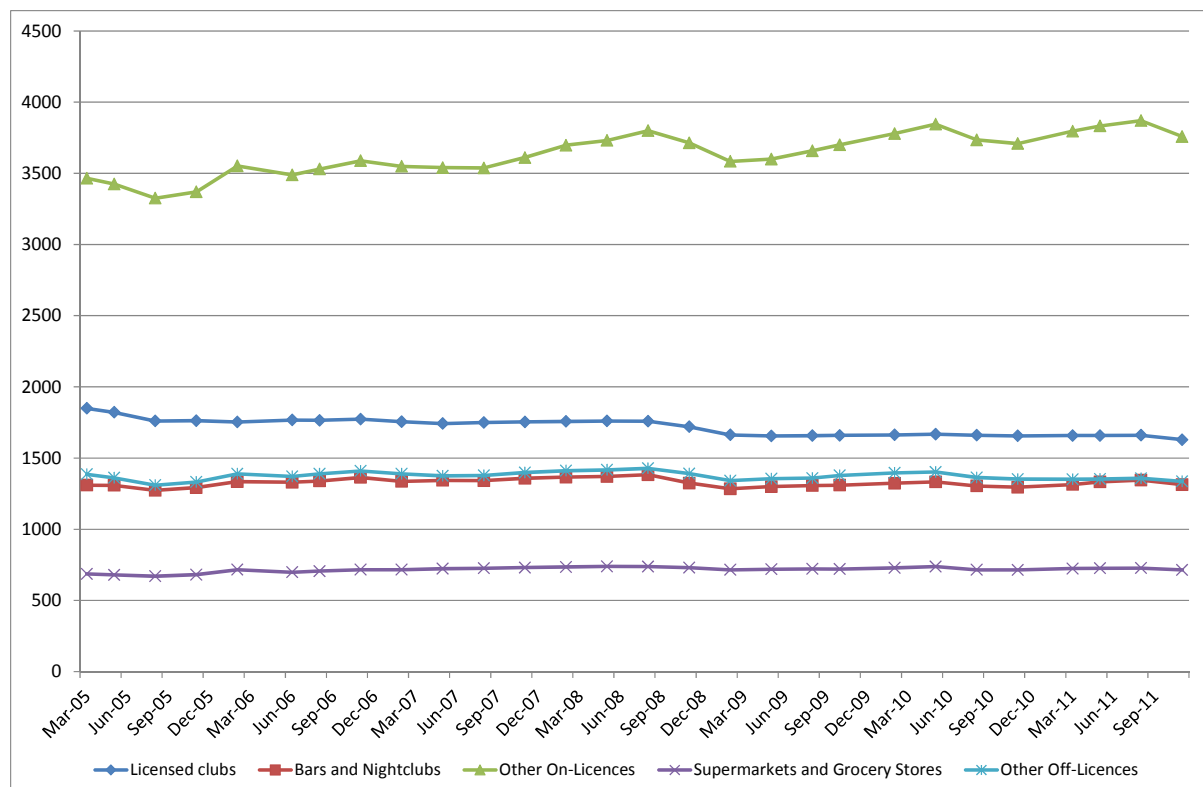
restaurants and cafés). A similar logic applies to off-licences, where the types of customer catered for by supermarkets and grocery stores may be different from those of other off-licence outlets. Previous research has shown that the effects are different by licence type (Cameron et al., 2012c, 2012d). Note that dual-licensed outlets are included in the counts twice – once as on-licences, and once as off-licences. The total North Island outlet count for each licence type is presented as quarterly data in Figure 1. During this period, the total number of licences increased by 2.4 percent, from 8130 in March 2005 to 8329 in November 2011.² The increase in total licences between 2005 and 2011 masks a significant variation between different licence types. The number of other on-licences (restaurants, cafés, hotels, etc.) grew by 8.5 percent in this period, from 3465 to 3758, while the number of club licences fell by 11.9 percent, from 1849 to 1629. The number of each of the other licence types remained relatively stable, although the number of premises recorded as dual-licensed fell from 566 to 421 in this period (data not shown). Interestingly, the number of licences does not seem to follow a seasonal pattern. The global financial crisis did not appear to cause a significant drop in the number of licences, but equally, there did not appear to be a significant increase in the number of licences for the 2011 Rugby World Cup.³ It is possible that these two events offset each other in terms of their effects on the aggregate number of licences.

Counts for the number of outlets within each of the 1316 CAUs in the North Island were obtained. To ensure adequate base population sizes and contiguity within the spatial dataset, 132 CAUs were amalgamated and 12 CAUs were excluded from the dataset (a full list of amalgamated and excluded CAUs with reasons is included in Appendix I). Thus 1172 CAUs (including amalgamations) were used in the analysis. Outlet counts per CAU for each quarter were then converted into outlet densities per 10,000 usually resident population, using Statistics New Zealand subnational population estimates (at 30 June of each year), with quarterly linear interpolation.

² Counting dual licences as both on-licences and off-licences, the corresponding figures are a 0.6 percent increase, from 8696 in March 2005 to 8750 in November 2011.

³ There were only approximately 20 new licences granted in relation to the Rugby World Cup (Mark Lyne, personal communication), but a large increase in special licences, which are not included in our analysis.

Figure 1: North Island alcohol outlet counts by type, 2005-2011



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. The CAS dataset covered the period from 2005 to 2011, while the CARD dataset covered the period from 2006 to 2011. Each dataset was first cleaned to remove duplicate events and occurrences. The police data were then restricted to events that had been coded to specific offences, then broken down into seven categories (a more complete breakdown of the offences included in each category is given in Appendix II):

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 software, converted to counts per CAU per time period, then converted to counts per 10,000 usually resident population, using the same process as described above for outlet densities.

In addition to the above data, Statistics New Zealand subnational population estimates were used to create population density (persons per square kilometre). More police events are expected to occur in areas of higher population density. Data were also obtained from Statistics New Zealand on the New Zealand Deprivation Index (NZdep2006), a commonly used index of small-area socioeconomic

deprivation (Salmond *et al.*, 2007) that is expected to be related in particular to police events (Krivo and Peterson, 1996). For amalgamated CAUs, the deprivation variable was estimated as a population-weighted average of the component CAUs.

GEOGRAPHICALLY WEIGHTED REGRESSION

GWR was used to estimate the models in this paper. GWR addresses a common problem in geographically specific analysis, that of spatial heterogeneity. Spatial heterogeneity occurs when the relationship between two variables is different in different locations. Thus a simple global model will not capture the underlying diversity of spatial effects across the region being studied. Spatial heterogeneity can arise because the strengths of relationships between neighbouring areas differ. For instance, highly accessible areas, say metropolitan areas with dense road networks and large concentrations of economic activity, will exert stronger effects on their neighbours than relatively isolated and peripheral regions. In this particular application, the impacts of alcohol outlet density in one area on surrounding areas may be higher in areas of higher social deprivation.

To account for spatial heterogeneity, a number of locally linear spatial models have been developed. These models include the spatial expansion model of Casetti (1972; Jones and Casetti, 1992), the Drift Analysis of Regression Parameters (DARP) model proposed by Casetti (1982) and Casetti and Can (1999) and, probably best known of all, the family of non-parametric locally linear regression models introduced in McMillen (1996), McMillen and McDonald (1997) and Brunsdon *et al.* (1996). The last models are often called GWR models (LeSage, 1998). A detailed discussion of the derivation of the GWR estimator will not be entered into here; a particularly concise treatment can be found in LeSage (1998, pp. 154-156).

The main distinguishing feature of the GWR methodology is the use of a distance-weighted sub-sample of observations to produce locally linear estimates for every point in space. This may be thought of as analogous to a kernel density estimator. In lay terms this means that a separate equation is fitted for every location in the dataset, with the data used being weighted to reflect the separation between locations. This yields a large number of parameter estimates, equal to the number of independent variables in the model multiplied by the number of locations. In the case where multiple models are run, the number of parameter estimates is obviously increased by a factor equal to the number of models.

There are, however, limitations to the implementation of the standard GWR approach (LeSage, 1998). First, the GWR local parameter estimates are obtained using the same set of sample data points, albeit reweighted. Hence the estimates obtained for each location in the dataset will not be independent, and conventional measures of dispersion for the estimates will, in all likelihood, be inaccurate. Second, the standard non-parametric GWR model does not handle the presence of outliers well. Shifts in spatial regime or the presence of spatial enclaves may therefore result in aberrant observations being accorded undue weight. Given that the GWR model weights observations that are nearby more heavily than those that are far away, the effects of any such aberrant outliers will spill over into the locally linear estimates for surrounding points. Finally, the standard GWR approach can suffer from 'weak data' problems, as the distance weighting used in obtaining estimates may result in the effective number of observations being inadequately small.

The GWRs presented in this report were conducted by running essentially separate analyses for each dependent variable. This approach differs from previous analyses of similar data for Manukau City conducted by Cameron *et al.* (2012c, 2012d), who used spatial seemingly unrelated regression to run analyses of all dependent variables simultaneously. We overcame the problem of outliers noted above by amalgamating CAUs, as described on page 9. Each dependent and explanatory variable used in the GWRs was first converted to an annual average in the period considered in the study, with 2005 data excluded because the police event data did not cover the entire calendar year. The exception to this is the New Zealand Deprivation Index variable, which did not vary within each CAU during the period considered. While it would have been ideal to adopt a panel approach, the use of panel GWR techniques is still in its infancy (see Yu, 2010) and it was thought better to adopt a technique with well known properties. The GWR estimation itself was run on the freely available GWR 4.0 software (<http://www.st-andrews.ac.uk/geoinformatics/gwr/gwr-software>), downloadable from the Centre for GeoInformatics at the University of St Andrews (Scotland). Distance weighting in the GWRs was calculated based on centroid-to-centroid Euclidean distance, i.e. the distance between the centre of the CAU and those of other nearby CAUs.

One of the key parameters in GWR is the bandwidth, which determines how great an influence surrounding areas have on the locally specific parameter estimates. We determined the bandwidth to be used in the GWR through an iterative process. Initially we attempted to identify an optimal bandwidth size using the 'golden section' methodology (Fotheringham *et al.*, 2002), which attempts to select the bandwidth with the best statistical properties. However, that method yielded results that over-smoothed the parameter estimates, eliminating much of the spatial heterogeneity. Instead we adopted an iterative approach for the models reported here, in which a number of fixed kernel specifications were experimented with before a specification based on the 30 nearest neighbours was settled on. On the surface, the choice of a given number of nearest neighbours to be included in the analysis might suggest problems for rural areas, where the CAUs are geographically much larger and so a larger geographical area is included in location-specific regression. However, this is unlikely to pose a significant problem for the analysis or interpretation, because each observation is weighted by the distance to the CAU in question. In rural CAUs, the weighting of neighbouring observations is therefore much smaller than in urban CAUs. The choice of 30 nearest neighbours achieved a balance between increasing the degree of observed spatial heterogeneity, decreasing the precision of estimates, and avoiding the weak data problem noted earlier.

These results are presented in the following section, starting with global models, which are essentially the results of a standard regression model ignoring any spatial interactions or locally specific parameter estimates. The spatial heterogeneity of these locally specific parameter estimates is summarised using boxplots, and the actual parameter estimates for two case studies are then presented using thematic maps.

RESULTS

This section presents the analytical results. First, we present the results of global models for the whole of the North Island for each of the eight dependent variables. In these global models, the

parameter estimates do not vary geographically. Second, we demonstrate the variability in estimates that exists for more locally specific locations (CAUs), which justifies the use of GWR. Finally, we examine this variability more closely, using detailed maps of two case studies – violent offences and motor vehicle accidents.

The global model results from the eight GWRs (i.e. one regression for each of the eight dependent variables) are presented in Table 2. The global models have no spatially varying coefficients – in essence they are obtained by running a standard ‘ordinary least squares’ regression model. The first number in each cell is the coefficient, with the standard error (an estimate of the preciseness of the coefficient) in parentheses below it. Following Cameron *et al.* (2012c, 2012d), because the dependent variable and all of the outlet-related variables are densities measured per 10,000 population, each coefficient may be interpreted as the marginal effect of an additional outlet of that type in a given CAU on the number of events in that CAU in a single year, holding all other factors constant. For instance, an additional licensed club in a CAU is associated with an additional 3.197 antisocial behaviour events.

More generally, in Table 2 licensed club density is significantly positively associated with antisocial behaviour, dishonesty offences, property abuses, property damage and violent offences. Bar and nightclub density is significantly positively associated with all police event types and with motor vehicle accidents.⁴ Other on-licence density is significantly positively associated with antisocial behaviour, dishonesty offences, property abuses, property damage, violent offences and motor vehicle accidents. Supermarket and grocery store density is significantly positively associated with antisocial behaviour, dishonesty offences, property abuses, property damage, sexual offences and violent offences, and significantly negatively associated with motor vehicle accidents. It is also weakly negatively associated with drug and alcohol offences. Other off-licence density is significantly positively associated with dishonesty offences and motor vehicle accidents, and significantly negatively associated with antisocial behaviour, property abuses and property damage. It is also weakly negatively associated with violent offences.

Similar to past studies in New Zealand (Cameron *et al.*, 2012c, 2012d; Day *et al.*, 2012), social deprivation (as measured by NZDep2006) is the most significant predictor of police events, and is significantly positively associated with all police event types, suggesting that police events of all types occur more frequently in poorer and more deprived areas. However, it is significantly negatively associated with motor vehicle accidents. Population density is significantly positively associated with all police event types with the exception of property abuses, and significantly negatively associated with motor vehicle accidents.

⁴ In this report, we refer to the relationship between variables being ‘significant’ at the 5 percent level of significance, and ‘weakly significant’ between the 5 percent and 10 percent levels of significance.

Table 2: GWR global model parameter estimates and diagnostics for the North Island for each dependent variable

	Antisocial behaviour	Dishonesty offences	Drug and alcohol offences	Property abuses
Club density	3.197 ^{***} (0.562)	2.183 ^{**} (1.079)	0.026 (0.043)	0.672 ^{***} (0.149)
Bar and nightclub density	14.73 ^{***} (0.626)	13.43 ^{***} (1.200)	1.335 ^{***} (0.048)	2.395 ^{***} (0.166)
Other on-licence density	3.357 ^{***} (0.315)	4.324 ^{***} (0.604)	0.0004 (0.024)	0.779 ^{***} (0.084)
Supermarket and grocery store density	5.710 ^{***} (1.225)	9.816 ^{***} (2.350)	-0.170 [*] (0.093)	2.536 ^{***} (0.325)
Other off-licence density	-7.817 ^{***} (0.950)	6.994 ^{***} (1.822)	-0.040 (0.072)	-1.610 ^{***} (0.252)
NZ Deprivation Index	1.030 ^{***} (0.073)	0.642 ^{***} (0.140)	0.035 ^{***} (0.006)	0.250 ^{***} (0.019)
Population density	2.175 ^{***} (0.452)	4.655 ^{***} (0.867)	0.109 ^{***} (0.034)	0.076 (0.120)
Intercept	-990.1 ^{***} (71.02)	-552.0 ^{***} (136.3)	-28.97 ^{***} (5.406)	-223.6 ^{***} (18.85)
Global Adjusted R²	0.7927	0.6331	0.7133	0.6926
Global Log-Likelihood	15665	17193	9628.6	12556
Global AIC	15683	17211	9646.6	12574
GWR Adjusted R²	0.9455	0.8953	0.8806	0.9343
GWR Log-Likelihood	13860	15491	8362.0	10515
GWR AIC	14200	15831	8702.3	10855

Table 2 (continued)

	Property damage	Sexual offences	Violent offences	Motor vehicle accidents
Club density	1.267 ^{***} (0.206)	-0.031 (0.020)	0.853 ^{***} (0.237)	0.129 (0.085)
Bar and nightclub density	2.871 ^{***} (0.229)	0.321 ^{***} (0.023)	5.311 ^{***} (0.264)	0.511 ^{***} (0.095)
Other on-licence density	0.666 ^{***} (0.115)	0.004 (0.011)	0.557 ^{***} (0.133)	0.266 ^{***} (0.047)
Supermarket and grocery store density	3.698 ^{***} (0.449)	0.270 ^{***} (0.044)	2.901 ^{***} (0.517)	-1.124 ^{***} (0.185)
Other off-licence density	-0.816 ^{***} (0.348)	0.008 (0.034)	-0.758 [*] (0.401)	0.460 ^{***} (0.144)
NZ Deprivation Index	0.268 ^{***} (0.027)	0.015 ^{***} (0.003)	0.539 ^{***} (0.031)	-0.023 ^{**} (0.011)
Population density	0.308 [*] (0.165)	0.097 ^{***} (0.016)	0.482 ^{**} (0.191)	-0.781 ^{***} (0.068)
Intercept	-239.7 ^{***} (26.01)	-13.07 ^{***} (2.558)	-491.7 ^{***} (29.99)	59.37 ^{***} (10.74)
Global Adjusted R²	0.6496	0.5199	0.7335	0.3412
Global Log-Likelihood	13311	7874.4	13645	11237
Global AIC	13329	7892.4	13663	11255
GWR Adjusted R²	0.8923	0.7893	0.9270	0.5040
GWR Log-Likelihood	11696	6669.0	11896	10672
GWR AIC	12037	7009.2	12236	11012

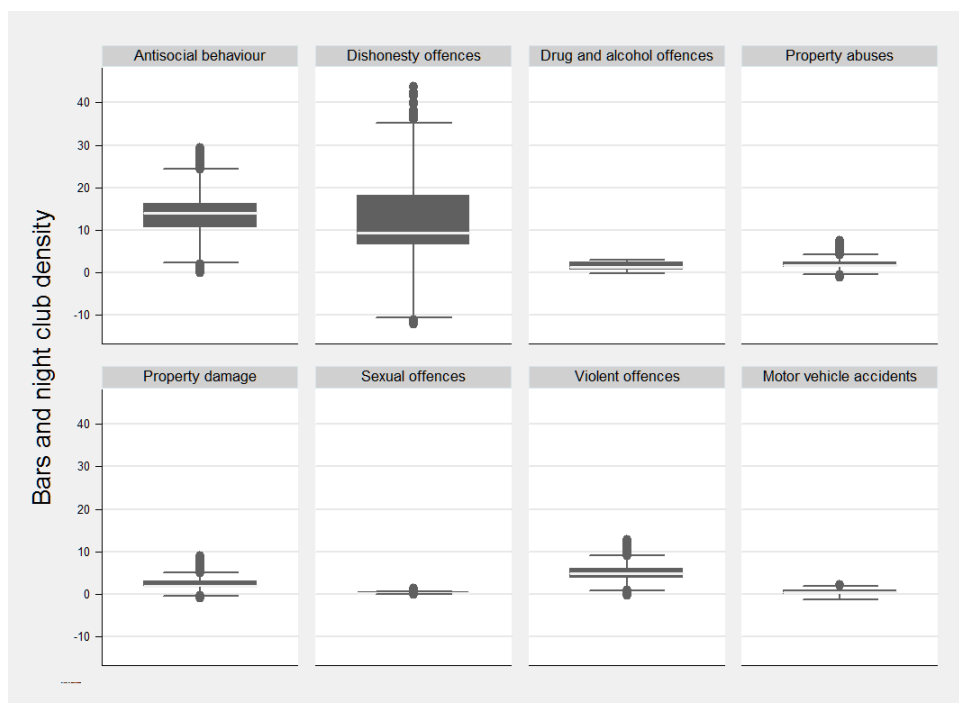
*** Significant at the 1 percent level; ** Significant at the 5 percent level; * Significant at the 10 percent level.

Table 2 also presents diagnostics for the global models as well as for the GWR models with spatially varying coefficients, for comparison. The adjusted R² shows the proportion of the variability in the dependent variable that is explained by the explanatory variables. In each case the global models explain a large proportion of the variation, with the minimum value being around 34 percent for the motor vehicle accident model. However, in all cases the explanatory power of the spatially varying models is greater. The log-likelihood and AIC are two further measures of the goodness-of-fit of the models. Smaller numbers are better for both of these measures, and in all cases the spatially varying models have unambiguously better goodness-of-fit. This suggests that, while the global models do an adequate job of explaining the variation in police events and motor vehicle accidents in each CAU, models where the coefficients are locally specific are better.

The results in Table 2 demonstrate the effect of an additional outlet of a given type across all CAUs in the North Island *on average*. The diagnostics show that the models are improved by an explicit consideration of the significant *spatial variation* in the coefficients as well. The parameter estimates in the GWR models vary widely for different locations, and Figure 2 presents boxplots of the parameter estimates for bar and nightclub density, for each dependent variable (police events and motor vehicle accidents). These boxplots illustrate the variability in locally specific parameter estimates, by showing the median, upper and lower quartiles, and maximum and minimum of these estimates for each year. Similar boxplots for other dependent variables are included in Appendix III, along with boxplots showing the variability in local R^2 values.

While the global model parameter estimates for the effect of bar and nightclub density (shown in Table 2) show that this variable is amongst the largest and most significant in terms of parameter estimate, it is clear from Figure 2 that the locally specific parameter estimates vary widely. For instance, while the global effect of bar and nightclub density on dishonesty offences indicates that an additional bar or nightclub in a CAU is associated with about 13.4 additional dishonesty offences per year (Table 2), the locally specific parameter estimates vary substantially, between -12.1 and 43.7 (Figure 2). In contrast, some of the locally specific parameter estimates show much less variation. For instance, the locally specific parameter estimates for the relationship between bar and nightclub density and sexual offences shown in Figure 2 vary only between -0.08 and 1.23 (the corresponding global parameter estimate from Table 2 is 0.3 and statistically significant).

Figure 2: Spatial heterogeneity in the parameter estimates (y-axis) for the relationship between bar and nightclub density and each dependent variable



While boxplots such as Figure 2 are a useful way of summarising the extent of spatial heterogeneity in parameter estimates, the most effective way of demonstrating how the effect of each explanatory variable on each dependent variable varies spatially is through the use of maps. Given the size of the system estimated in this report, with models for eight dependent variables, five categories of alcohol

outlet density, and two control variables (deprivation and population density), it is not feasible to present maps for *all* of the effects in the pages of this report. Instead, we concentrate the report on two case studies – violent offences and motor vehicle accidents. The following two sections present these case studies only, focusing on the parameter estimates from those two models. The parameter estimates from all models, for all combinations of dependent and explanatory variable, are available as an electronic appendix to this report, in the form of a Geographic Information Systems (GIS) shape file (Appendix IV).

The two case studies make extensive use of maps. The colour palette employed in these maps was chosen to represent clearly the degree to which the dependent variable (violent offences or motor vehicle accidents) is positively (or negatively) associated with the explanatory variable. The colour palette follows a seven-colour traffic-light system – the largest positive values, where the dependent variable is most strongly positively associated with the explanatory variable, are red. From the perspective of a policy-maker, areas that are red or orange in colour are likely to be of greatest concern. For each map, any statistically significant negative relationships have been grouped into a single category, with statistically significant positive relationships spread approximately evenly over the remaining categories. Insignificant relationships are all shown in grey. Each mapped relationship is treated independently in this report – thus the colours should not be directly compared between maps of different relationships, because the same colour may represent different sizes of parameter estimates on different maps.

CASE STUDY 1: VIOLENT OFFENCES

The first of the two case studies specifically describes the relationships between the different outlet densities and violent offences. Table 2 on page 14 demonstrated that the most substantial positive relationships with violent offences in the global models were observed for bar and nightclub density, and supermarket and grocery store density. Other on-licence density and licensed club density also had significant positive relationships with violent offences, while other off-licence density had a marginally significant negative relationship with violent offences. This case study presents the results when these relationships are allowed to vary between different locations, supported by maps, with the key features of each map highlighted in the text.

Figure 3 shows the spatial distribution of the relationship between licensed club density and violent offences, with red and orange representing the largest positive relationships (i.e. the areas where an additional licensed club is associated with more than three additional violent offences per year). In the global model (Table 2) the overall effect was statistically significant and positive, with each additional licensed club associated with about 0.8 additional violent offences per year. However, as Figure 3 demonstrates, the size of the relationship varies substantially across the North Island. The global model masks that the majority of CAUs have insignificant relationships between licensed club density and violent offences (shown in grey on the map). These include mainly rural areas (except in the central and eastern North Island), as well as all of the smaller urban centres. The parameter estimates are largest in South Auckland and the Wellington region. However, there is a statistically significant negative relationship between licensed club density and violent offences in the northwest of the Waikato region – in this area an additional licensed club is associated with *fewer* violent offences per year.

Figure 3: Locally specific point parameter estimates for the relationship between licensed club density and violent offences in the North Island, 2006-2011

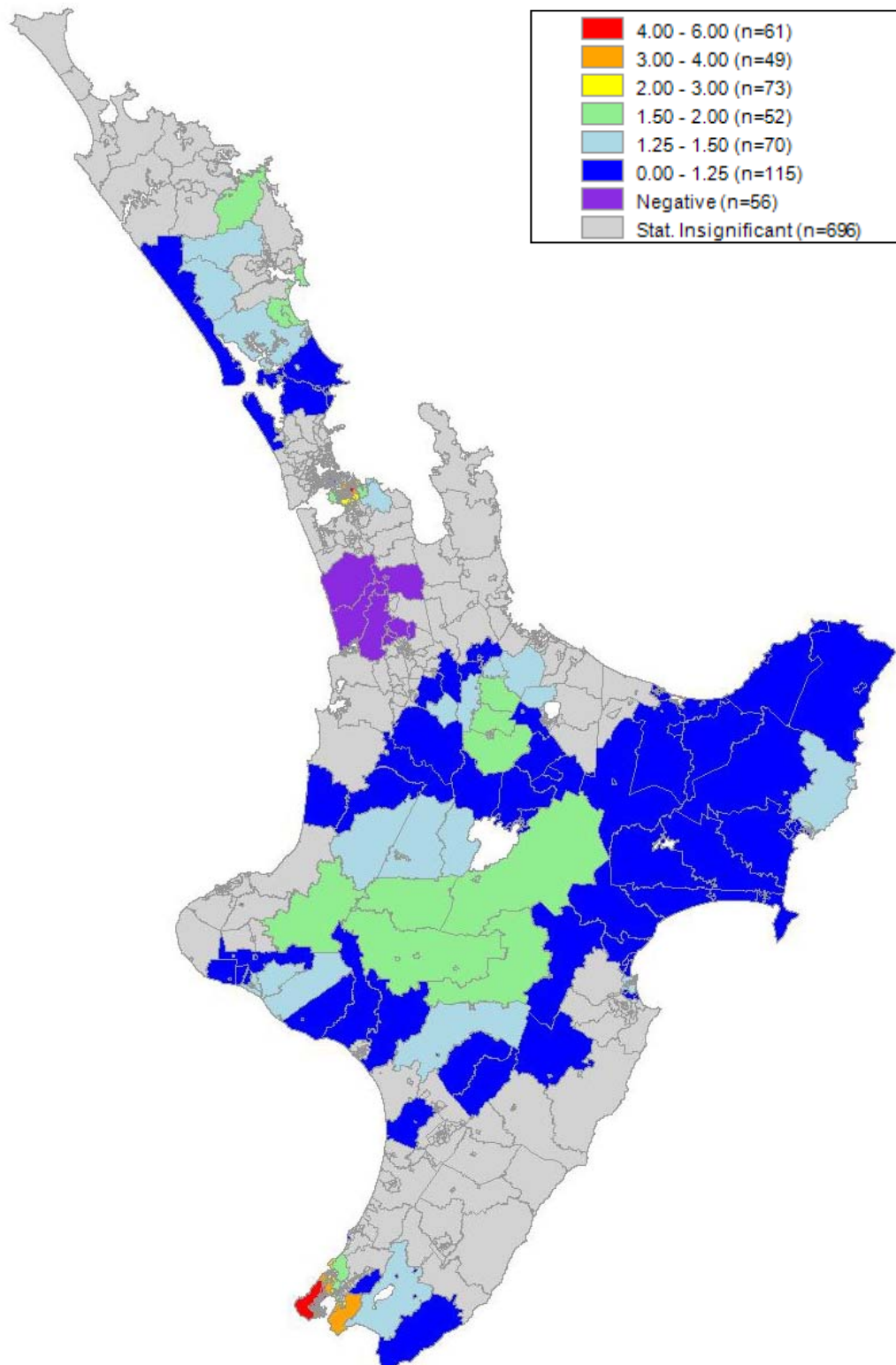


Figure 4 shows the relationship between licensed club density and violent offences in the Auckland region. The parameter estimates are largest in South Auckland, particularly in the suburbs of East Tamaki, Otara and Otahuhu, where an additional licensed club is associated with more than four additional violent offences per year. The surrounding suburbs also have large parameter estimates. There is a second area of large positive relationships in West Auckland (between the suburbs of Glen Eden and Avondale). However, central Auckland has significant negative relationships between licensed club density and violent offences – that is, in central Auckland an additional licensed club is associated with *fewer* violent offences per year.

Figure 4: Locally specific point parameter estimates for the relationship between licensed club density and violent offences in the Auckland region, 2006-2011

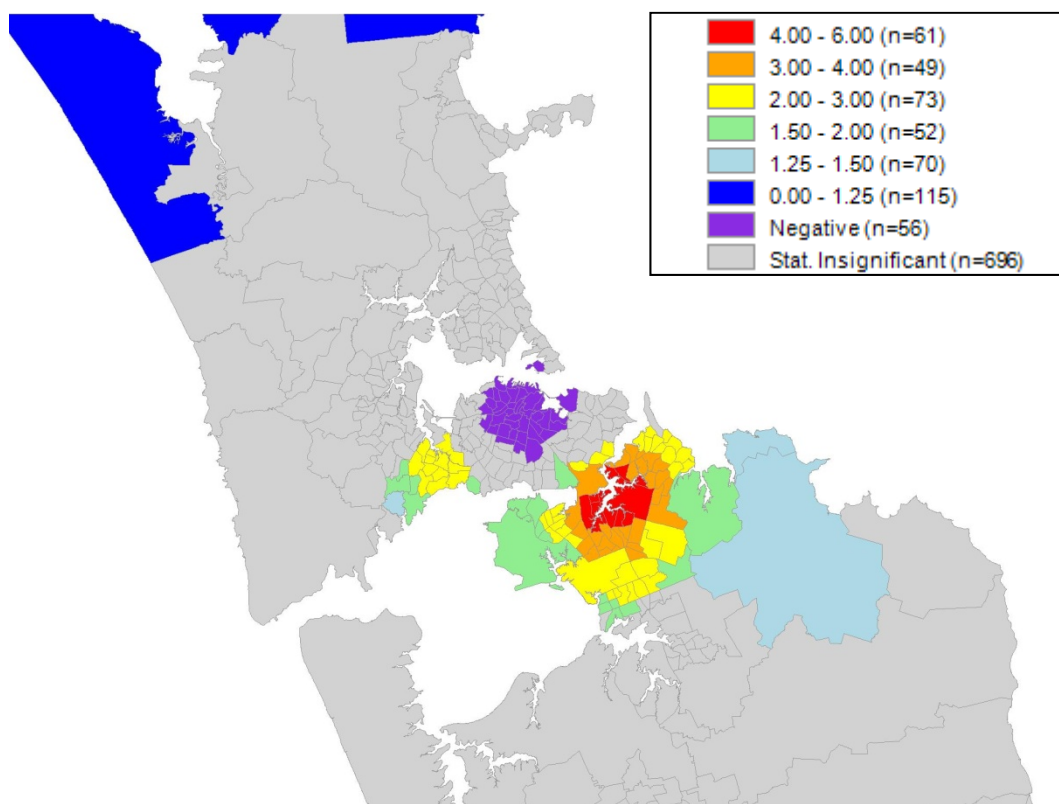


Figure 5 shows the relationship between licensed club density and violent offences in the Wellington region. The parameter estimates are largest across much of the central city and extending to the west coast; in these areas an additional licensed club is associated with more than four additional violent offences per year. The surrounding suburbs also have large parameter estimates, including Petone, Eastbourne and western and southern Porirua city. However, the relationship between licensed club density and violent offences is not generally statistically significant in the Hutt Valley.

Figure 5: Locally specific point parameter estimates for the relationship between licensed club density and violent offences in the Wellington region, 2006-2011

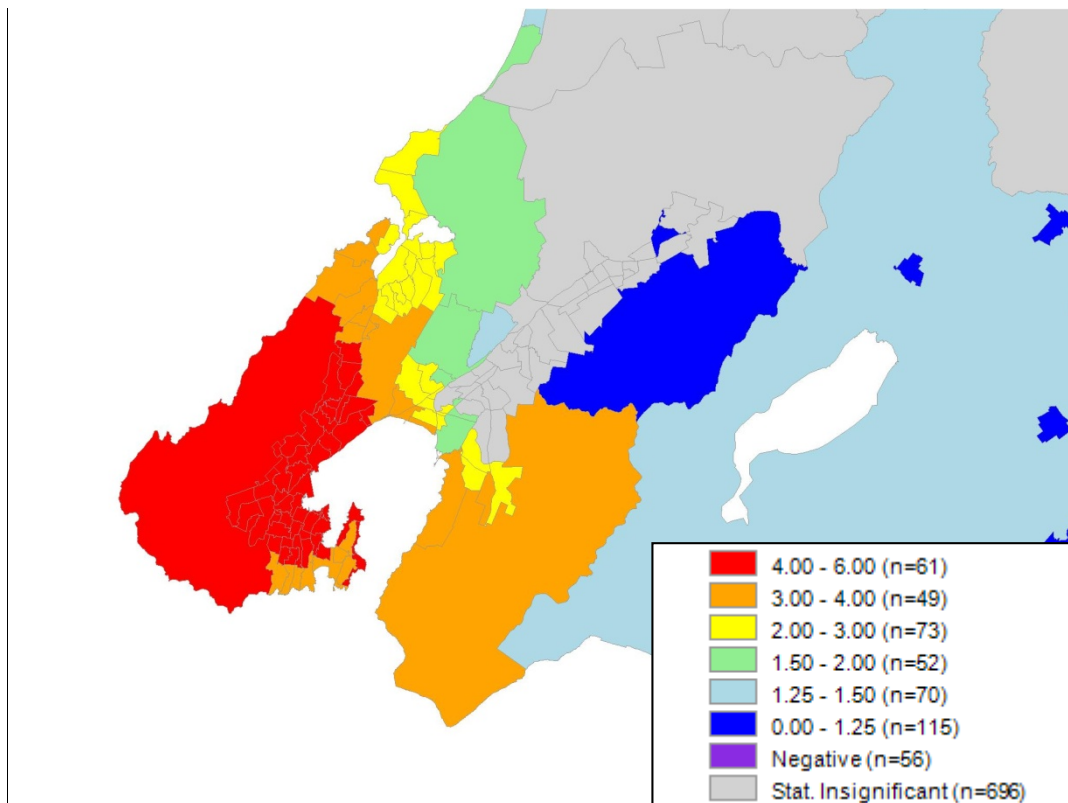


Figure 6 shows the spatial distribution of the relationship between bar and nightclub density and violent offences, with red and orange representing the largest positive relationships (i.e. the areas where an additional bar or nightclub is associated with more than six additional violent offences per year). In the global model (Table 2) the overall effect was statistically significant and positive, with each additional bar or nightclub associated with about 5.3 additional violent offences per year. Figure 6 demonstrates that the size of the parameter estimates for the relationship between bar and nightclub density and violent offences varies substantially across the North Island. With the exception of Hawke’s Bay (including Napier city but not Hastings), almost all CAUs show a statistically significant relationship. The estimated parameters are largest in the Wellington region, as well as central Northland (including Whangarei), South Auckland, Tauranga city (including Mount Maunganui) and the rural areas surrounding Whanganui. In all of these areas an additional bar or nightclub is associated with six or more additional violent offences per year. The relationship is smallest (but still statistically significant) in the central and eastern North Island (including Gisborne, Rotorua and Taupo), Whanganui city and Taranaki (including New Plymouth). In these areas an additional bar or nightclub is associated with fewer than four additional violent offences per year.

Figure 7 shows the relationship between bar and nightclub density and violent offences in the Auckland region. The estimated parameters are largest in South Auckland, in central Manukau and Manurewa in particular, where an additional bar or nightclub is associated with nine or more additional violent offences per year. There are also pockets of large parameter estimates in West Auckland (between the suburbs of Glen Eden and Mount Albert) and in the northern North Shore (from Glenfield and Campbells Bay to Dairy Flat and Long Bay) extending southwest to Waitakere. In these

areas an additional bar or nightclub is associated with five or more additional violent offences per year.

Figure 8 shows the relationship between bar and nightclub density and violent offences in the Wellington region. The parameter estimates are largest in the rural Wellington region, where an additional bar or nightclub is associated with nine or more additional violent offences per year. The relationship is somewhat smaller (although still large relative to much of the North Island) in the central city, with the areas to the east and south of the central city having the smallest relationships between an additional bar or nightclub and violent offences. However, across the entire region an additional bar or nightclub is associated with *at least* five additional violent offences per year.

Figure 6: Locally specific point parameter estimates for the relationship between bar and nightclub density and violent offences in the North Island, 2006-2011

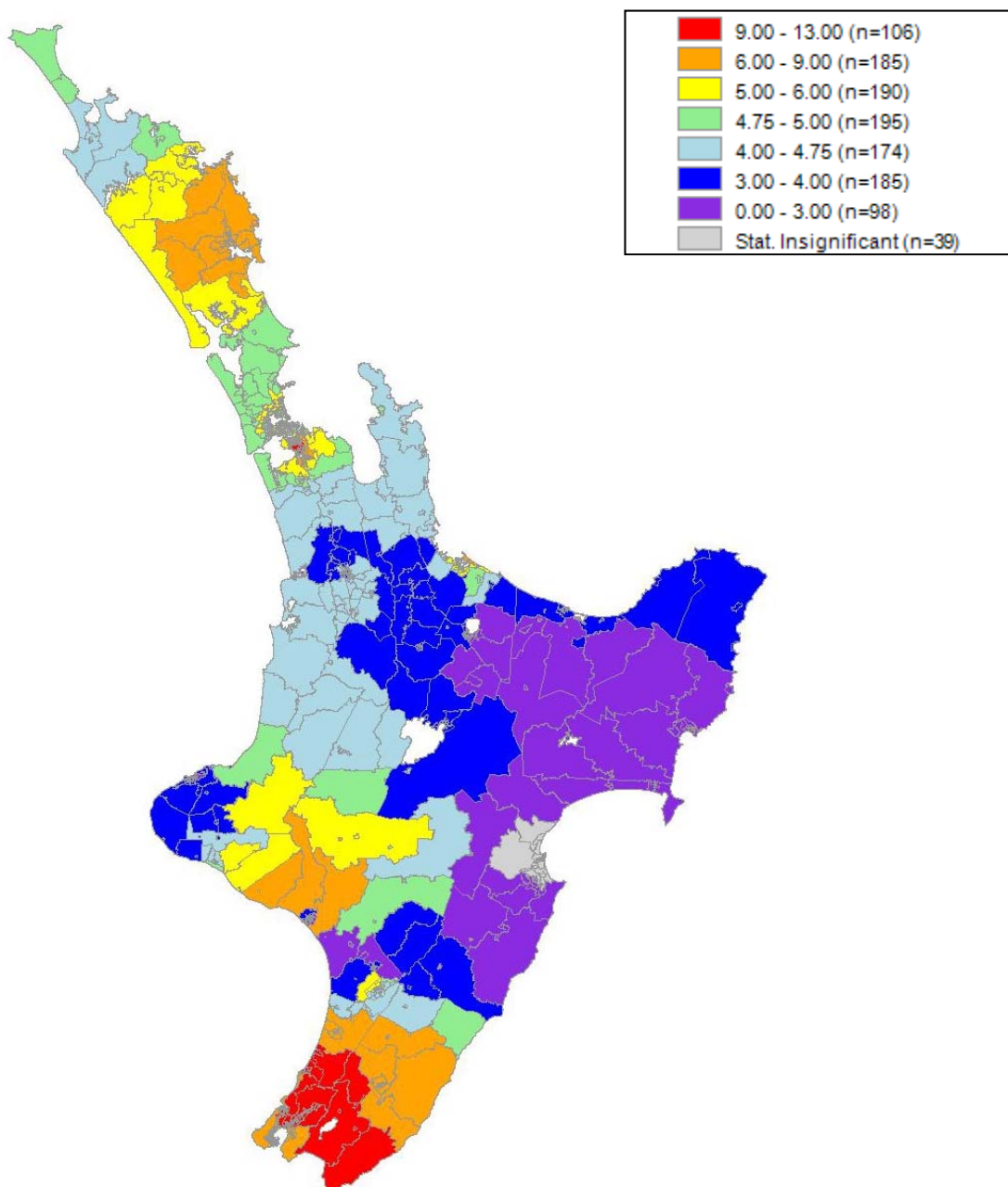


Figure 7: Locally specific point parameter estimates for the relationship between bar and nightclub density and violent offences in the Auckland region, 2006-2011

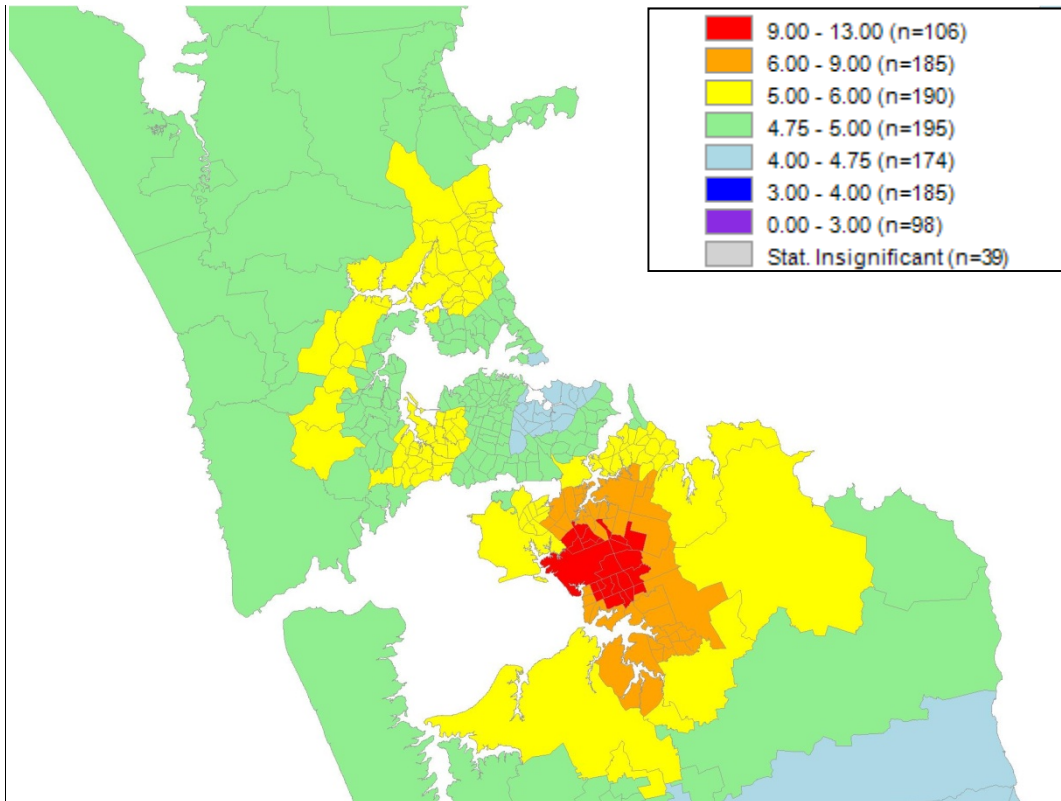


Figure 8: Locally specific point parameter estimates for the relationship between bar and nightclub density and violent offences in the Wellington region, 2006-2011

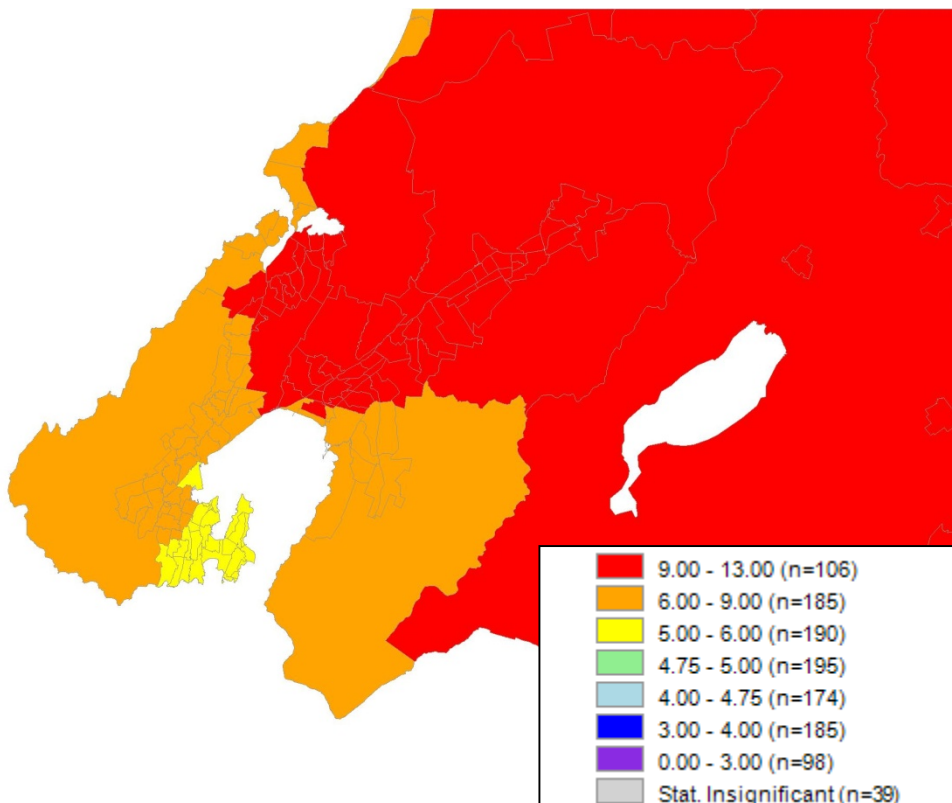


Figure 9 shows the spatial distribution of the relationship between other on-licence density (i.e. on-licence density excluding bars and nightclubs) and violent offences, with red and orange representing the largest positive relationships (i.e. the areas where an additional on-licence outlet is associated with more than 1.3 additional violent offences per year). In the global model (Table 2) the overall effect was statistically significant and positive, with each additional other on-licence outlet associated with about 0.56 additional violent offences per year. Figure 9 demonstrates that there are large areas where the relationship is statistically insignificant (shown in grey), notably Northland (including Whangarei), Waikato (including Hamilton), Bay of Plenty (including Tauranga and Rotorua) and southern Hawke's Bay (including Hastings). The parameter estimates are largest in the rural Manawatu, central Hawke's Bay, Whanganui and southern Taranaki (including Hawera) areas. In all of these areas an additional on-licence outlet is associated with 1.7 or more additional violent offences per year. However, the relationship between other on-licence density and violent offences is negative in South Auckland (including Manukau City, Mangere, Flat Bush and the rural areas to the east of Manukau) and in the Wellington region. In these areas an additional on-licence outlet is associated with *fewer* violent offences per year. The exception is central Wellington, where the relationship is statistically insignificant between the suburbs of Karori and Kelburn in the north and west, and Miramar and Lyall Bay in the east.⁵

Figure 10 shows the spatial distribution of the relationship between supermarket and grocery store density and violent offences, with red and orange representing the largest positive relationships (i.e. the areas where an additional licensed supermarket or grocery store is associated with more than nine additional violent offences per year). In the global model (Table 2) the overall effect was statistically significant and positive, with each additional other on-licence outlet associated with about 2.9 additional violent offences per year. As Figure 10 shows, the relationship between supermarket and grocery store density and violent offences varies substantially across the North Island. There are large areas where the relationship is statistically insignificant (shown in grey). These include much of the central and upper North Island, with the exceptions of a small area in South Auckland (see Figure 11) and the area around Rotorua. There are also large areas with statistically significant negative relationships, notably Northland (but excluding Whangarei), central Auckland and parts of the North Shore, northern and eastern Waikato, and southern Taranaki (including Hawera). In these areas, an additional licensed supermarket or grocery store is associated with *fewer* violent offences per year. The parameter estimates are largest in central Wellington and Hawke's Bay (including Napier), where an additional licensed supermarket or grocery store is associated with nine or more additional violent offences per year.

Figure 11 shows the relationship between supermarket and grocery store density and violent offences in the Auckland region. Figure 11 clearly shows the negative relationship in central Auckland and parts of the North Shore, where an additional licensed supermarket or grocery store is associated with *fewer* violent offences per year. It also shows the significant positive relationship in the suburbs of Mangere and Otahuhu. In these suburbs an additional licensed supermarket or grocery store is associated with more than 3.5 additional violent offences per year.

⁵ Additional maps for Auckland and Wellington are not included for this relationship, because the relationships do not vary substantially within those areas, other than as already noted in the text.

Figure 12 shows the relationship between supermarket and grocery store density and violent offences in the Wellington region. The parameter estimates are largest in the central city, where an additional licensed supermarket or grocery store is associated with more than 11 additional violent offences per year. The relationship weakens the farther away from the central city the CAU is, such that in central and southern Porirua city an additional licensed supermarket or grocery store is associated with fewer than 3.5 additional violent offences per year. In the Hutt Valley and north of central Porirua, the relationship becomes statistically insignificant (shown in grey).

Figure 9: Locally specific point parameter estimates for the relationship between other on-licence density and violent offences in the North Island, 2006-2011

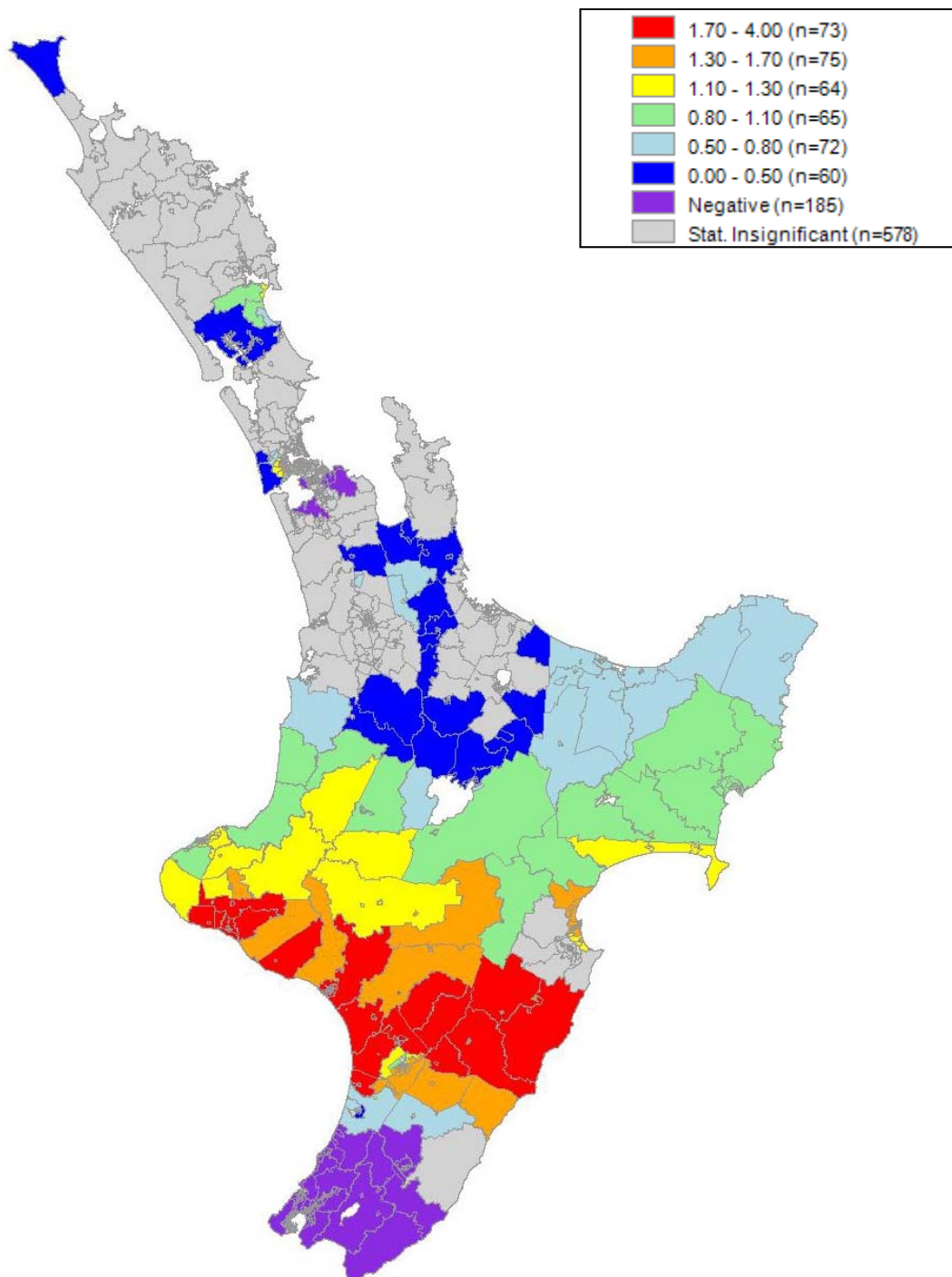


Figure 10: Locally specific point parameter estimates for the relationship between supermarket and grocery store density and violent offences in the North Island, 2006-2011

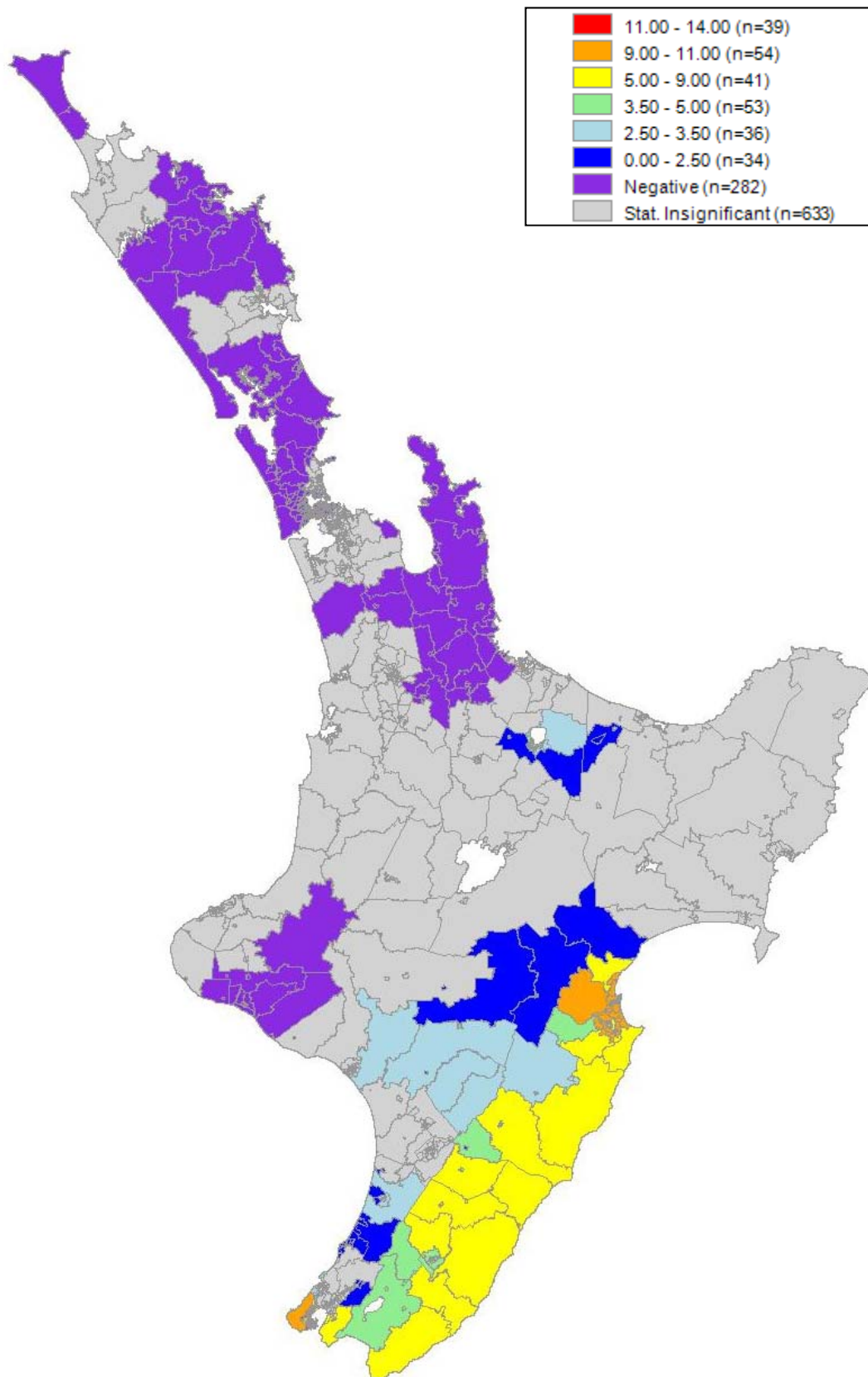


Figure 11: Locally specific point parameter estimates for the relationship between supermarket and grocery store density and violent offences, Auckland region, 2006-2011

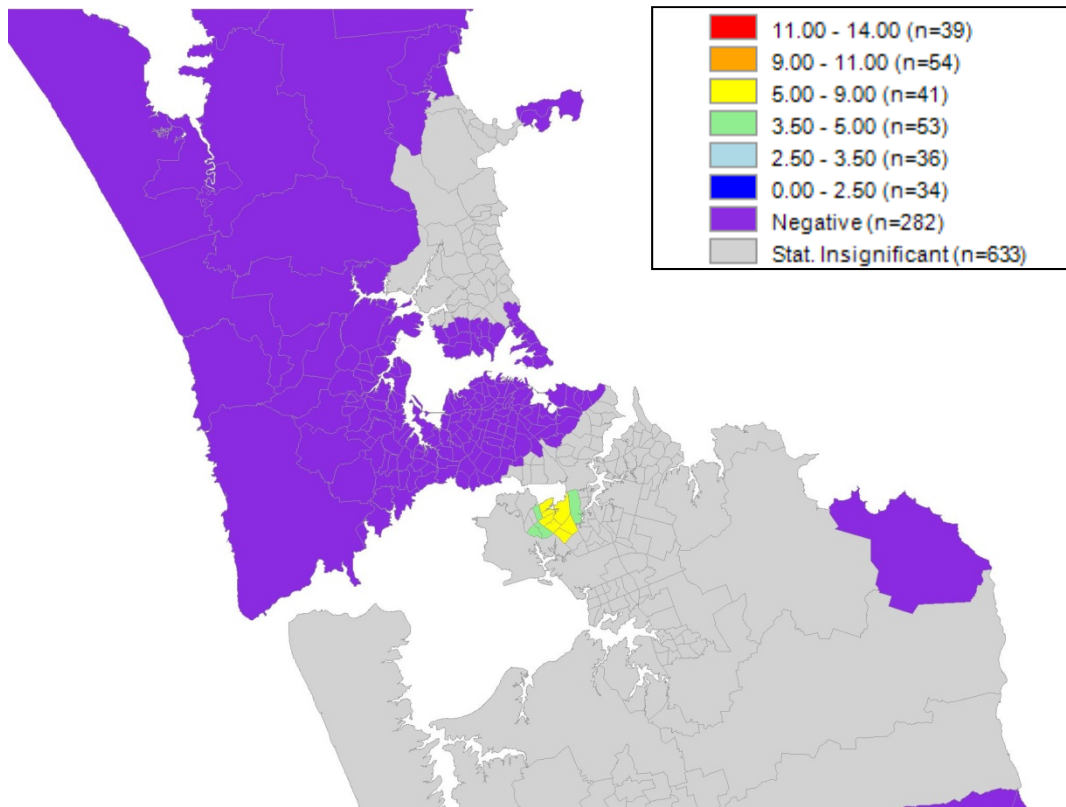


Figure 12: Locally specific point parameter estimates for the relationship between supermarket and grocery store density and violent offences, Wellington region, 2006-2011

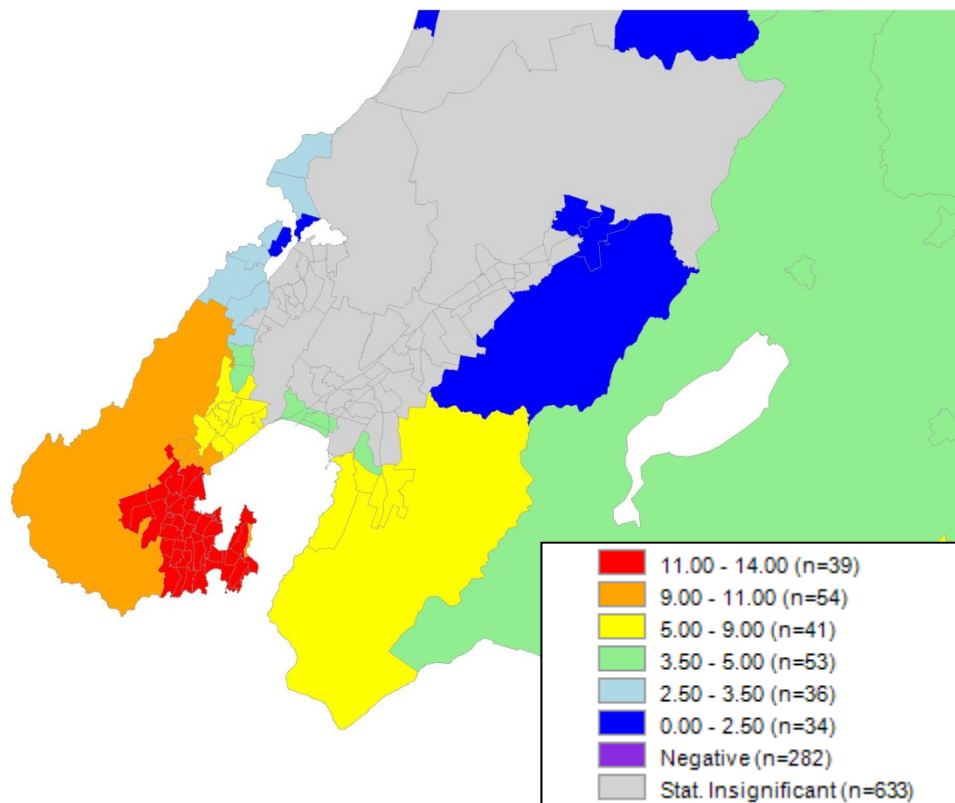


Figure 13 shows the spatial distribution of the relationship between other off-licence density (i.e. off-licence density excluding supermarkets and grocery stores) and violent offences, with red and orange representing the largest positive relationships (i.e. the areas where an additional off-licence outlet is associated with more than eight additional violent offences per year). In the global model (Table 2) the overall effect was marginally statistically significant and negative, with each additional off-licence outlet associated with about 0.76 fewer violent offences per year. As might be expected from the global model results, Figure 13 shows that much of the North Island has a statistically insignificant relationship between off-licence density and violent offences (much of Northland [including Whangarei], Waikato [including Hamilton], Bay of Plenty [including Tauranga and Rotorua], northern Taranaki [including New Plymouth] and Hawke's Bay [including Napier and Hastings]) – these areas are shown in grey in Figure 13. Furthermore, large areas across the central North Island (including Whanganui, Palmerston North, Taupo and Gisborne) have statistically significant negative relationships. In these areas an additional off-licence outlet is associated with *fewer* violent offences per year. The relationship is significant and positive only in areas south of Auckland and in Coromandel, Wellington and Wairarapa.

Figure 14 shows the relationship between other off-licence density and violent offences in the Auckland region. Most of the north, west and south of the city has a statistically insignificant relationship between other off-licence density and violent offences (shown in grey). However, the relationship is positive and statistically significant in the central city and in the far south of urban Auckland (Takanini to Drury). In these areas, an additional off-licence outlet is associated with more than 2.7 additional violent offences each year. There are other areas where the relationship is positive and statistically significant but smaller in size, including the suburbs of Mangere in South Auckland and Devonport on the North Shore. In these areas an additional off-licence outlet is associated with fewer than 2.7 additional violent offences per year.

The pattern of relationships is quite different for the Wellington region, as shown in Figure 15. In Wellington, the central city has a statistically significant negative relationship between other off-licence density and violent offences. That is, in this area an additional off-licence outlet is associated with *fewer* violent offences per year. In contrast, most of the rest of the region shows a statistically significant positive relationship between off-licence density and violent offences. The parameter estimates are largest in most of Porirua city and parts of Upper Hutt, where an additional off-licence outlet is associated with more than 10.5 additional violent offences per year. The relationship is less strong, but still significant and positive, in rural parts of the region, where an additional off-licence outlet is associated with more than 3.3 additional violent offences per year.

Figure 13: Locally specific point parameter estimates for the relationship between other offence density and violent offences in the North Island, 2006-2011

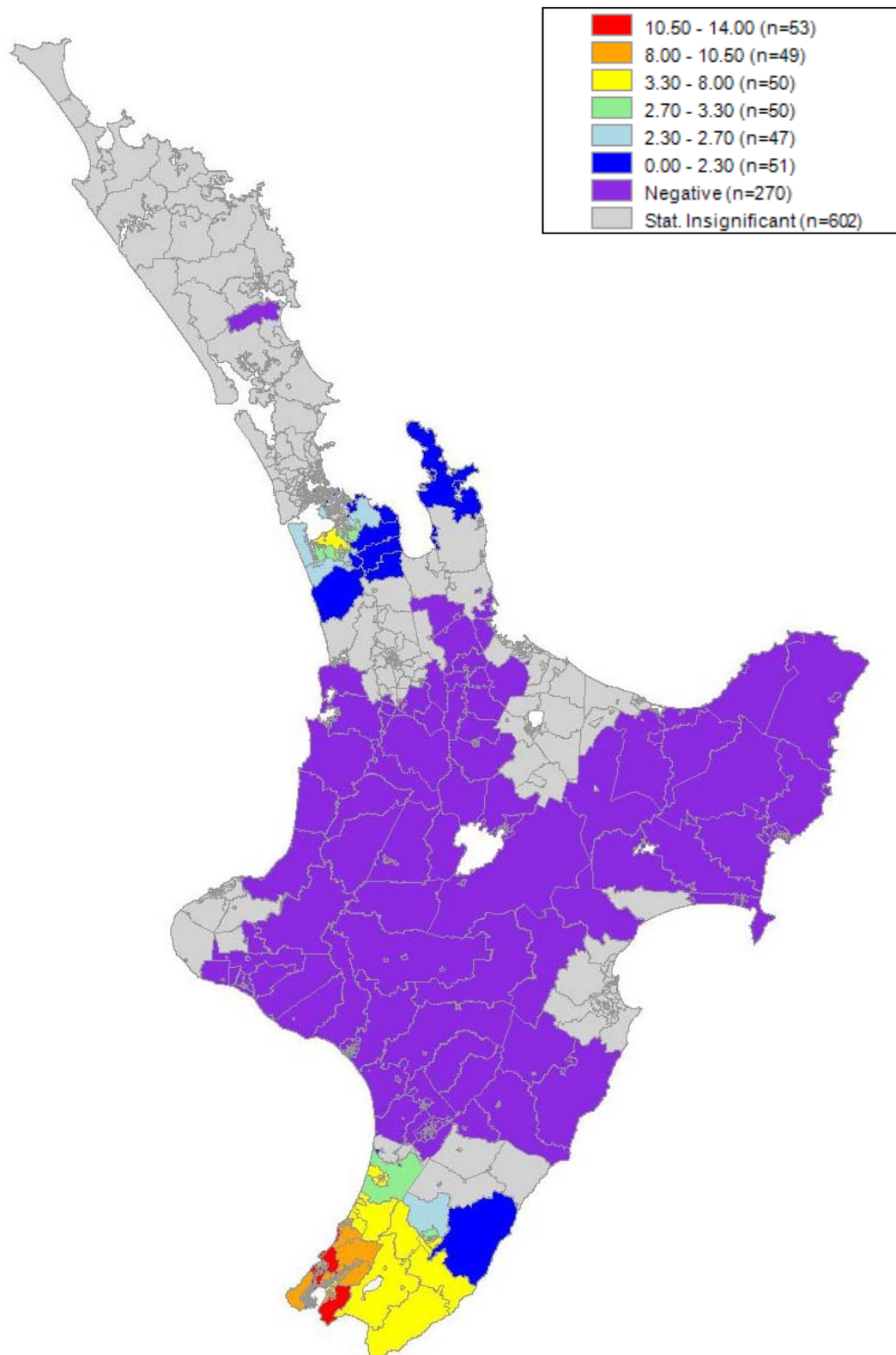


Figure 14: Locally specific point parameter estimates for the relationship between other off-licence density and violent offences in the Auckland region, 2006-2011

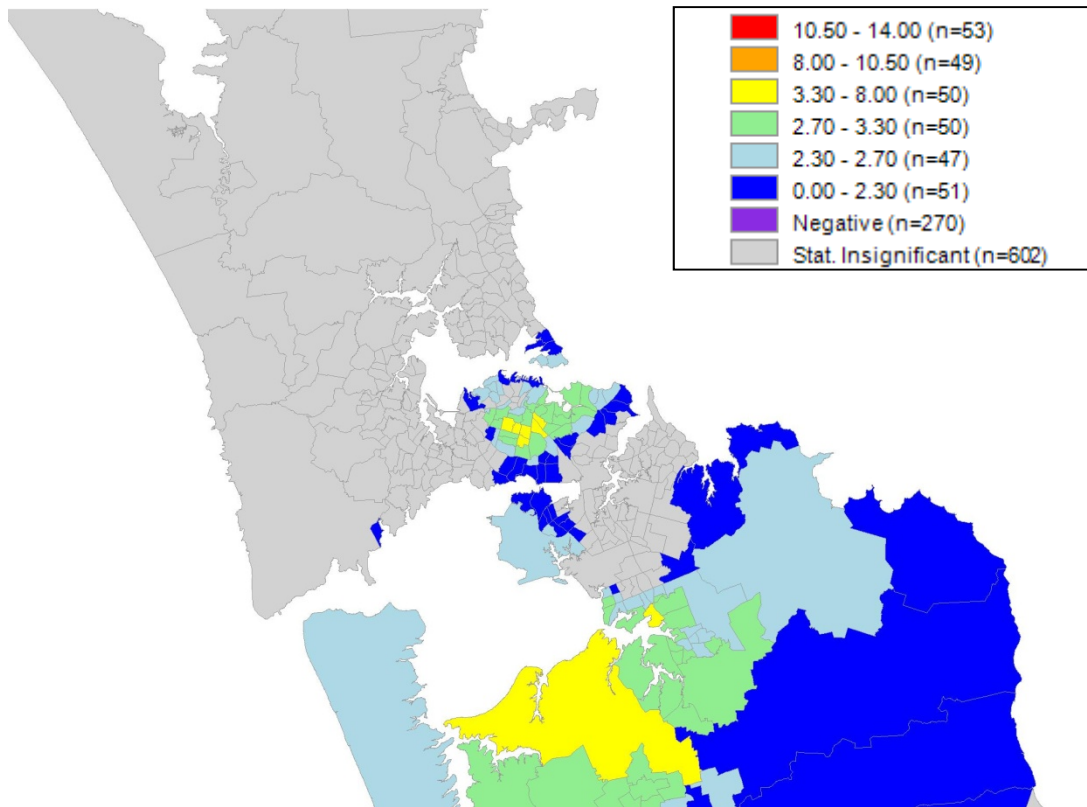
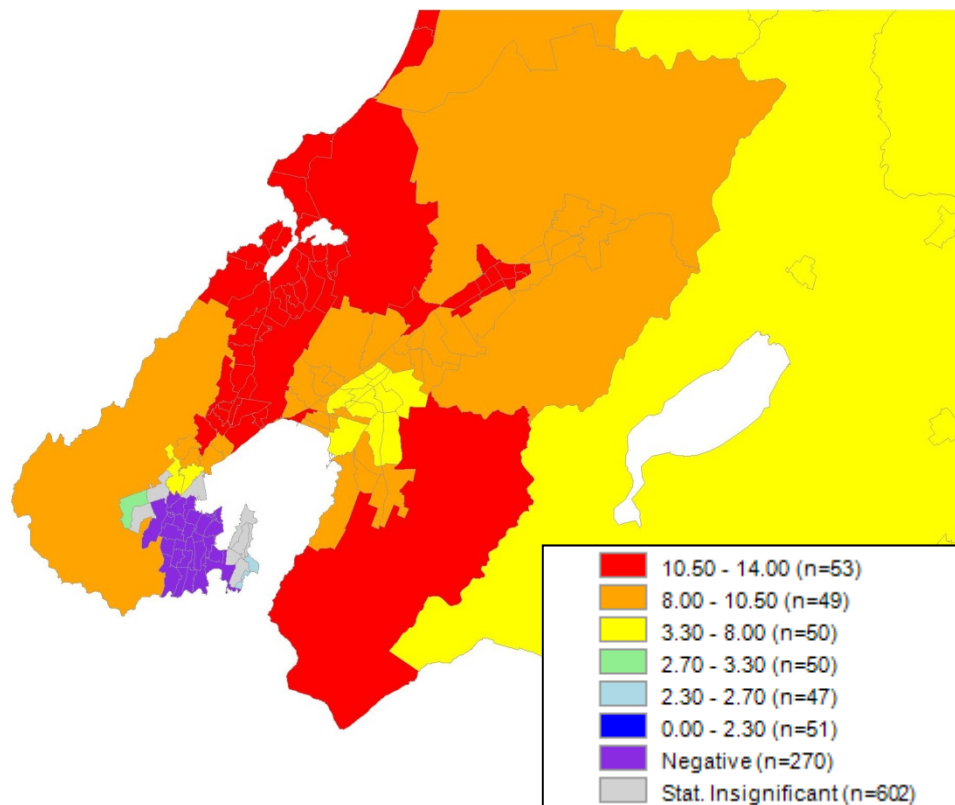


Figure 15: Locally specific point parameter estimates for the relationship between other off-licence density and violent offences in the Wellington region, 2006-2011



CASE STUDY 2: MOTOR VEHICLE ACCIDENTS

The second case study specifically describes the relationships between the different outlet densities and motor vehicle accidents. Table 2 on page 14 demonstrated that the most substantial positive relationships with motor vehicle accidents in the global model were observed for bar and nightclub density and other off-licence density. Other on-licence density also had a significant positive relationship with motor vehicle accidents, while supermarket and grocery store density had a significant negative relationship with motor vehicle accidents. As with the first case study, this case study presents the results when these relationships are allowed to vary between different locations, supported by maps, with the key features of each map highlighted in the text.

Figure 16 shows the spatial distribution of the relationship between licensed club density and motor vehicle accidents, with red and orange representing the largest positive relationships (i.e. the areas where an additional licensed club is associated with more than 1.6 additional motor vehicle accidents per year). In the global model (Table 2) the overall effect was statistically insignificant and positive. This is supported by Figure 16, where nearly three-quarters of all CAUs have a statistically insignificant relationship between licensed club density and motor vehicle accidents (shown in grey). However, there are some areas where the relationship is statistically significant and positive, including north Auckland, parts of central Auckland city, Hawke's Bay and parts of the Wellington region. In southern coastal Hawke's Bay, an additional licensed club is associated with 1.6 or more additional motor vehicle accidents per year. In contrast, the relationship is statistically significant and negative in the Waikato and Hauraki districts, between Huntly and Paeroa. In this area, an additional licensed club is associated with *fewer* motor vehicle accidents.

Figure 17 shows the relationship between licensed club density and motor vehicle accidents in the Auckland region. This figure clearly shows that most of the city has a statistically insignificant relationship between licensed club density and motor vehicle accidents (shown in grey). However, the area between Parnell and Glen Innes east of the city centre has a statistically significant positive relationship. In this area an additional licensed club is associated with more than 0.9 additional motor vehicle accidents per year. Also, north of the city the relationship becomes statistically significant and positive, especially in the Silverdale and Stanmore Bay areas, where an additional licensed club is associated with more than 1.6 additional motor vehicle accidents per year.

Figure 16: Locally specific point parameter estimates for the relationship between licensed club density and motor vehicle accidents in the North Island, 2006-2011

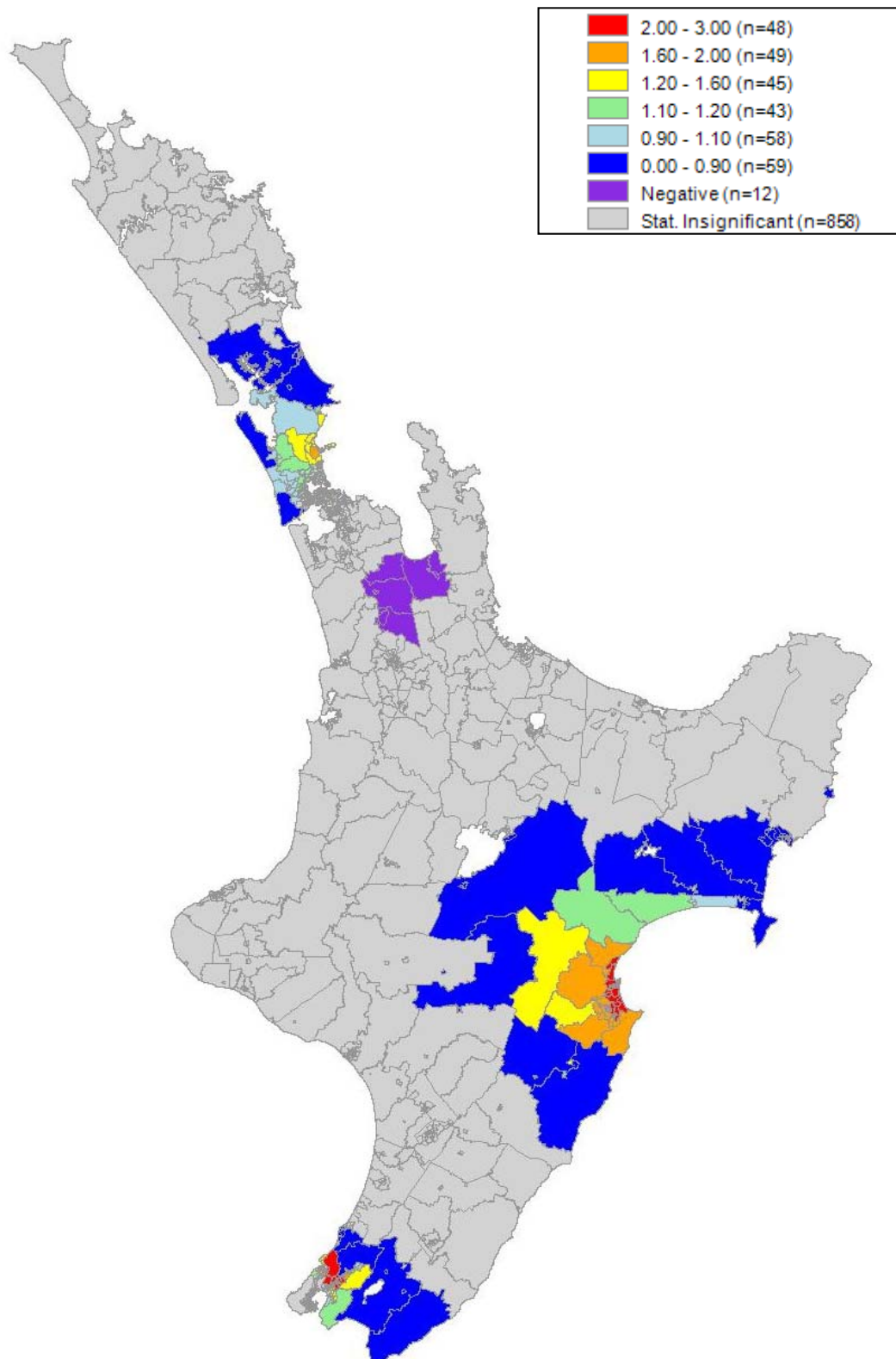


Figure 17: Locally specific point parameter estimates for the relationship between licensed club density and motor vehicle accidents in the Auckland region, 2006-2011

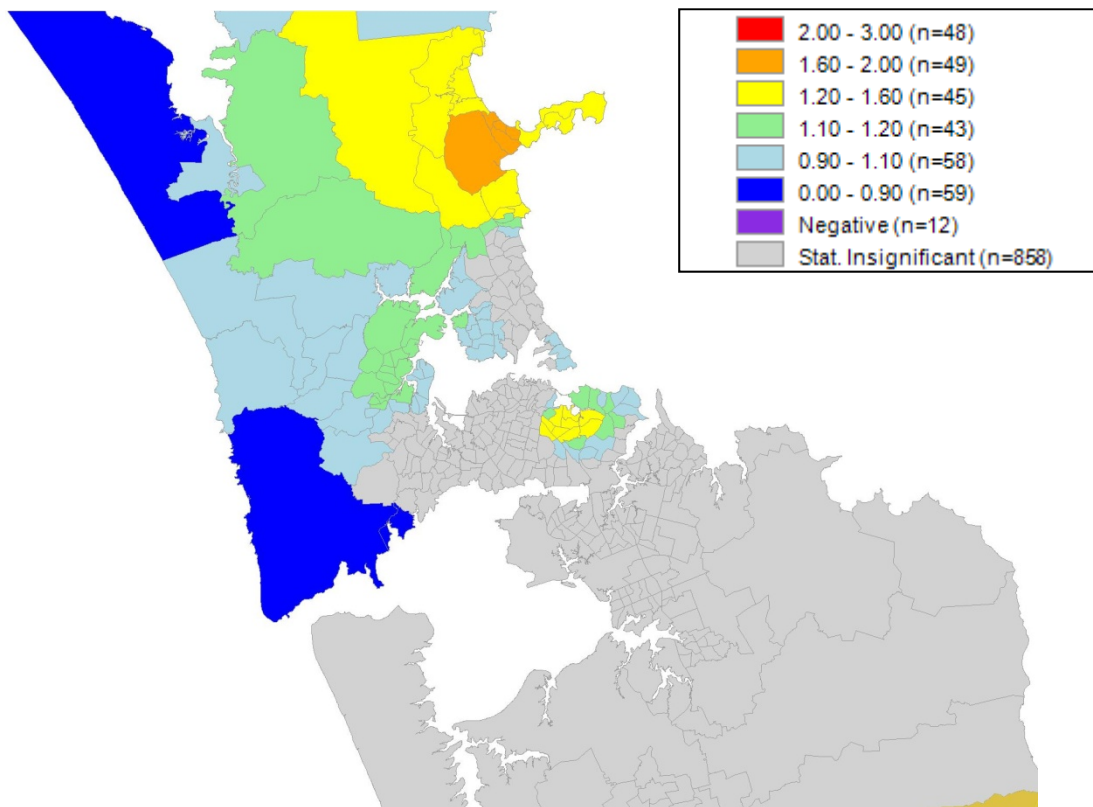


Figure 18 shows the relationship between licensed club density and motor vehicle accidents in the Wellington region. The parameter estimates are largest in the Hutt Valley and Porirua city, where an additional licensed club is associated with more than 1.6 additional motor vehicle accidents per year. The relationship is less strong in rural areas of the region, where an additional licensed club is associated with fewer than 0.9 additional motor vehicle accidents per year. However, the relationship is statistically insignificant in the central city and surrounding areas (shown in grey in Figure 18).

Figure 19 shows the spatial distribution of the relationship between bar and nightclub density and motor vehicle accidents, with red and orange representing the largest positive relationships (i.e. the areas where an additional bar or nightclub is associated with more than 0.8 additional motor vehicle accidents per year). In the global model (Table 2) the overall effect was statistically significant, with each additional bar or nightclub associated with about 0.5 additional motor vehicle accidents per year. However, as shown in Figure 19, a large proportion of CAUs have statistically insignificant relationships between bar and nightclub density and motor vehicle accidents (shown in grey), particularly in the central and southern parts of the North Island (including Tauranga, Gisborne, New Plymouth, Whanganui, Palmerston North and Hastings) and in parts of Northland (including Whangarei). The relationship is statistically significant and negative in the Rotorua area, parts of Hawke's Bay (including Napier) and parts of the Wellington region (including the central city, Upper Hutt and the Kapiti Coast). In these areas an additional bar or nightclub is associated with fewer motor vehicle accidents per year. However, in the north of the North Island the relationship is both statistically significant and positive. It is largest in Waikato (including most of Hamilton), parts of central Auckland and the area just to the north of Kaipara Harbour (including Dargaville). In these

areas, an additional bar or nightclub is associated with 0.9 or more additional motor vehicle accidents per year.

Figure 18: Locally specific point parameter estimates for the relationship between licensed club density and motor vehicle accidents in the Wellington region, 2006-2011

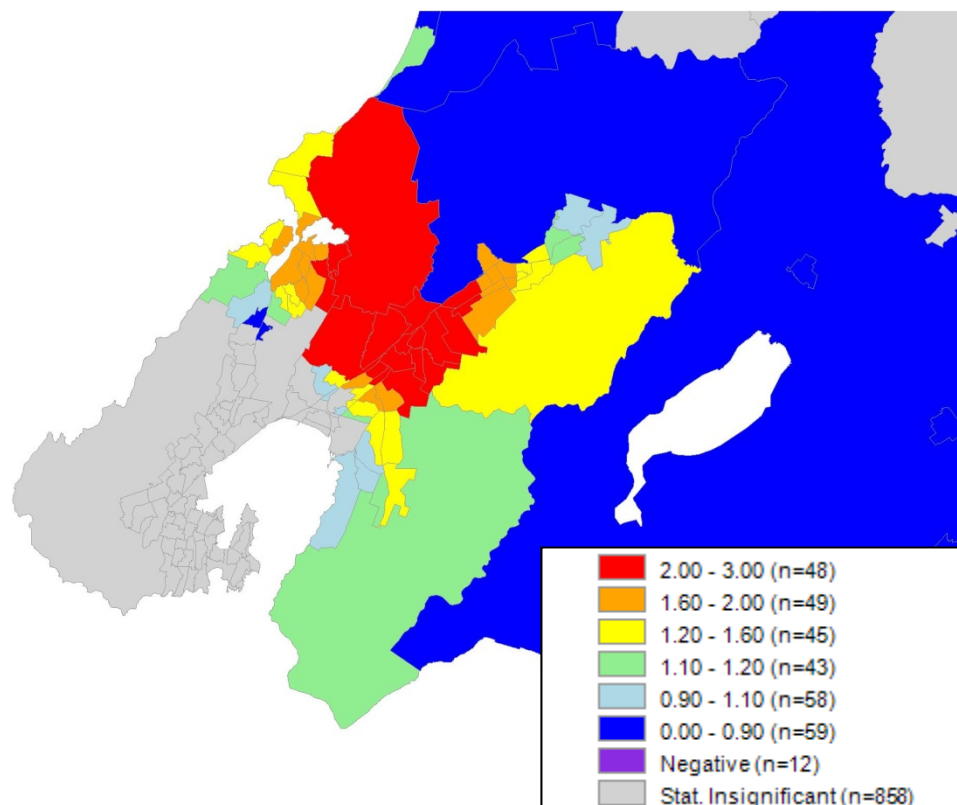


Figure 19: Locally specific point parameter estimates for the relationship between bar and nightclub density and motor vehicle accidents in the North Island, 2006-2011

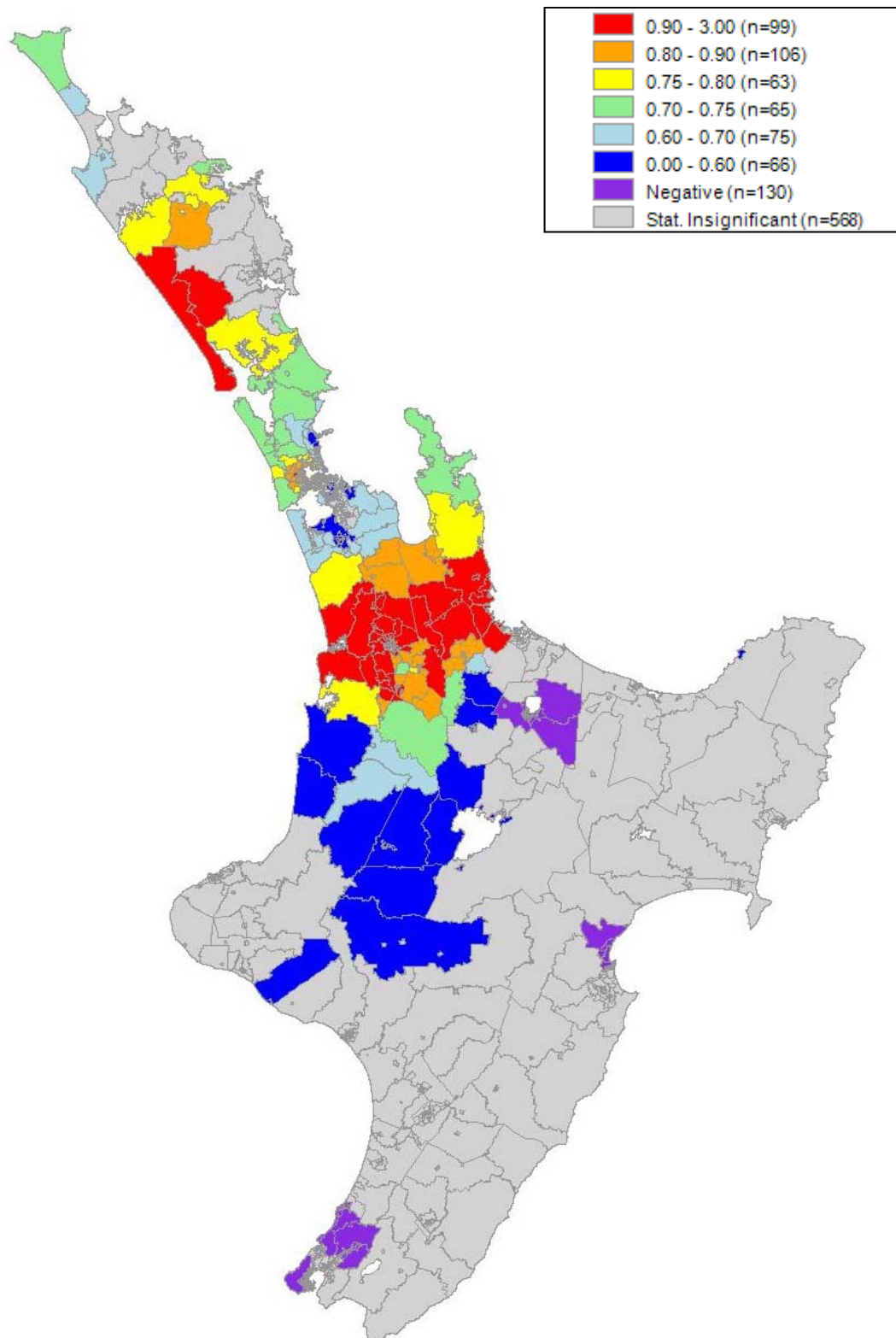


Figure 20 shows the relationship between bar and nightclub density and motor vehicle accidents in the Auckland region. The estimated parameters are clearly largest in the central city and West Auckland, where an additional bar or nightclub is associated with more than 0.8 additional motor vehicle accidents per year. The parameter estimates get smaller the farther the CAU is from the city's central business district, and is statistically insignificant in much of South Auckland (shown in grey).⁶

Figure 20: Locally specific point parameter estimates for the relationship between bar and nightclub density and motor vehicle accidents in the Auckland region, 2006-2011

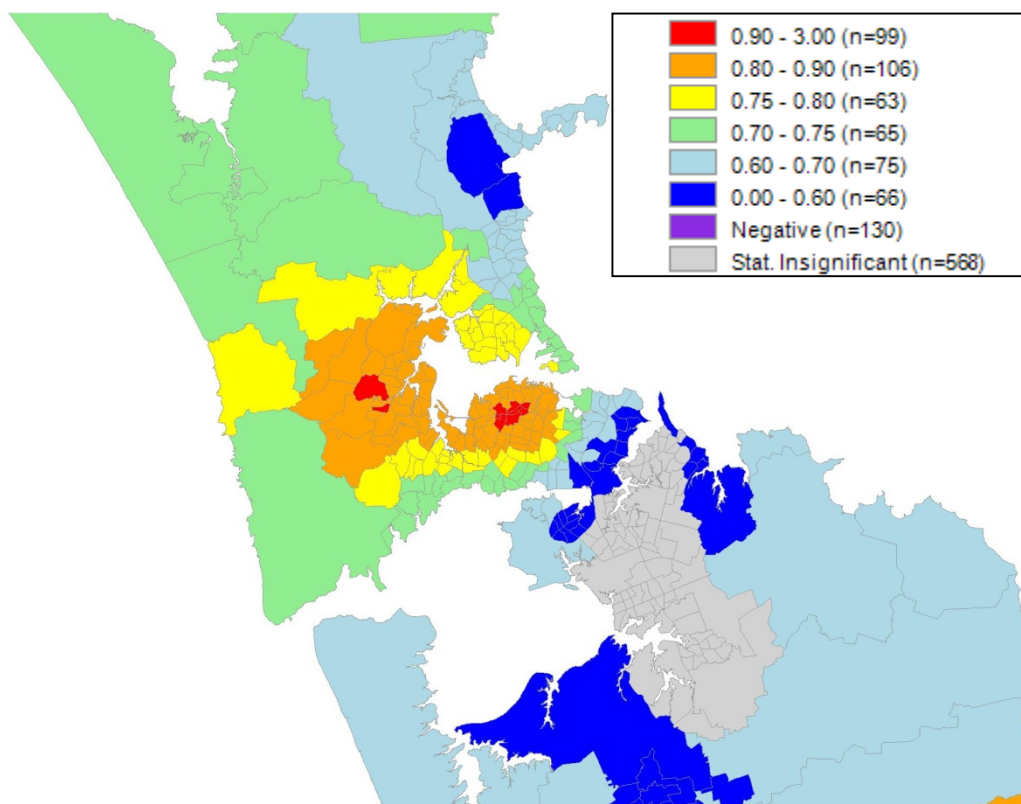


Figure 21 shows the spatial distribution of the relationship between other on-licence density (i.e. on-licence density excluding bars and nightclubs) and motor vehicle accidents, with red and orange representing the largest positive relationships (i.e. the areas where an additional licensed club is associated with more than 0.6 additional motor vehicle accidents per year). In the global model (Table 2) the overall effect was statistically significant, with each additional on-licence outlet associated with about 0.27 additional motor vehicle accidents per year. However, Figure 21 reveals that a large proportion of CAUs in the North Island have a statistically insignificant relationship between other off-licence density and motor vehicle accidents (shown in grey), particularly in the northern part of the North Island (including Whangarei, most of Auckland city and Tauranga), in Hawke's Bay (including Napier and Hastings) and in northern Wairarapa and central Manawatu (including Palmerston North). The relationship is significant and negative in northern Hamilton city, where an additional on-licence outlet is associated with *fewer* motor vehicle accidents per year. In other areas the relationship is significant and positive, and the parameter estimates are largest in the area around New Plymouth

⁶ An additional map for Wellington is not included for this relationship because the relationship does not vary substantially within that region, other than as already noted in the text describing Figure 19.

and parts of Wellington city, Upper Hutt, and the Kapiti Coast, where an additional on-licence outlet is associated with more than 0.8 additional motor vehicle accidents per year.

Figure 22 shows the relationship between other on-licence density and motor vehicle accidents in the Wellington region. The CAUs in the area between the central city and Island Bay and Lyall Bay in the south all show statistically insignificant relationships between other on-licence density and motor vehicle accidents, as does much of Lower Hutt (shown in grey). However, north of the central city the relationship is very strong, with large positive parameter estimates, especially between Karori and Ngaio, where an additional on-licence outlet is associated with more than 0.8 additional motor vehicle accidents per year.⁷

⁷ An additional map for Auckland is not included for this relationship because the relationship does not vary substantially within that region, other than as already noted in the text describing Figure 21.

Figure 21: Locally specific point parameter estimates for the relationship between other on-licence density and motor vehicle accidents in the North Island, 2006-2011

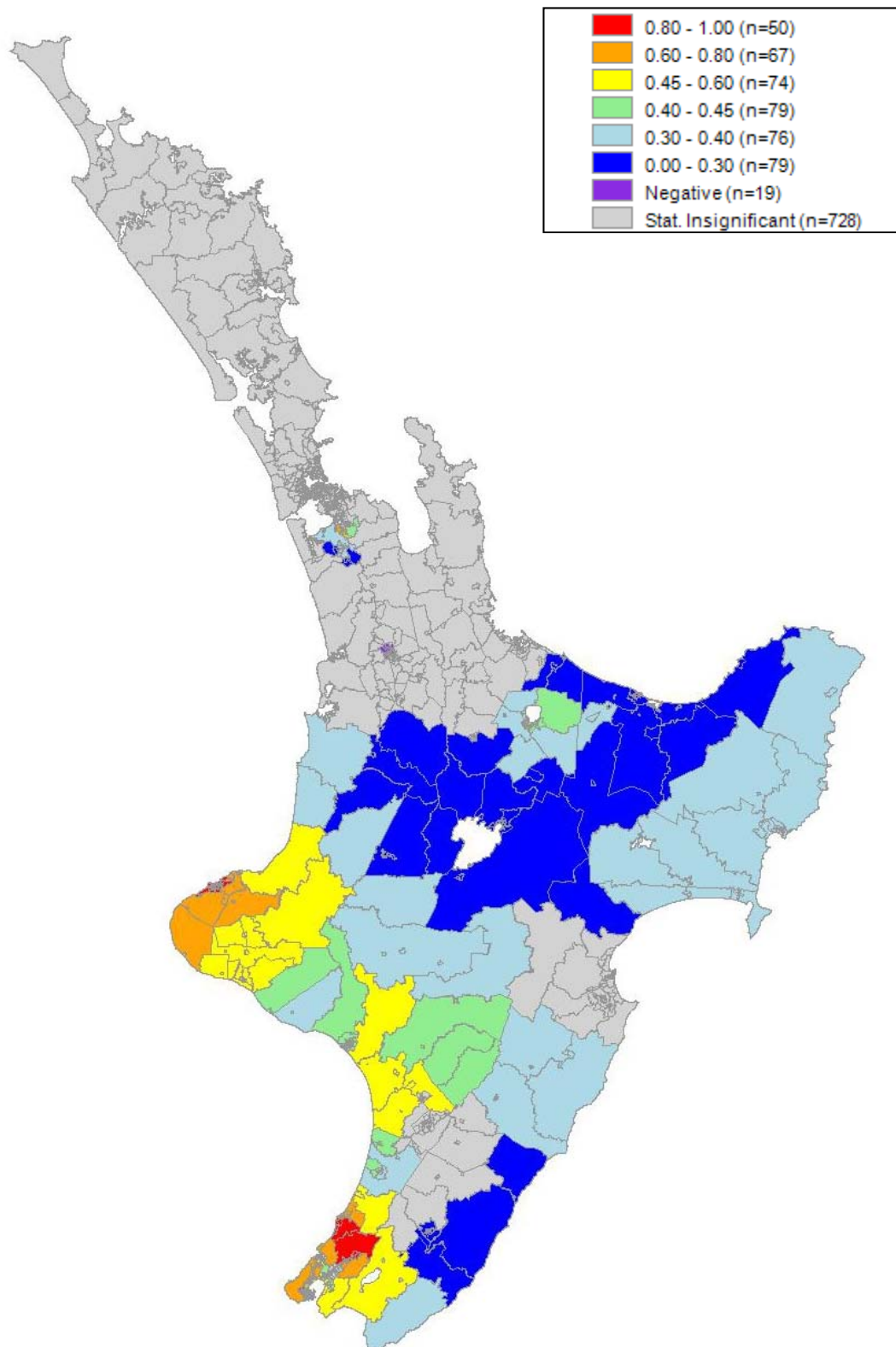


Figure 22: Locally specific point parameter estimates for the relationship between other on-licence density and motor vehicle accidents in the Wellington region, 2006-2011

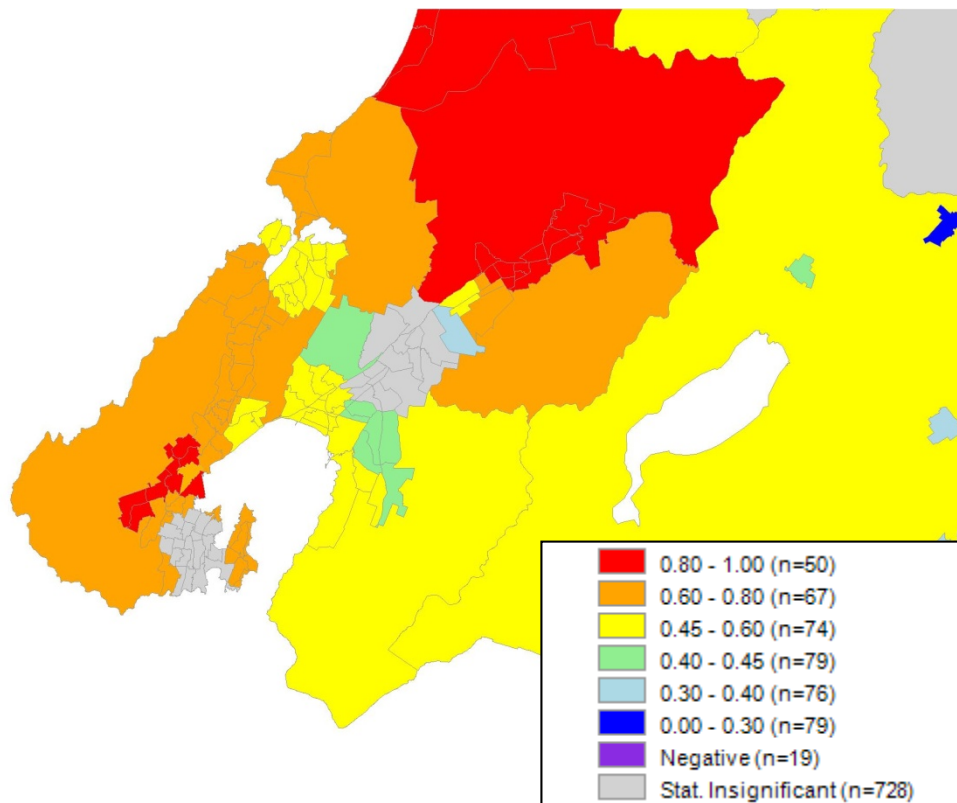


Figure 23 shows the spatial distribution of the relationship between supermarket and grocery store density and motor vehicle accidents, with red and orange representing the largest positive relationships (i.e. the areas where an additional licensed supermarket or grocery store is associated with more than 2.85 additional motor vehicle accidents per year). In the global model (Table 2) the overall effect was statistically significant and negative, with each additional supermarket or grocery store associated with about 1.1 fewer motor vehicle accidents per year. Figure 23 confirms this, with almost all of the North Island having either a statistically insignificant (shown in grey) or a statistically significant and negative relationship (shown in purple) between supermarket and grocery store density and motor vehicle accidents. The only areas where the relationship is statistically significant and positive are Hawke's Bay (including parts of Hastings), northern Wairarapa (around Eketahuna) and central Wellington.

Figure 23: Locally specific point parameter estimates for the relationship between supermarket and grocery store density and motor vehicle accidents, North Island, 2006-2011

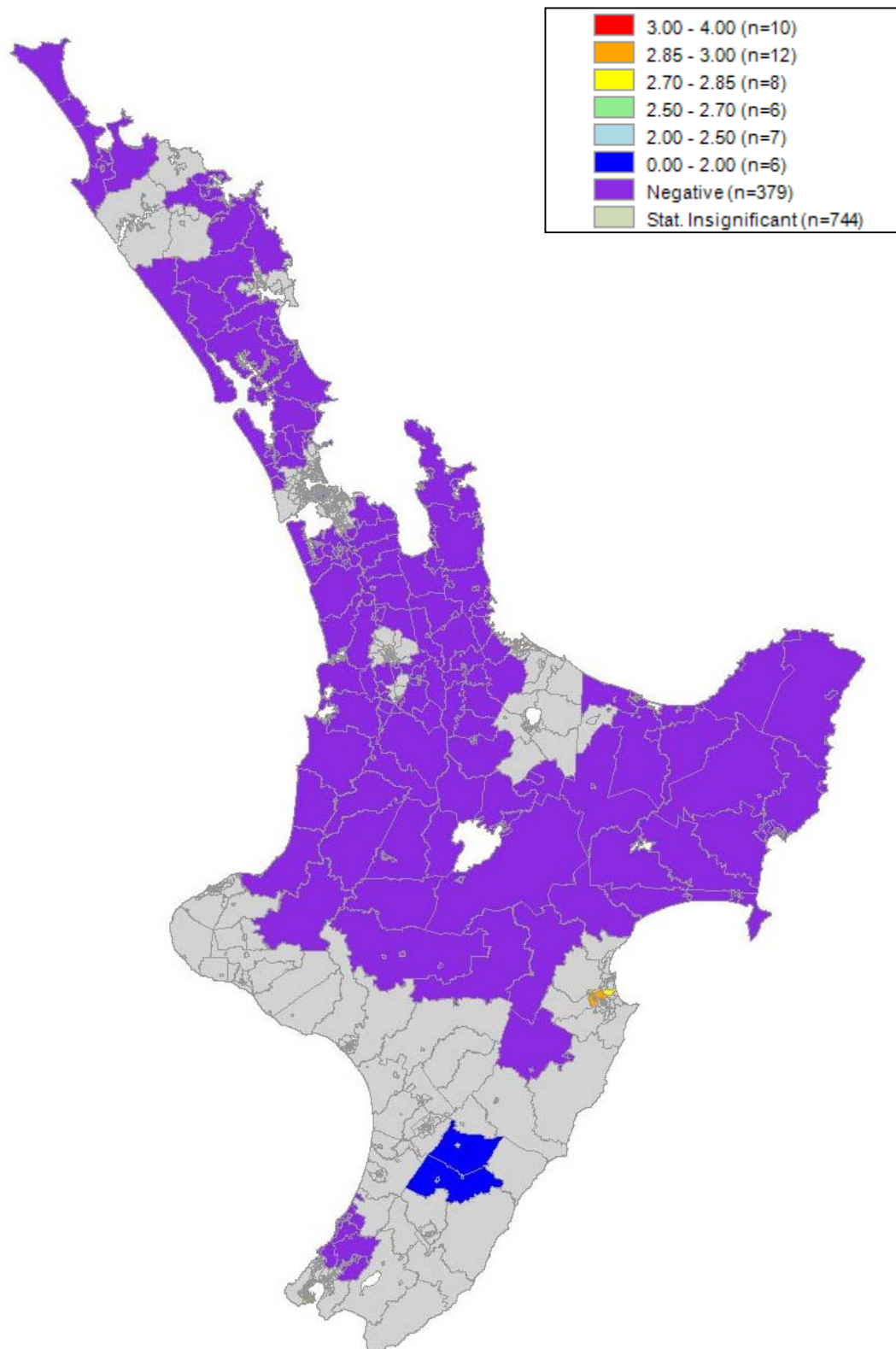


Figure 24 shows the relationship between supermarket and grocery store density and motor vehicle accidents in the Wellington region. The statistically significant and positive relationship in the central city is clear from Figure 24, in particular the area between Brooklyn and Newtown, where an additional supermarket or grocery store is associated with more than three additional motor vehicle accidents each year.⁸ North of central Porirua and in Upper Hutt, the relationship is statistically significant and negative. In these areas an additional licensed supermarket or grocery store is associated with *fewer* motor vehicle accidents each year.

Figure 24: Locally specific point parameter estimates for the relationship between supermarket and grocery store density and motor vehicle accidents, Wellington region, 2006-2011

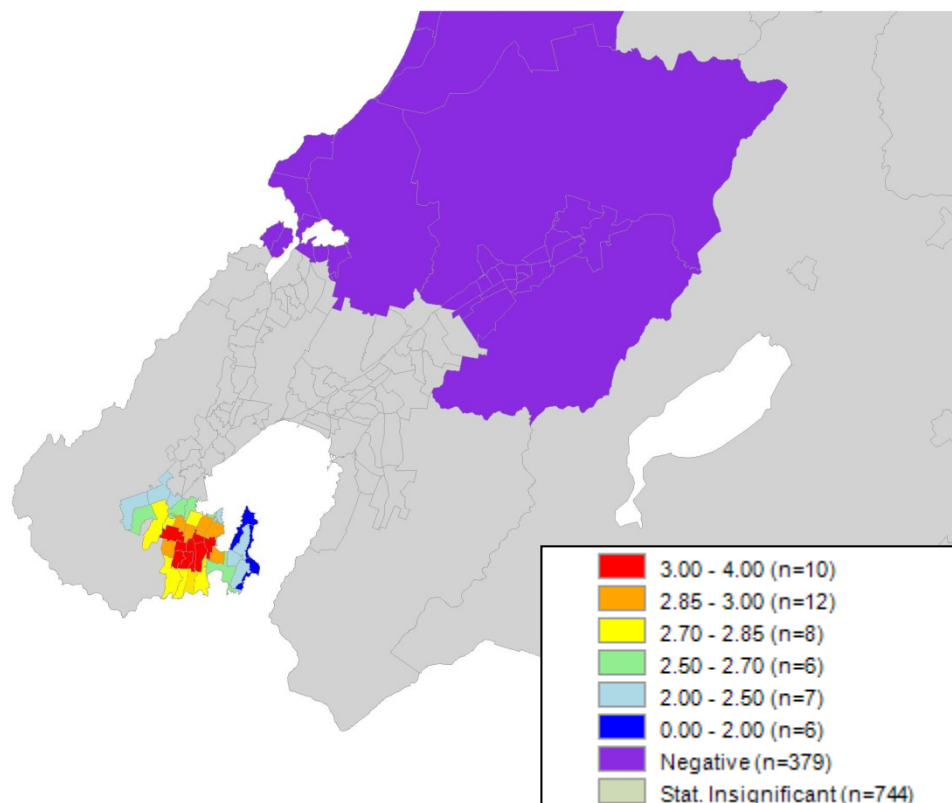


Figure 25 shows the spatial distribution of the relationship between other off-licence density (i.e. off-licence density excluding supermarkets and grocery stores) and motor vehicle accidents, with red and orange representing the largest positive relationships (i.e. the areas where an additional off-licence outlet is associated with more than 1.6 additional motor vehicle accidents per year). In the global model (Table 2) the overall effect was statistically significant, with each additional off-licence outlet associated with about 0.46 additional motor vehicle accidents per year. However, Figure 25 shows that many CAUs across Northland (including Whangarei), the central North Island (including Tauranga, Rotorua, New Plymouth, Whanganui and Palmerston North) and Wellington city have statistically insignificant relationships between other off-licence density and motor vehicle accidents (shown in grey). In addition, many CAUs in south Taranaki, Hawke's Bay (including Napier and Hastings) and the East Coast (including Gisborne) show statistically significant negative relationships. In these areas an additional off-licence outlet is associated with *fewer* motor vehicle accidents per

⁸ An additional map for Auckland is not included for this relationship, because the relationship does not vary substantially within that region, other than as already noted in the text describing Figure 23.

year. The relationship is significantly positive in other areas, and the parameter estimates are largest in South Auckland, north Waikato (including Hamilton) and north of Wellington city. In these areas an additional off-licence outlet is associated with more than 1.4 additional motor vehicle accidents per year.

Figure 26 shows the relationship between other off-licence density and motor vehicle accidents in the Auckland region. The statistically significant and positive relationships in South Auckland are clear from Figure 26. In particular, the area between the suburbs of Mangere, Howick and Pakuranga has the largest parameter estimates, where an additional off-licence outlet is associated with more than 1.8 additional motor vehicle accidents each year.

Figure 27 shows the relationship between other off-licence density and motor vehicle accidents in the Wellington region. It is clear from Figure 27 that the estimated parameters are largest in the area north of central Porirua, the Kapiti Coast and Upper Hutt. In these areas an additional off-licence outlet is associated with more than 1.4 additional motor vehicle accidents per year. In contrast, the relationship is statistically insignificant in the central city, Petone and most of Lower Hutt (shown in grey).

Figure 25: Locally specific point parameter estimates for the relationship between other off-licence density and motor vehicle accidents in the North Island, 2006-2011

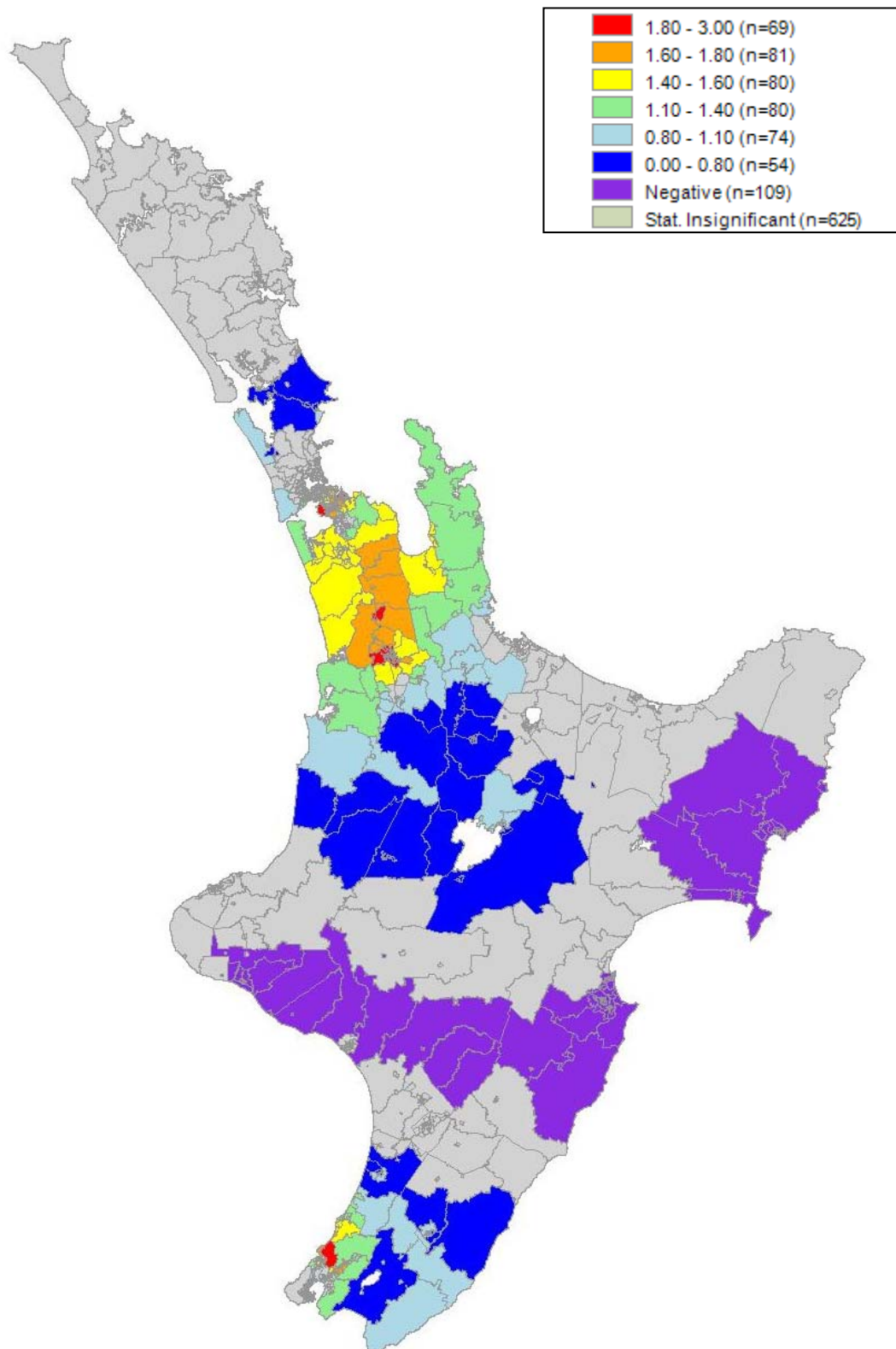


Figure 26: Locally specific point parameter estimates for the relationship between other off-licence density and motor vehicle accidents in the Auckland region, 2006-2011

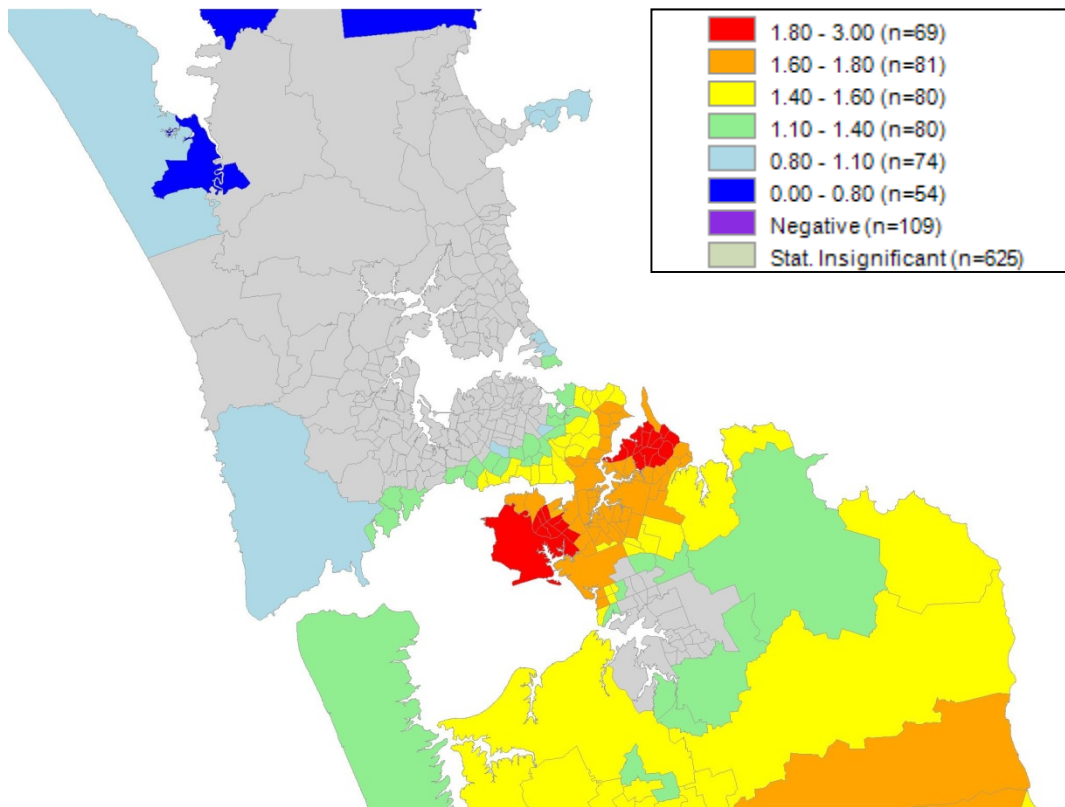
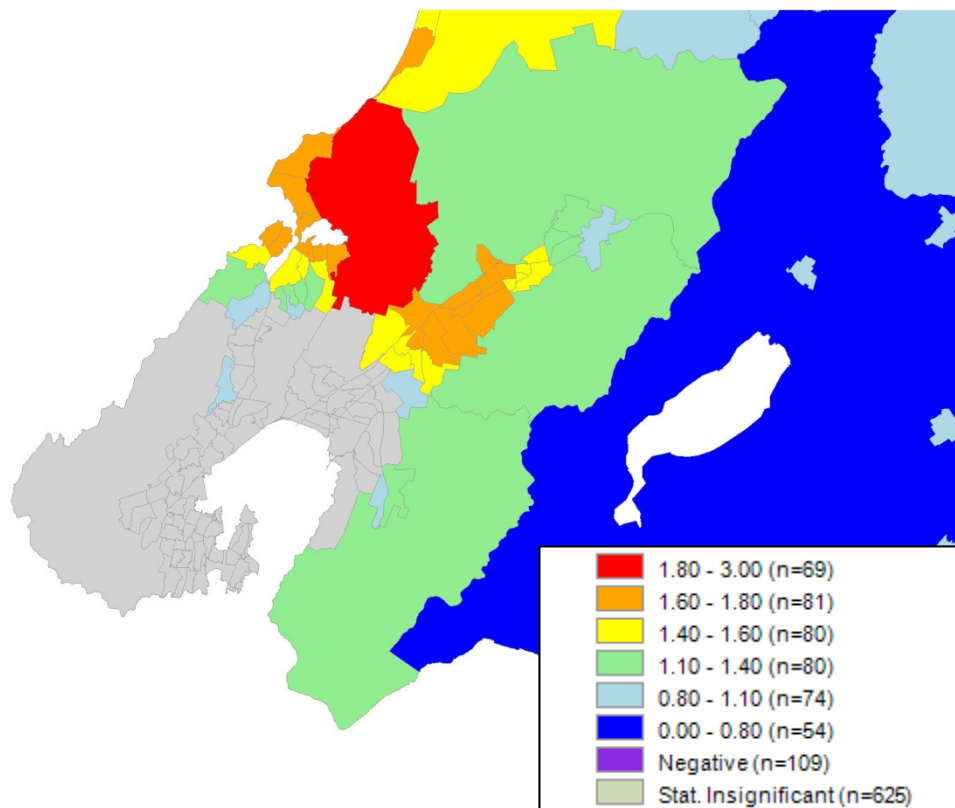


Figure 27: Locally specific point parameter estimates for the relationship between other off-licence density and motor vehicle accidents in the Wellington region, 2006-2011



DISCUSSION AND CONCLUSION

It is somewhat appealing to believe that the density of alcohol outlets of different types would be related to drinking behaviour and, consequently, to measures of alcohol-related harm. However, the international and New Zealand literature has demonstrated in previous ecological studies that the relationships are not straightforward – they appear to be context specific in the sense that they probably depend on a range of factors that are not easily accounted for in the quantitative evaluations (for extensive reviews of previous studies see Cameron *et al.*, 2012a, Livingston *et al.*, 2007 and Popova *et al.*, 2009). These factors might include locally specific differences in drinking patterns and preferences, demographic and structural differences in the population distribution, differences in access to transport networks, and differences in the amenity or character of different areas. Indeed, previous international research has shown that neighbourhood characteristics can affect the observed relationships (Mair *et al.*, 2013; Livingston, 2008). Results are therefore best interpreted with local knowledge in order to understand the factors that underlie the observed relationships.

This report has clearly shown that it would be extremely problematic and probably incorrect to assume that the relationship between outlet density (of any type) is constant across space. The case studies clearly demonstrate that there exist wide differences in the relationships across the North Island of New Zealand. The same outlet density may be statistically insignificantly related to measures of alcohol-related harms in one area, while simultaneously statistically significantly and positively (or negatively) related to those same harms in other areas. The significant spatial variations demonstrated in our two case studies may help to explain the wide variety of results obtained in previous ecological studies, both in New Zealand and elsewhere.

Our approach was to use GWR to estimate the spatially explicit relationships between different types of alcohol outlet density and measures of alcohol-related harm in the North Island of New Zealand. This approach differs from those taken in past studies (e.g. see Cameron *et al.*, 2012c, 2012d and Day *et al.*, 2012), which assumed that the relationships did not vary between different places. We have shown that the GWR approach, which allows for locally specific relationships to be identified, substantially improves the goodness-of-fit of the resulting econometric models, improving the quality of the resulting parameter estimates.

The global model results (which ignored locally specific effects) demonstrated that bar and nightclub density was the outlet density that had the largest absolute relationship with police events and motor vehicle accidents, and was significantly positively associated with all categories of police event and with motor vehicle accidents. The sizes of the effects were similar to those reported in earlier research for Manukau City by Cameron *et al.* (2012d), who used a similar categorisation of police events. The density of licensed supermarkets and grocery stores 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 (predominantly made up of restaurants, cafés and accommodation providers) were significantly positively related to many of the categories of police event.

The global model results for other off-licence density (predominantly made up of bottle stores) were interesting and may be unexpected. Other off-licence density was significantly positively associated with dishonesty offences and motor vehicle accidents, but significantly negatively associated with antisocial behaviour, property crime and violent offences. The absence of a significant positive relationship between off-licence density and police events may have been due to the location of drinking (and any resulting harms) being separated from the location of purchase. Since drinkers may purchase alcohol from off-licence outlets in one location but consume the alcohol in other locations, we might expect not to see a strong relationship between off-licence density and alcohol-related harms. However, the relationships for supermarket and grocery store density are both significant and positive in many cases, so the simple separation between purchase and drinking locations must not be the only factor that results in the observed relationships in this study. The differences may arise because supermarkets are more frequently located in urban retail areas, while other off-licence outlets are more widely distributed. Or they may arise because of differences in the product mix offered at these different outlet types (supermarkets and grocery stores cannot sell spirits, for instance). A further investigation of the differences in observed effects between supermarket and grocery store density and other off-licence density is warranted. However, our results are not entirely irreconcilable with previous research in New Zealand. Our first case study revealed that the relationship between other off-licence density and violent offences was significant and negative in much of the central (and incidentally, rural) North Island, but significant and positive in South Auckland and urban Wellington city. In comparison, Cameron *et al.* (2012d) showed positive (and large) estimates relating off-licence density to a range of police events in (predominantly urban) Manukau City.

The spatial differences in parameter estimates are the key result from this research, and are ably demonstrated by the two case studies presented in this report, for violent offences and motor vehicle accidents. Even for relationships that are on average large and statistically significant in the global models, there are local areas where the relationship is not statistically significant. And the reverse is also true – when a relationship is on average statistically insignificant in the global model, there are some areas where it is statistically significant. The existence of a substantial amount of spatial variability in the relationships between alcohol outlet densities and measures of social harm is particularly pertinent given the current development of local alcohol policies by many local authorities in New Zealand. The Sale and Supply of Alcohol Act 2012 has given local authorities the ability to develop and adopt policies that differ from the national defaults in terms of outlet density and location, hours of sale and other conditions of liquor licences within their boundaries. Our research has demonstrated that the relationships between alcohol outlet density and some measures of alcohol-related social harms (police events and motor vehicle accidents) vary substantially between districts, and thus the development of local alcohol policies is warranted.

However, we have not demonstrated substantial amounts of local variability *within* districts. For instance, within most urban areas with the exception of Auckland and Wellington cities, the relationships observed between outlet density measures and alcohol-related harm measures appear not to vary much. So while local alcohol policies themselves may serve a useful purpose in allowing local authorities to take their particular communities' needs and aspirations into account as well as the nature of alcohol-related harms in those communities, it does not appear that substantially different

regimes in different parts of each district are particularly necessary. Perhaps a distinction between urban and rural areas, or between central business districts and outlying suburbs, is all that is necessary to deal with differences in the impacts of alcohol outlet density within local alcohol policies.

Finally, it is worth noting some limitations of this research. First, while this report adds to the growing weight of literature in New Zealand showing significant relationships between outlet density (or outlet proximity) and measures of alcohol-related harm, we are unable to establish causality definitively. Thus we cannot say for certain that outlet density is the cause of the higher (or lower) number of police events or motor vehicle accidents in each CAU. In order to infer causality properly, a randomised controlled experiment where the number of alcohol outlets is altered through a random process would be required. It is unlikely that such a randomised experiment is possible. Alternatively, natural experiments or panel data may be used, although such data are still not definitive in terms of causality. Notwithstanding this concern, our results are at least consistent with the past literature and consistent with a causal story that derives from availability theory, i.e. that a greater availability of alcohol leads to increased consumption, which in turn leads to more social harms. Second, our research considered the spatial variations in the relationships, but neglected any temporal variation by taking the annual average of the variables over the five-year period of the study. It is likely that the relationships between outlet densities and alcohol-related harms vary not just across space, but across time as well.⁹ Third, we used a bandwidth that was limited to 30 nearest neighbours in the estimation of each location-specific relationship. A smaller bandwidth may have identified more local variations in parameter estimates – however, estimation with a smaller bandwidth comes at a cost of lower precision of each estimate.

Future research should build on the methodological developments outlined in this report. Nationwide (or even island-wide) studies that do not account for the local spatial variability in relationships between outlet density and harms are potentially missing important information that limits their applicability. Future studies should make increasing use of locally specific models such as GWR, or limit their spatial extent to particular regions or local authority areas. Furthermore, the temporal variation in results should be explicitly considered, such as by using panel data models.

⁹ We note that, as part of this research, we developed five annual GWR models for each dependent variable, i.e. one for each year between 2006 and 2011. The qualitative implications of the results from the annual models do not differ significantly from those reported in this report, so for simplicity of interpretation and space constraints we have omitted the annual results from consideration. These more detailed annual results are available from the authors on request.

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APPENDIX I – AMALGAMATED AND EXCLUDED CAUS

Amalgamated CAUs

The following groups of CAU were amalgamated in this research, in order to ensure adequate base population size (small populations result in high densities of events and outlets that create outliers in the analysis). Each CAU was amalgamated to a neighbour such that the amalgamated area was entirely contained within the same District Licensing Authority area. In the list below, the first listed CAU is the CAU into which the other CAUs were amalgamated.

Burbush CAU – includes Rotokauri CAU
Cloustone Park CAU – includes Maidstone CAU
Cloustoneville CAU – includes Nabhra CAU
Douglas CAU – includes Whangamomona CAU
Elsthorpe-Flemington CAU – includes Porangahau CAU
Flagstaff CAU – includes Sylvester CAU
Grenada North CAU – includes Horokiwi and Takapu CAUs
Harania East CAU – includes Mangere Station CAU
Hatfields Beach CAU – includes Waiwera CAU
Hokianga North CAU – includes Kohukohu CAU
Iwitahi CAU – includes Rangipo, Rangitaiki, Taharua and Te More CAUs
Kahui CAU – includes Rahotu CAU
Kaitawa CAU – includes Peka Peka CAU
Kuirau CAU – includes Ohinemutu CAU
Kuratau CAU – includes Omori CAU
Lake Alice CAU – includes Koitiata CAU
Leigh CAU – includes Matheson Bay CAU
Lichfield CAU – includes Mangakaretu CAU
Maewa CAU – includes Oroua Bridge CAU
Makakaho CAU – includes Waitotara CAU
Marokopa CAU – includes Taharoa CAU
Maungataniwha CAU – includes Tuai CAU
Moawhango CAU – includes Ngamatea CAU
Morningside CAU – includes Port-Limeburners CAU
Newlands South CAU – includes Ngauranga East CAU
Ngapuke CAU – includes Owhango CAU
Opua East CAU – includes Opua West CAU
Opuawhanga CAU – includes Redoubt CAU
Oroua Downs-Waitohi CAU – includes Ohakea, Rakiraki, Swanson and Tangimoana CAUs
Oruanui CAU – includes Rangatira CAU
Otahuhu West – includes Middlemore CAU
Otangiwai-Heao CAU – includes Ohura CAU
Owahanga CAU – includes Mara CAU
Owhata West CAU – includes Poets Corner CAU
Pauatahanui CAU – includes Paekakariki Hill and Resolution CAUs
Pohonui-Porewa CAU – includes Mangaweka CAU
Poraiti CAU – includes Onekawa West CAU
Poroporo CAU – includes Maraetotara CAU
Pukete West CAU – includes Te Rapa CAU
Puketiri CAU – includes Whanawhana CAU
Rangoon Heights CAU – includes Ngauranga West CAU
Raurimu CAU – includes National Park CAU
Regent CAU – includes Whangarei Central CAU
Rotorangi CAU – includes Allen Road CAU

Strathmore CAU – includes Amisfield CAU
Tauranga Central CAU – includes Sulphur Point CAU
Te Kainga CAU – includes Kaiwharawhara CAU
Three Mile Bush CAU – includes Western Hills CAU
Toko CAU – includes Midhirst CAU
Twyford CAU – includes Woolwich CAU
Waikato Western Hills CAU – includes Rotowaro CAU
Waipa Valley CAU – includes Tiroa CAU
Wairakei-Aratiatia CAU – includes Taupo East CAU
Waiwhero CAU – includes Arahiwi CAU
Waiwhetu South CAU – includes Gracefield CAU
Wawa CAU – includes Kingleith CAU
Wharewaka CAU – includes Maunganamu CAU

Excluded CAUs

The following CAUs were excluded from the analysis because of extremely low population size and a lack of outlets or events:

Auckland City-Marinas, Evans Bay Marina, Gulf Harbour Marina, Half Moon Bay Marina, Inlet-Waitemata Harbour, Port-Taranaki, Seaview Marina, Tauranga City-Marinas, and Wellington City-Marinas CAUs

The following CAUs were excluded from the analysis because they are non-contiguous with other CAUs in the analysis:

Islands-Mototapu, Kawau, Matakana Island and Waiheke Island CAUs

APPENDIX II – 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 offences and Trespass

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

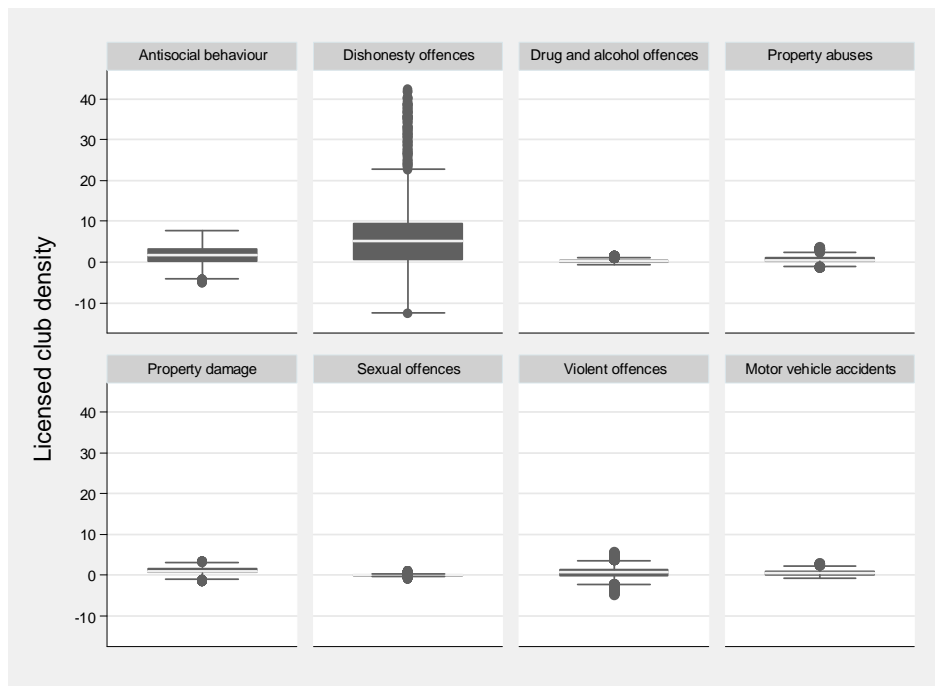
Sexual offences – includes Indecent videos, Rape, Sexual affronts, Sexual attacks and Unlawful sex

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

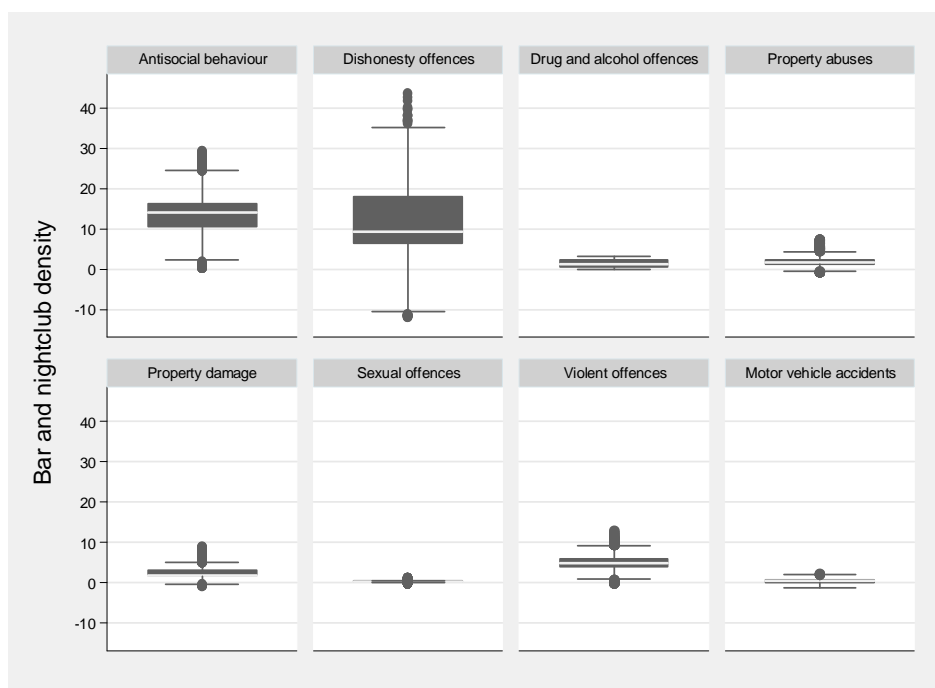
Note: The subcategories listed above are those that are used in the Police Communications and Resource Deployment (CARD) database.

APPENDIX III – SPATIAL HETEROGENEITY IN THE PARAMETER ESTIMATES, BY EXPLANATORY VARIABLE

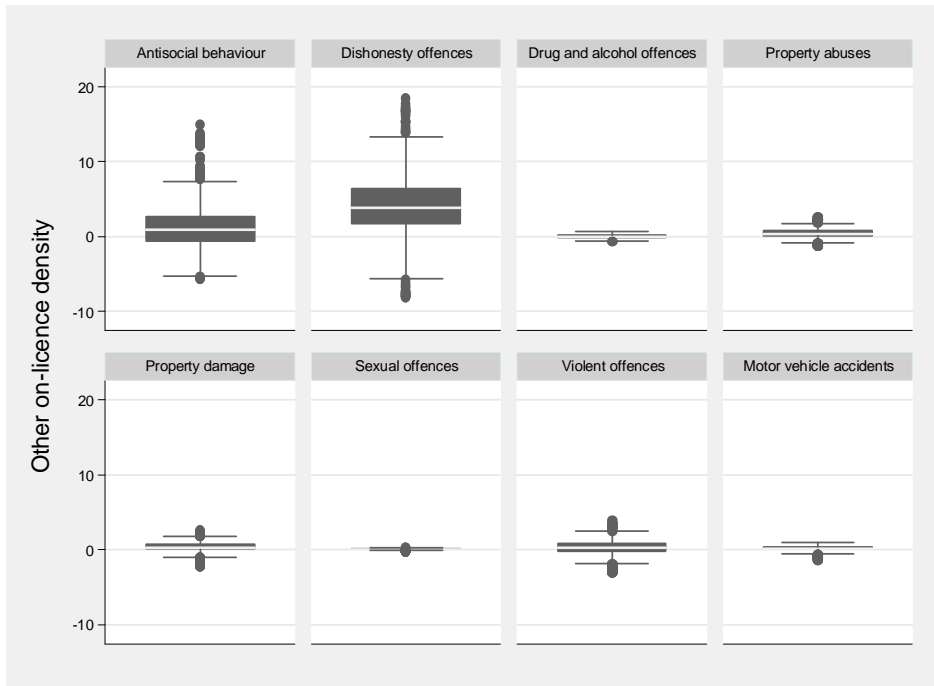
Licensed club density



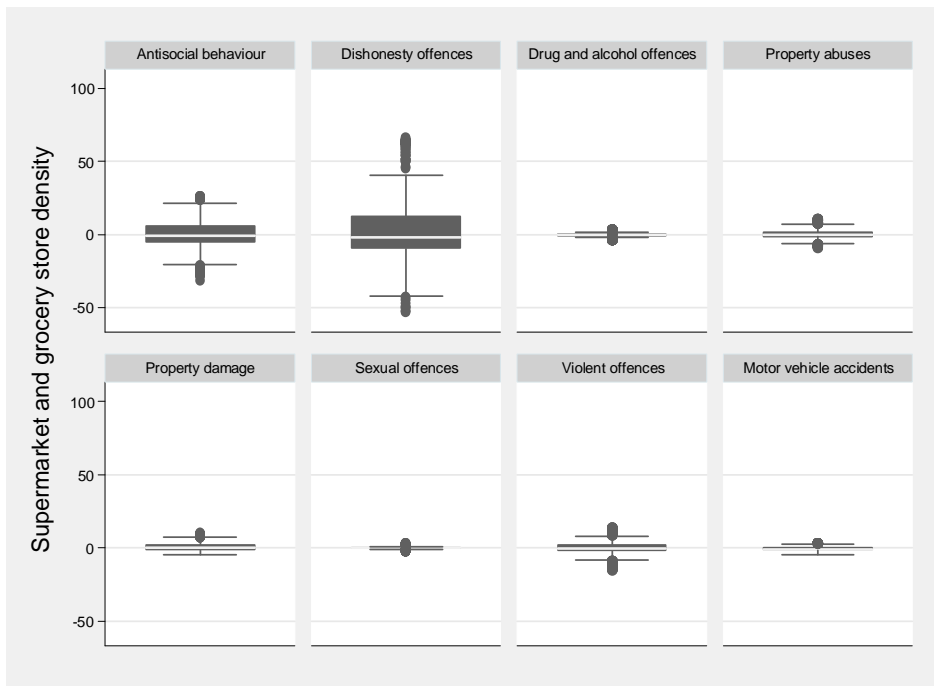
Bar and nightclub density



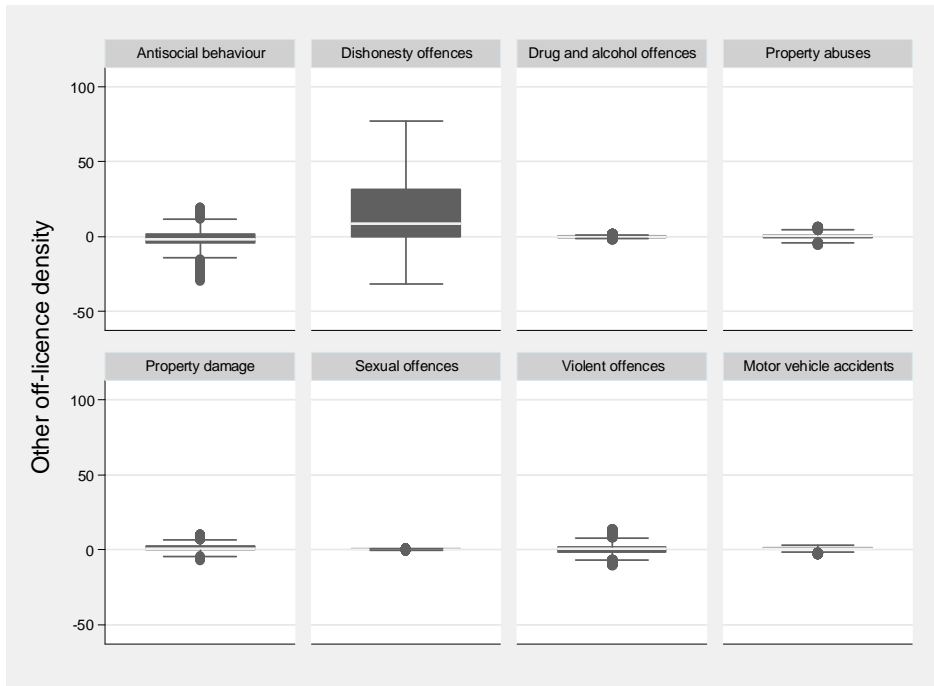
Other on-licence density



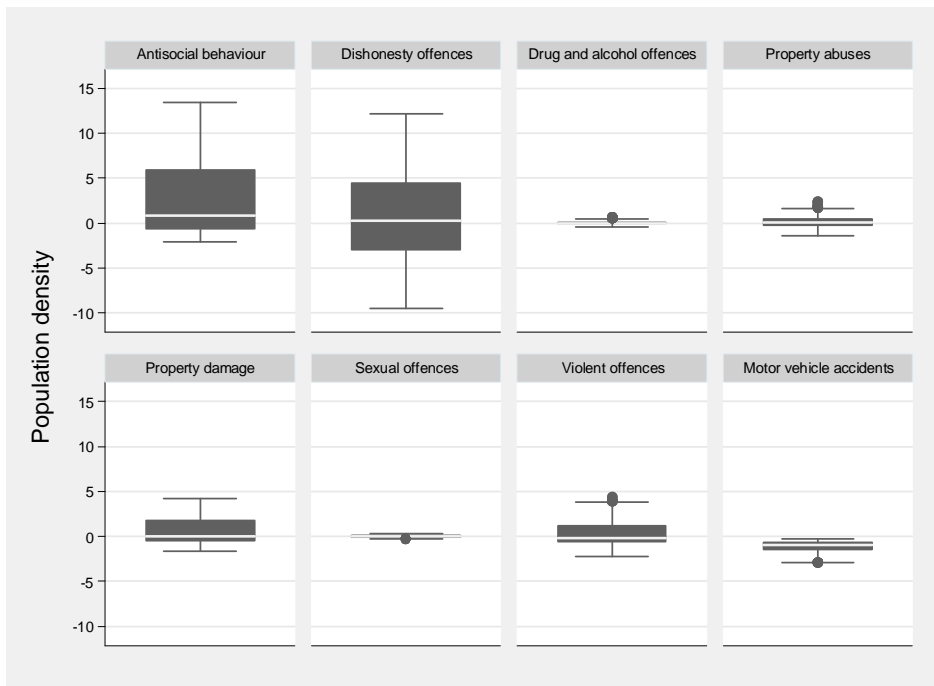
Supermarket and grocery store density



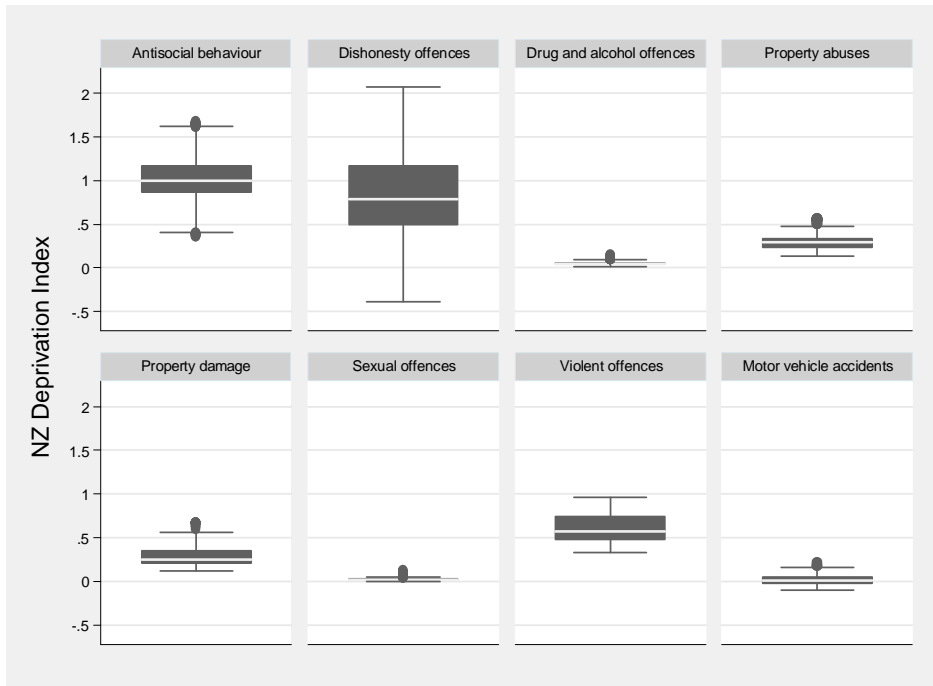
Other off-licence density



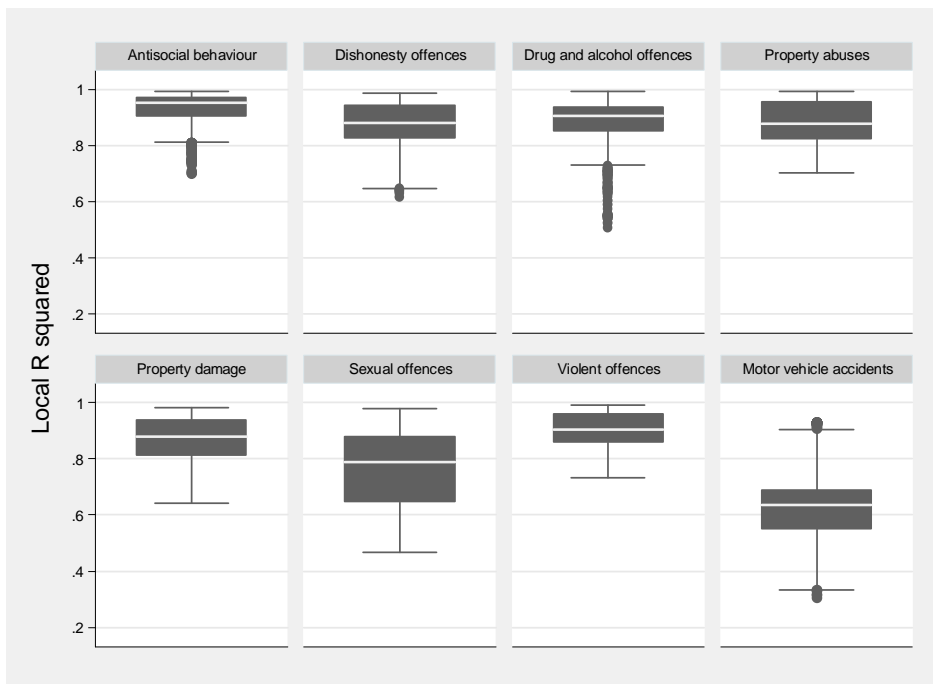
Population density



NZ Deprivation Index



Local R^2



APPENDIX IV – ELECTRONIC APPENDIX

The electronic appendix is available as a Geographic Information Systems (GIS) shape file and associated database file, and can be used to generate maps that show the parameter estimates between any of the dependent variables (police events and motor vehicle accidents) and explanatory variables (outlet density by type).

Note: Some degree of prior knowledge of GIS is required in order to generate appropriate maps with the data in the electronic appendix.

The following naming convention is used for variable names in the database file:

aaa_bbb_cc

where *aaa* represents the dependent variable, *bbb* represents the explanatory variable and *cc* represents the estimate. The dependent variables available include antisocial behaviour (ASB), dishonesty offences (DIS), drug and alcohol offences (DRG), property abuses (PRA), property damage (PRD), sexual offences (SEX), violent offences (VIO) and motor vehicle accidents (MVA). The explanatory variables include social deprivation (NZD), population density (POP), licensed club density (CLB), bar and nightclub density (BAR), other on-licence density (ONL), supermarket and grocery store density (SUP) and other off-licence density (OFF). The estimates provided are the raw coefficient estimate (ES), the t-statistic (TS) and a modified coefficient estimate (ME). The ME sets all of the coefficients that are not statistically significant at the 10 percent level to -9999, but is otherwise identical to the ES. The ME measure was employed to generate the maps presented in this report.

In addition, the locally specific R^2 estimates are available in the database file, using the naming convention: *aaa_R2*.

Finally, the database file also includes additional values for the area unit number (AU_NO), which corresponds to Statistics New Zealand's numbering convention,¹⁰ the area unit name (AU_NAME),¹¹ a unique identification number for each CAU (ID), and x- and y-coordinates for the geographic centroid of the CAU, based on the New Zealand Transverse Mercator (NZTM) coordinate system (X_COORD and Y_COORD).

¹⁰ In the case of merged CAUs, the number is that of the CAU with the largest population in 2006. See Appendix I for details of merged CAUs.

¹¹ In the case of merged CAUs, the name is that of the CAU with the largest population in 2006. See Appendix I for details of merged CAUs.