Health & Place 65 (2020) 102397

Contents lists available at ScienceDirect

Health and Place

journal homepage: http://www.elsevier.com/locate/healthplace

Close proximity to alcohol outlets is associated with increased crime and hazardous drinking: Pooled nationally representative data from New Zealand

M. Hobbs [a,b,*], L. Marek [a], J. Wiki [a], M. Campbell [a,c], B.Y. Deng [b], H. Sharpe [d], J. McCarthy [e], S. Kingham [a,c]

[a] GeoHealth Laboratory, Geospatial Research Institute, University of Canterbury, Christchurch, Canterbury, New Zealand
[b] Health Sciences, University of Canterbury, Christchurch, Canterbury, New Zealand
[c] School of Earth and Environment, College of Science, University of Canterbury, Christchurch, Canterbury, New Zealand
[d] Health Promotion Agency, Wellington, New Zealand
[e] Geospatial, Ministry of Health, Wellington, New Zealand

A B S T R A C T

This nationwide study investigated the relationship between proximity to alcohol outlets (off-licence, on-licence, and other-licence) and two adverse outcomes; hazardous drinking and crime (common assault, non-aggravated sexual assault, aggravated sexual assault, and tobacco and liquor offences). After adjustment for important individual- and area-level factors, close proximity to alcohol outlets was associated with increased risk of hazardous drinking, with strong associations for on-licence outlets. Proximity alcohol outlets was also strongly associated with all crime outcomes, often with a dose-response relationship. Nationally representative New Zealand data showed that close proximity to alcohol outlets was associated with increased crime and hazardous drinking.

1. Introduction

Globally, alcohol is a leading preventable cause of premature mortality, disability and social harm (Connor et al., 2015; James et al., 2018). In New Zealand, 5.4% of all premature deaths are attributable to alcohol (Connor et al., 2013, 2015). Alcohol use disorders (AUD) are classified as mental disorders, with alcohol dependence (AD) being the most severe form (Rehm et al., 2017). Individuals affected by AUD have diminished control over their alcohol consumption which often leads to increased alcohol-related morbidity and mortality (Connor et al., 2015). This can also have wider reaching social consequences, such as a breakdown in interpersonal relationships and an increase in risk taking behaviours and crime (Steinberg, 2008; Brown and Murphy, 2020). In New Zealand one third of police apprehensions involved alcohol, and in 2017 alcohol accounted for 19% of fatal road traffic collisions (Ministry of Transport, 2016). Particular ethnic groups, such as Māori, are disproportionately affected, with a mortality rate 2.5 times that of non-Māori (Connor et al., 2015; Ministry of Health, 2018). In particular, Māori have a much greater alcohol-related mortality rate of 34 deaths per 100,000 whilst non-Māori mortality rate is 14 deaths per 100,000 (Connor et al., 2013). There is little ground for the recommendation of alcohol for health reasons and the negative health and social consequences far outweigh any benefit (Connor et al., 2015).

The body of literature on how alcohol outlets may relate to the adverse outcomes of social- or alcohol-related harm, such as hazardous drinking or crime, is expanding both internationally and within New Zealand (Day et al., 2012; Popova et al., 2009; Gorman et al., 2018). While research investigating the association between alcohol outlet location and criminal offending in New Zealand is less forthcoming, Day et al. (2012) used a cross-sectional ecological design to examine the association between serious violent crime in 2005–2007 and alcohol outlet density in New Zealand (Day et al., 2012). This study showed that territorial authorities (large geographical areas) with the shortest travel distance to alcohol outlets were associated with the highest incidence of serious violent crime. Moreover, another New Zealand-focused study showed that higher densities of certain types of on-licence outlets such as clubs and bars were also associated with a number of criminal offences and motor vehicle accidents (Cameron et al., 2012, 2016) in Manukau City. There is a plethora of evidence positively associating higher alcohol outlet density with alcohol consumption (Schonlau et al., 2008) and binge drinking (Connor et al., 2011). Indeed, a longitudinal study (Halonen et al., 2013) from Finland found that the closer one lived to a bar, the more likely they would be to report risky alcohol behaviour. While evidence seems to suggest that alcohol outlet availability is associated with alcohol-related harm and levels of crime, there are

* Corresponding author. Manawa Building, 276 Antigua Street, University of Canterbury–Te Whare Wānanga o Waitaha, Christchurch 8140, New Zealand.
E-mail address: matt.hobbs@canterbury.ac.nz (M. Hobbs).

https://doi.org/10.1016/j.healthplace.2020.102397
Received 29 May 2020; Received in revised form 29 June 2020; Accepted 9 July 2020
Available online 5 August 2020

inconsistencies that may be due to methodological limitations in data and methods.

The existing body of research is limited by the fact that the majority of studies have been carried out in North America (Holmes et al., 2014) and may not be generalisable to other countries. Moreover, few studies have nationally representative data from which they gather information on levels of hazardous drinking, with fewer still pooling data over time to increase statistical power. Furthermore, nationally representative crime data alongside both population-level exposures and alcohol outlets, disaggregated by licence type, are often inaccessible at a fine geographical scale. This is an important consideration as previous research has highlighted differences in associations by off-licence, on-licence or other types of alcohol outlets (Trangenstein et al., 2018; Pridemore and Grubesic, 2011). Indeed, there may also be differences by crime type when broken down into finer categories. Finally, alcohol outlets also generally cluster in space and locate in areas within deprived areas (Breetzke et al., 2018). It is plausible that the association between alcohol outlets and alcohol-related harm is moderated by factors such as area-level deprivation, such that the association between alcohol outlets and alcohol-related harm may be stronger in levels of high deprivation compared to low. Such limitations in current evidence require further exploration.

This study aims to investigate the relationship between proximity to alcohol outlets and outcomes of hazardous drinking and crime, using pooled nationally representative data from the New Zealand Health Survey (NZHS). Using the meshblock of residence for each participant (meshblocks are the smallest geographical area for which statistical data are published (Statistics New Zealand, 2018)), NZHS data were combined with nationally representative police data and alcohol outlet location data at census area unit (CAU) level (a geographical unit to which meshblocks aggregate). It then investigates if associations between alcohol outlet proximity and both hazardous drinking and crime change by factors such as area-level deprivation. We hypothesise that closer proximity to alcohol outlets is associated with a higher incidence of both crime and hazardous drinking. We also expect this relationship will differ in strength by sub-categories of both alcohol outlet type and crime and that the association between proximity to alcohol outlets and both hazardous drinking and crime is strongest in the most deprived areas.

2. Methods

2.1. Study setting and hazardous drinking

A nationwide cross-sectional study in New Zealand (total population 4,951,500 as at December 31, 2019) was conducted using individual-level data sourced from the NZHS (adult questionnaire). This provides information on sociodemographic variables, health behaviours, and self-reported health status. Cross-sectional data from adults (respondents aged 15+) were pooled across two years (NZHS, 2016–17 and 2017–18) to provide an approximate temporal match to alcohol outlet licence data (2015–18). Further details on the design of the NZHS have been outlined in detail elsewhere (Ministry of Health, 2018; Ministry of Health, 2017). Briefly, the NZHS selects participants how usually reside in New Zealand using a multistage, stratified, probability proportional to size sampling design (Ministry of Health, 2017) which aims to increase the sampling of priority population including Māori and Pacific populations. One adult and one child (if any in the household) are randomly selected from each selected household to take part in the survey and visited by a trained interviewer (80% response rate in 2017/18). The NZHS includes a variety of questions and measures on a range of sociodemographic factors, health behaviours, and health outcomes (Ministry of Health, 2017). Key data extracted for this purpose of this study included age (years), sex (male/female), ethnicity (Māori, Pacific, Asian and European/Other), education-level (low: none, moderate: school, college or other, and high: university) and meshblock of residence. Meshblocks are defined as the smallest geographic unit for which statistical data is collected; the 2013 census comprised 46,629 units (Statistics New Zealand, 2018).

Within the NZHS, hazardous drinking was also extracted. This was measured using the 10-question Alcohol Use Disorders Identification Test (AUDIT) developed by the World Health Organization (World health Organisation (WHO), 2019). The AUDIT is a 10-item questionnaire that covers three aspects of alcohol use: alcohol consumption, dependence and adverse consequences. An AUDIT score is the total of the scores obtained for each of the 10 items. Hazardous drinkers are those who obtain an AUDIT score of 8 or more, representing an established pattern of drinking that carries a high risk of future damage to physical or mental health. Hazardous drinkers (total population) were defined as adults who obtained an AUDIT score of 8 or more, among the total number of respondents (World health Organisation (WHO), 2019).

2.2. Alcohol outlets

Alcohol outlet data in New Zealand were sourced from the Alcohol Regulatory & Licensing Authority (ARLA) for the period 2015–2018 from the current and active licence register. All alcohol outlets (n = 19,035) were extracted from the database based on the proprietary classifications provided by ARLA. The sale of alcohol to the public in New Zealand requires the seller to have a licence. Data were removed if duplicates (n = 3657) or if conveyance services (n = 203) such as airlines who were often registered at the airport rather than actual location of sale. Highways (major national highway in NZ) were then checked manually (n = 165) as address records often contained a highway rather than specific postal address. Subsequently, 14 records were removed as addresses could not be identified. This resulted in a final sample of 13,989 alcohol outlets that were geocoded in ArcGIS online world geocoding service; 13,694 were successfully matched and 295 were tied results. We then tested a random sample of 100 records to investigate if they were geocoded to the correct CAU, 92% were correct. Within the final sample, 2148 were club licences, 3423 were off-licence, 8077 were on-licence, and 341 were special license. See appendices for a full breakdown of license type and category.

2.3. Crime

Crime data were obtained from New Zealand Police for the period January to December 2018 to provide a temporal match to alcohol outlet and NZHS data. Based on previous evidence (Day et al., 2012; Gorman et al., 2018; Gruenewald et al., 2006) and data available at census area unit (CAU) level this included data on common assault, aggravated sexual assault, non-aggravated sexual assault, and liquor and tobacco offences. Such crimes which include assault have previously been linked to the location of alcohol outlets within New Zealand (Day et al., 2012) and internationally (Schonlau et al., 2008; Connor et al., 2011; Pridemore and Grubesic, 2011; Gruenewald et al., 2006; Yu et al., 2009). While less evidence has explored how liquor and tobacco offences are related to the location of alcohol outlets this is another plausible and important area of research (Halonen et al., 2013; Holmes et al., 2014). Data were supplied and processed to provide each CAU with a count of each crime category. Count per CAU was then used as the outcome of interest with separate models for each crime category.

2.4. Environmental data and spatial analysis

Data on area-level deprivation was obtained from NZDep2018 which combines eight variables from the 2018 Census that reflect eight dimensions of material and social deprivation (Atkinson et al., 2019). These dimensions reflect lacks of income, employment, communication, support, qualifications, owned home, living space and dry living conditions. NZDep2018 provides a deprivation score for each meshblock in New Zealand which were divided into quintiles (quintile one = least deprived). NZDep 2018 were also converted to CAU geographies to be

congruent with other data collected i.e. police data and proximity to alcohol outlets. We used the new Statistical Standard for Geographic Areas 2018 (SSGA18) to define rural and urban areas. The classification was defined as a: i) major urban area (a population of 100,000 or more), ii) large urban area (a population 30,000 to 99,999), medium urban area (a population of 10,000 to 29,999), small urban area (a population of 1000 to 9999), and rural (a population of <1000) (Statistics New Zealand, 2019). Distance from the population-weighted centroids were calculated via the road network (Beere, 2016) to define access to the nearest alcohol outlet for each individual in the NZHS. While several studies have noted that proximity and density measures are often highly correlated (Burgoine et al., 2011, 2013; Hobbs et al., 2016; Sparks et al., 2011) we calculated and used proximity to the nearest alcohol outlet to update previous evidence carried out within New Zealand (Day et al., 2012).

2.5. Statistical analysis

Descriptive statistics were presented as mean (standard deviation) or median where appropriate and as n (%) to summarise key predictor variables and outcomes. For all alcohol outlets distance from the population-weighted centroid of the 2018 meshblock were calculated via road network (Beere, 2016). For analyses with hazardous drinking proximity to meshblock were used for analyses and for crime mean distance per CAU were used. We investigated the association between hazardous drinking and alcohol outlet proximity using logistic regression models (adjusted odds ratio [95% confidence intervals (CI)]. In this study, adults with hazardous drinking were defined as a dichotomous variable (in which there are only two possible outcomes of hazardous (1) or not hazardous drinking (0)). For instance, an adjusted odds ratio (AOR) for any independent variable gives the relative amount by which the odds of the outcome (hazardous drinking) increase (AOR greater than 1) or decrease (AOR less than 1) when the value of the independent variable is increased by 1 unit, adjusting for other covariates. We used negative binomial models to investigate the association between count of crime events per CAU and alcohol proximity (incidence rate ratio (IRR) [95% CI]). The IRRs were obtained by exponentiating the regression coefficients, i.e. exponentiating the relative change in the incidence rate brought by a one-unit change in an independent variable holding other independent variables constant. Sampling weights were used to approximate the total population in New Zealand. Sample weights were obtained from the NZHS (Ministry of Health, 2017). The NZHS uses the calibrated weighting method to reflect the probabilities of selection of each respondent and to make use of external population benchmarks (typically obtained from a population Census) to correct for any discrepancies between the sample and the population benchmarks (Ministry of Health, 2017). This improves the precision of estimates and reduces bias due to nonresponse. Models adjusted for key covariates including age group, sex, ethnicity, area-level deprivation, education-level, and rural/urban classification.

While conceptually individuals were nested within geographical areas, all models used a cluster option with observations clustered within district health boards as any smaller geographic areas meant the model did not converge. It could be argued that multilevel models are recognised as the gold standard, however models that were both weighted to be nationally representative and multilevel did not converge. Pearson residual, deviance residual and Pregibon leverage regression diagnostics test were used, with little if any influential cases identified. Multicollinearity was not an issue and Receiver Operating Characteristic (ROC) curve analysis provided an area under the ROC curve (AUC) score of scores from 0.74 to 0.76 which suggests a fair diagnostic performance of the model (Metz, 1978). Following these checks on the model specification, effect modification was assessed based on previous evidence by investigating if an interaction term was significant and then stratifying regression analyses by area-level deprivation quartiles (Q1, Q2, Q3, Q4 and Q5) and ethnicity (Māori, Pacific, Asian, European/other). Models were built within STATA V15.1 and geographical analyses for proximity calculations were conducted within ArcGIS v10.7.1.

3. Results

3.1. Descriptive statistics

Table 1 shows the descriptive statistics of the study population while Table 2 shows the prevalence of hazardous drinking. The prevalence of hazardous drinking was highest in those aged 20–24 (32.63% [29.85–35.54]) and declined with age (Table 2). When split by ethnicity, the highest prevalence was among Māori (32.33% [30.70–33.99]) and when examined by area-level deprivation, the most deprived areas showed the highest prevalence (22.16% [20.95–23.41]). When examined by rural/urban classification, medium urban areas had the highest prevalence (21.31% [19.36–23.41]). As shown in Table 3, the median distance to an alcohol outlet from the population weighted centroid of meshblock in New Zealand was 1174.34 m [1146.59–1202.09]. When attached to NZHS data there were few differences by sex. However, there were differences by age with those aged 20–24 years and 75+ years often having a shorter distance to the nearest alcohol outlet (all types and overall). Differences by ethnicity were also noted. For instance, Pacific (693.72m [646.80–740.65]) and Asian 752.04m [687.31–816.76] populations were closer to alcohol outlets of all types than European/Other 1275.99m [1239.45–1312.53] and Māori (1254.27m [1189.32–1319.23]). This pattern existed across off-, on-, and other-licence alcohol outlets. Differences were noted by area-level deprivation, for instance, the most deprived areas had a shorter road network distance to the nearest alcohol outlet compared to the least

Table 1
Study sample characteristics (n (%)) (New Zealand Health Survey, 2016/17 and 2017/18).

Variable	Weighted percentage (raw n)
Age	
15–19	8.16 (1403)
20–24	9.20 (1176)
25–34	17.59 (4470)
35–44	15.08 (4394)
45–54	16.46 (4.280)
55–64	14.75 (4399)
65–74	10.83 (3829)
75+	7.93 (2963)
Sex	
Male	48.78 (11,822)
Female	51.22 (15,632)
Ethnicity	
Māori	12.77 (5598)
Pacific	5.40 (1478)
Asian	12.87 (2550)
European/Other	68.96 (17,828)
Education-level	
Low	24.67 (7355)
Moderate	48.94 (12,853)
High	26.39 (5836)
Area-level deprivation	
Q1 (least deprived)	20.13 (3716)
Q2	20.28 (4425)
Q3	20.22 (5226)
Q4	20.35 (6558)
Q5 (most deprived)	19.02 (7529)
Urban/rural classification	
Major urban	52.29 (12,252)
Large urban	12.90 (5455)
Medium urban	9.25 (2872)
Small urban	9.65 (3044)
Rural	15.91 (3818)

Table 2
The prevalence (%) of hazardous drinking [95% confidence intervals] by age, sex, ethnicity, area-level deprivation and rural/urban classification (New Zealand Health Survey, 2016/17 and 2017/18). Data are median [95% CI].

	Hazardous drinking (units)
Overall	
Age	
15–19	16.56 [14.40–18.98]
20–24	32.63 [29.85–35.54]
25–34	25.74 [24.09–27.47]
35–44	22.11 [20.64–23.66]
45–54	21.61 [20.03–23.29]
55–64	15.47 [14.16–16.87]
65–74	11.52 [10.28–12.89]
75+	4.61 [3.78–5.62]
Sex	
Male	27.15 [26.12–28.21]
Female	12.53 [11.86–13.32]
Ethnicity	
Māori	32.33 [30.70–33.99]
Pacific	19.20 [16.84–21.80]
Asian	6.40 [5.26–7.80]
European/Other	19.83 [19.05–20.63]
Area-level deprivation	
Q1 (least deprived)	16.28 [14.84–17.82]
Q2	17.47 [16.07–18.96]
Q3	21.50 [20.06–23.02]
Q4	21.03 [21.03–22.37]
Q5 (most deprived)	22.16 [20.95–23.41]
Rural/urban classification	
Major urban area	18.91 [18.01–19.85]
Large urban area	20.76 [19.39–22.21]
Medium urban area	21.31 [19.36–23.41]
Small urban area	18.76 [16.97–20.69]
Rural	19.97 [18.29–21.75]

deprived areas (Q1 (least deprived) 1425.96m [1339.37–1512.55], Q5 (most deprived) 672.60m [644.45–700.75]). This pattern was again shown for off-, on- and other-licence alcohol outlets.

3.2. Associations between proximity to alcohol outlets and hazardous drinking

First, we investigated associations between all alcohol outlets and the likelihood of hazardous drinking (Table 4). Compared to those with the closest proximity (Q1 <292 m) those in Q2 (292m–525m) had reduced risk of hazardous drinking (OR = 0.84 [95% CI 0.73–0.96]). Confirming these findings for Q2, individuals in Q3 (526m–868m) and Q4 (>868m) also had a reduced odds of hazardous drinking (OR = 0.82 [0.71–0.94] and OR = 0.79 [0.65–0.97] respectively). Second, we investigated associations between proximity to off-licence alcohol outlets and odds of hazardous drinking. Compared to those with the closest proximity (Q1 licence (<422 m) to off-licence alcohol outlets only those within Q3 (774m–1381m; OR = 0.81 [0.69–0.95]) had a reduced odds of hazardous drinking. Overall results were inconsistent as there were no associations for those within Q2 (423m–773m; OR = 0.96 [0.79–1.14]) or Q4 (>1381m; OR = 0.85 [0.62–1.07]). Third, we explored relationships between proximity to on-licence alcohol outlets and hazardous drinking, where the most consistent associations were demonstrated. Compared to those residing within the closest proximity of on-licence alcohol outlets (Q1, <481 m) those within Q2 (482m–855m; OR = 0.79 [0.69–0.92]), Q3 (856m–1457m; OR = 0.82 [0.73–0.93]) and Q4 (>1457m; OR = 0.81 [0.69–0.98]) had reduced odds of hazardous drinking. Finally, we explored other types of alcohol outlet licence. However, compared to those with the closest proximity other-types of alcohol outlets (Q1<594m), there were no significant associations with hazardous drinking for Q2 (594m–1001m; OR = 1.03 [0.88–1.21]), Q3 (1002m–1715m; OR = 0.97 [0.80–1.18]), and Q4 (>1715m; OR = 0.91 [0.76–1.08]).

3.3. Associations between proximity to alcohol outlets and crime

As shown in Table 5, several notable associations existed between all measures of alcohol outlet proximity and all crime outcomes. First, we investigated if the count of common assault in a CAU was related to

Table 3
Proximity (median meters) to nearest alcohol outlet by age, sex, ethnicity, area-level deprivation, and rural/urban classification.

	All alcohol outlets	Off	On	Other
Overall	1174 [1146–1202]	1900 [1859–1942]	1959 [1919–2000]	2161 [2100–222]
Age				
15–19	1248 [1116–1379]	2047 [1835–2260]	2012 [1836–2188]	2060 [1887–2234]
20–24	977 [877–1078]	1561 [1426–1695]	1598 [1453–1726]	1788 [1599–1978]
25–34	1072 [1003–1142]	1647 [1552–1742]	1765 [1663–1868]	2029 [1872–2187]
35–44	1200 [1127–1274]	1943 [1838–2048]	1994 [1888–2099]	2283 [2101–2465]
45–54	1337 [1259–1415]	2154 [2040–2267]	2114 [2011–2218]	2365 [2205–2524]
55–64	1262 [1197–1328]	2183 [2073–2293]	2204 [2103–2306]	2237 [2116–2358]
65–74	1176 [1104–1247]	1897 [1792–2003]	2066 [1947–2186]	2172 [2032–2313]
75+	995 [929–1061]	1577 [1476–1678]	1775 [1663–1887]	2175 [1919–2432]
Sex				
Male	1216 [1173–1260]	1952 [1888–2016]	2002 [1939–2065]	2338 [2141–2336]
Female	1133 [1098–1169]	1851 [1798–1905]	1919 [1866–1972]	2087 [2011–2164]
Ethnicity				
Māori	1254 [1189–1319]	1868 [1781–1956]	2287 [2165–2408]	2176 [2054–2298]
Pacific	693 [646–740]	1007 [945–1069]	1216 [1148–1284]	1309 [1249–1369]
Asian	752 [687–816]	1128 [1052–1204]	1170 [1093–1248]	1401 [1323–1480]
European/Other	1275 [1239–1312]	2120 [2065–2176]	2104 [2053–2155]	2366 [2282–2451]
Area-level deprivation				
Q1 (least deprived)	1425 [1339–1512]	2441 [2304–2578]	2191 [2084–2298]	2878 [2618–3138]
Q2	1473 [1388–1558]	2573 [2442–2704]	2340 [2235–2446]	2560 [2403–2717]
Q3	1226 [1163–1290]	1886 [1798–1975]	2038 [1945–2131]	2105 [1989–2222]
Q4	1044 [994–1093]	1555 [1489–1621]	1875 [1790–1960]	1944 [1864–2024]
Q5 (most deprived)	672 [644–700]	995 [961–1030]	1213 [1242–1388]	1267 [1207–1326]
Rural/urban classification				
Major urban area	607 [597–616]	899 [886–911]	935 [921–949]	1244 [1218–1269]
Large urban area	598 [582–614]	960 [940–981]	870 [850–890]	1157 [1132–1182]
Medium urban area	600 [582–618]	862 [838–885]	905 [883–928]	1214 [1167–1261]
Small urban area	536 [514–558]	932 [875–988]	1316 [1221–1410]	2788 [2350–3225]
Rural	4228 [4080–4377]	7152 [6952–7352]	7222 [7036–7408]	6166 [5952–6381]

Data are median [95% CI].

Table 4
Associations between proximity to alcohol outlets and hazardous drinking.

		OR [95% CI]		
	All	Off-licence	On-licence	Other-licence
Intercept	0.47 [0.36–0.61]	0.44 [0.36–0.55]	0.46 [0.35–0.60]	0.40 [0.30–0.53]
Age group				
15–19	REF	REF	REF	REF
20–24	2.87 [1.94–4.23] *	2.89 [1.96–4.27] *	2.87 [1.94–4.22] *	2.88 [1.96–4.24] *
25–34	2.25 [1.71–2.96] *	2.26 [1.73–2.96] *	2.25 [1.71–2.95] *	2.25 [1.72–2.96] *
35–44	1.75 [1.27–2.41] *	1.75 [1.27–2.41] *	1.74 [1.26–2.40] *	1.74 [1.26–2.11] *
45–54	1.55 [1.13–2.12] *	1.55 [1.12–2.13] *	1.54 [1.12–2.10] *	1.54 [1.12–2.11] *
55–64	0.96 [0.73–1.26]	0.97 [0.73–1.26]	0.95 [0.72–1.26]	0.96 [0.73–1.26]
65–74	0.67 [0.48–0.94] *	0.68 [0.48–0.94] *	0.67 [0.47–0.94] *	0.67 [0.47–0.93] *
75+	0.23 [0.16–0.34] *	0.24 [0.16–0.34] *	0.24 [0.16–0.34] *	0.23 [0.16–0.34] *
Sex				
Male	REF	REF	REF	REF
Female	0.36 [0.32–0.40] *	0.36 [0.33–0.40] *	0.36 [0.32–0.40] *	0.36 [0.32–0.40] *
Ethnicity				
Māori	REF	REF	REF	REF
Pacific	0.46 [0.38–0.56] *	0.47 [0.38–0.57] *	0.47 [0.39–0.57] *	0.47 [0.38–0.56] *
Asian	0.13 [0.10–0.16] *	0.13 [0.10–0.16] *	0.13 [0.10–0.16] *	0.13 [0.11–0.17] *
European/Other	0.65 [0.59–0.71] *	0.65 [0.59–0.72] *	0.65 [0.59–0.71] *	0.65 [0.59–0.72] *
Education level				
Low	REF	REF	REF	REF
Moderate	1.04 [0.94–1.16]	1.05 [0.94–1.16]	1.05 [0.95–1.16]	1.05 [0.94–1.17] *
High	0.77 [0.65–0.91] *	0.77 [0.65–0.91] *	0.77 [0.66–0.91] *	0.77 [0.65–0.91] *
Area-level deprivation				
Q1 (least deprived)	REF	REF	REF	REF
Q2	1.02 [0.89–1.17]	1.04 [0.92–1.18]	1.03 [0.90–1.17]	1.04 [0.92–1.17]
Q3	1.31 [1.11–1.54] *	1.33 [1.13–1.55] *	1.32 [1.12–1.56] *	1.33 [1.13–1.58] *
Q4	1.20 [1.04–1.38] *	1.21 [1.06–1.38] *	1.22 [1.06–1.39] *	1.23 [1.07–1.41] *
Q5 (most deprived)	1.22 [1.06–1.39] *	1.23 [1.07–1.41] *	1.24 [1.09–1.42] *	1.24 [1.09–1.41] *
Rural/urban classification				
Major urban area	REF	REF	REF	REF
Large urban area	1.02 [0.84–1.24]	1.04 [0.85–1.26]	1.03 [0.85–1.24]	1.01 [0.83–1.24]
Medium urban area	0.88 [0.70–1.09]	0.87 [0.70–1.08]	0.91 [0.74–1.12]	0.87 [0.71–1.08]
Small urban area	1.18 [0.92–1.51]	1.17 [0.91–1.51]	1.21 [0.93–1.56]	1.20 [0.93–1.55]
Rural	1.11 [0.92–1.32]	1.10 [0.88–1.38]	1.10 [0.88–1.37]	1.10 [0.91–1.33]
Proximity to alcohol outlets				
Q1 (closest proximity)	REF	REF	REF	REF
Q2	0.84 [0.73–0.96] *	0.96 [0.79–1.14]	0.79 [0.69–0.92] *	1.03 [0.88–1.21]
Q3	0.82 [0.71–0.94] *	0.81 [0.69–0.95] *	0.82 [0.73–0.93] *	0.97 [0.80–1.18]
Q4 (furthest proximity)	0.79 [0.65–0.97] *	0.85 [0.62–1.07]	0.81 [0.69–0.98] *	0.91 [0.76–1.08]

All alcohol outlets (Q1 <292; Q2 292–525; Q3 526–868; Q4 >868).
Off-licence (Q1<422; Q2 423–773; Q3 774–1381; Q4 >1381).
On-licence (Q1<481; Q2 482–855; Q3 856–1457; Q4 >1457).
Other-licence (Q1<594; Q2 594–1001; Q3 1002–1715; Q4>1715).

proximity to alcohol outlets. Strong associations were seen across all types of outlets. For instance, compared to those with the closest proximity to all types of alcohol outlets (Q1<292m), those within Q2 (292m–525m, IRR = 0.65 [0.49–0.87]), Q3 (526m–868m, IRR = 0.53 [0.39–0.72]), and Q4 (>868m, IRR = 0.49 [0.38–0.64]) had a reduced odds of common assault. Hence, closer proximity to all types of alcohol outlets was associated with increased odds of common assault. This pattern was consistent across other crime outcomes, with odds of non-aggravated sexual assault, aggravated sexual assault, and liquor and tobacco offences higher with closer proximity to alcohol outlets. In most associations, a dose-response relationship was seen. For example, in liquor and tobacco offences and on-licence alcohol outlets, compared to the closest proximity (Q1<481m) increasing distance was associated with decreased odds of liquor and tobacco offences in Q2 (482m–855m, IRR = 0.35 [0.19–0.62]); (Q3 856m–1457m, IRR = 0.24 [0.14–0.39]) and Q4 (>1457m, IRR = 0.15 [0.09–0.25]).

4. Discussion

Using nationwide data this study investigated associations between proximity to alcohol outlets such as off-licence, on-licence, and other-licence, and outcomes of hazardous drinking and crime. Results showed that close proximity to all types of alcohol outlets was associated with increased incidence of common assault, non-aggravated sexual assault, aggravated sexual assault, and tobacco and liquor offences, often with a dose-response relationship. While proximity to alcohol outlets was associated with hazardous drinking this was significant only for on-licence outlets. Our study adds to existing international evidence by pooling nationally representative data on hazardous drinking, using nationwide contemporary crime data, and by using a contemporary database of alcohol outlets to add evidence at a fine geographical level (Day et al., 2012). It also extends evidence by showing differences in associations by alcohol outlet type.

Previous evidence has shown a positive relationship between alcohol outlet density and the outcomes of increased local levels of alcohol consumption and various outcomes of crime (Cameron et al., 2012, 2016; Connor et al., 2011; Livingston et al., 2007). Indeed, previous analyses by the New Zealand Ministry of Health demonstrated that off-licence alcohol outlet density is greatest in the most deprived areas and higher levels of hazardous drinking occurred in the most deprived areas (Ministry of Health, 2015). Our study found that close proximity to alcohol outlets, in particular, on-license alcohol outlets was associated with greater odds of hazardous drinking. This is concerning as hazardous drinking represents an established pattern of drinking that carries a high risk of future damage to physical or mental health (World health Organisation (WHO), 2019). In New Zealand, hazardous drinking results

Table 5
Associations between proximity to alcohol outlets and crime.

	IRR [95% CI]			
All alcohol outlets	Common assault	Non-aggravated sexual assault	Aggravated sexual assault	Liquor and tobacco offences
Q1 (closest proximity)	REF	REF	REF	REF
Q2	0.65 [0.49–0.87] *	0.59 [0.37–0.94] *	0.82 [0.66–1.01]	0.29 [0.16–0.50] *
Q3	0.53 [0.39–0.72] *	0.45 [0.25–0.81] *	0.75 [0.64–0.87] *	0.15 [0.08–0.31] *
Q4 (furthest proximity)	0.49 [0.38–0.64] *	0.28 [0.17–0.46] *	0.70 [0.57–0.85] *	0.19 [0.09–0.38] *
Off-licence				
Q1 (closest proximity)	REF	REF	REF	REF
Q2	0.61 [0.43–0.85] *	0.70 [0.47–1.05]	0.77 [0.65–0.94] *	0.36 [0.17–0.79] *
Q3	0.56 [0.41–0.78] *	0.45 [0.27–0.76] *	0.87 [0.73–1.03]	0.14 [0.06–0.28] *
Q4 (furthest proximity)	0.43 [0.34–0.55] *	0.45 [0.28–0.71] *	0.63 [0.52–0.77] *	0.19 [0.10–0.35] *
On-licence				
Q1 (closest proximity)	REF	REF	REF	REF
Q2	0.63 [0.46–0.86] *	0.51 [0.29–0.89] *	0.80 [0.65–0.97] *	0.35 [0.19–0.62] *
Q3	0.55 [0.44–0.69] *	0.41 [0.26–0.64] *	0.77 [0.68–0.86] *	0.24 [0.14–0.39] *
Q4 (furthest proximity)	0.45 [0.38–0.54] *	0.44 [0.26–0.75] *	0.61 [0.54–0.70] *	0.15 [0.09–0.25] *
Other licence				
Q1 (closest proximity)	REF	REF	REF	REF
Q2	0.95 [0.67–1.33]	0.52 [0.30–0.93] *	0.94 [0.74–1.21]	0.71 [0.35–1.41]
Q3	0.73 [0.58–0.93] *	0.49 [0.31–0.78] *	0.82 [0.71–0.93] *	0.41 [0.21–0.75] *
Q4 (furthest proximity)	0.52 [0.39–0.71] *	0.30 [0.21–0.42] *	0.72 [0.58–0.91] *	0.33 [0.15–0.72] *

Note: All models adjusted for age, sex, ethnicity, area-level deprivation, education-level, and rural/urban classification. Models were run separately for each outcome and exposure hence 16 separate models were included here one for each licence type exposure and each type of crime.
All alcohol outlets (Q1<292; Q2 292,525; Q3 526–868; Q4 >868).
Off-licence (Q1<422; Q2 423–773; Q3 774–1381; Q4 >1381).
On-licence (Q1<481; Q2 482–855; Q3 856–1457; Q4 >1457).
Other-licence (Q1<594; Q2 594–1001; Q3 1002–1715; Q4 >1715).

in many chronic health conditions and physical injury (Meiklejohn et al., 2012). Our findings support previous evidence. For example, an Australian cross-sectional survey found associations between alcohol outlet density and risky drinking behaviours in urban areas amongst adolescents (Azar et al., 2016), while in New Zealand, associations were found between greater quantities of alcohol consumed and proximity to alcohol outlets, which was also associated with deprivation levels within the community (Huckle et al., 2008). The location of alcohol outlets in relation to an individual's residence is therefore associated with greater alcohol consumption and in greater quantities.

Research has highlighted that increased proximity and density of alcohol outlets is associated with higher levels of crime including serious violent crime (Day et al., 2012). Our study supports this evidence, demonstrating that closer proximity to alcohol outlets was associated with increased incidence of many types of crime including common assault, non-aggravated sexual assault, and liquor and tobacco offences, often with a dose-response relationship. US evidence supports this revealing that census tracts where alcohol outlets were destroyed during the 1992 Los Angeles riots experienced reductions in violent crime and those reductions were proportional to the number of outlets lost, again showing a dose-response association (Yu et al., 2009). This is also supported by international evidence including reviews and meta-analysis that have demonstrated consistency in these associations (Popova et al., 2009; Sherk et al., 2018). For instance, a US study concluded a greater density of alcohol outlets was related to higher rates of violent crime (Gorman et al., 2018). Finally, while we found no evidence for any moderation effects, other cross-sectional evidence from the US has found that neighbourhood characteristics such as deprivation level and community ethnicity impacted upon the association between alcohol outlet density and violence, and in some areas of low deprivation a greater density of bars had a protective effect on violence levels (Gruenewald et al., 2006).

This study has several limitations that should be acknowledged when interpreting findings. First, this study is ecological in design, thus the association between alcohol outlet access, hazardous drinking, and crime is related to geographical scale. Second, the cross-sectional study design limits the extent to which causal inference can be made. Third, other important factors such as license operating hours and actual use, which are important factors in the accessibility of alcohol, were not included in the available data for our analysis. Fourth, data on hazardous drinking are self-reported and may be subject to recall bias. We used also used centroid as the basis for proximity analyses and did not account for the mode of transport used. Finally, we cannot be certain that area-level crime was, in fact, specifically linked to alcohol usage we are assuming that people are shopping within their local area. We can, however, examine and present associations between these two factors. Given the high degree of alcohol involvement associated with crime, however, it is likely that such data are indicative of alcohol-related crimes, this could be an area for future research.

5. Conclusion

Alcohol is responsible for a range of social problems directly affecting the health and well-being of New Zealanders. Our nationwide study suggests that the availability of alcohol is an important influence on alcohol-related harm. It confirms previous evidence in New Zealand and shows a strong association between geographic access to alcohol outlets and various crime outcomes. It also demonstrates a dose-response relationship showing that areas with the greatest access to alcohol outlets also had the highest incidence of crime. Additionally, the incidence of crime reduced as the level of access decreased. We reinforce the notion that policies to reduce the accessibility of alcohol should involve restricting access to alcohol outlets, in particular in socially disadvantaged neighbourhoods where the prevalence of alcohol consumption, accessibility to alcohol outlets, and morbidity is the greatest.

Funding

The GeoHealth Laboratory is funded by the New Zealand Ministry of Health.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.healthplace.2020.102397.

References

Atkinson, J., Salmond, C., Crampton, P., 2019. NZDep2018 Index of Deprivation: Interim Research Report, December 2019. Wellington, New Zealand.

Azar, D., White, V., Coomber, K., Faulkner, A., Livingston, M., Chikritzhs, T., et al., 2016. The association between alcohol outlet density and alcohol use among urban and regional Australian adolescents. Addiction 111 (1), 65–72.

Beere, P., 2016. Creating a Road Network Analysis Layer with Travel Time Estimates from Open-Source Data. White Paper Report. Christchurch, New Zealand.

Breetzke, G., Elley, B., Gilbert, J., 2018. Post-earthquake Analysis of Crime and Alcohol in Christchurch. Health Promotion Agency, Wellington.

Brown, R., Murphy, S., 2020. Alcohol and social connectedness for new residential university students: implications for alcohol harm reduction. J. Furth. High. Educ. 44 (2), 216–230.

Burgoine, T., Alvanides, S., Lake, A.A., 2011. Assessing the obesogenic environment of North East England. Health Place 17 (3), 738–747.

Burgoine, T., Alvanides, S., Lake, A., 2013. Creating 'obesogenic realities'; do our methodological choices make a difference when measuring the food environment? Int. J. Health Geogr. 12, 33.

Cameron, M.P., Cochrane, W., McNeill, K., Melbourne, P., Morrison, S.L., Robertson, N., 2012. Alcohol outlet density is related to police events and motor vehicle accidents in Manukau City, New Zealand. Aust. N. Z. J. Publ. Health 36 (6), 537–542.

Cameron, M., Cochrane, W., Livingston, M., 2016. The Relationship between Alcohol Outlets and Harms: A Spatial Panel Analysis for New Zealand, 2007-2014. Health Promotion Agency, Wellington.

Connor, J.L., Kypri, K., Bell, M.L., Cousins, K., 2011. Alcohol outlet density, levels of drinking and alcohol-related harm in New Zealand: a national study. J. Epidemiol. Community Health 65 (10), 841–846.

Connor, J., Kydd, R., Shield, K., Rehm, J., 2013. Alcohol-attributable Burden of Disease and Injury in New Zealand: 2004 and 2007, Research Report Commissioned by the Health Promotion Agency. Health Promotion Agency, Wellington.

Connor, J., Kydd, R., Shield, K., Rehm, J., 2015. The burden of disease and injury attributable to alcohol in New Zealanders under 80 years of age: marked disparities by ethnicity and sex. N. Z.Med. J. 128 (1409), 15–28.

Day, P., Breetzke, G., Kingham, S., Campbell, M., 2012. Close proximity to alcohol outlets is associated with increased serious violent crime in New Zealand. Aust. N. Z. J. Publ. Health 36 (1), 48–54.

Gorman, D.M., Ponicki, W.R., Zheng, Q., Han, D., Gruenewald, P.J., Gaidus, A.J., 2018. Violent crime redistribution in a city following a substantial increase in the number of off-sale alcohol outlets: a Bayesian analysis. Drug Alcohol Rev. 37 (3), 348–355.

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

Halonen, J.I., Kivimäki, M., Virtanen, M., Pentti, J., Subramanian, S.V., Kawachi, I., et al., 2013. Living in proximity of a bar and risky alcohol behaviours: a longitudinal study. Addiction 108 (2), 320–328.

Hobbs, M., Green, M., Griffiths, C., Jordan, H., Saunders, J., McKenna, J., 2016. How Different Data Sources and Definitions of Neighbourhood Influence the Association between Food Outlet Availability and Body Mass Index: a Cross-Sectional Study. Perspectives in Public Health.

Holmes, J., Guo, Y., Maheswaran, R., Nicholls, J., Meier, P.S., Brennan, A., 2014. The impact of spatial and temporal availability of alcohol on its consumption and related harms: a critical review in the context of UK licensing policies. Drug Alcohol Rev. 33 (5), 515–525.

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

James, S.L., Abate, D., Abate, K.H., Abay, S.M., Abbafati, C., Abbasi, N., et al., 2018. Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet 392 (10159), 1789–1858.

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

Meiklejohn, J., Connor, J., Kypri, K., 2012. One in three New Zealand drinkers reports being harmed by their own drinking in the past year. N. Z.Med. J. 125 (1360), 28–36.

Metz, C.E., 1978. Basic principles of ROC analysis. Semin. Nucl. Med. 8 (4), 283–298.

Ministry of Health, 2015. Alcohol Use 2012/13: New Zealand Health Survey. Minsitry of Health, Wellington.

Ministry of Health, 2017. Methodology report 2016/17: New Zealand health survey Wellington: Ministry of health. In: This Methodology Report Details the Procedures and Protocols Followed to Ensure the New Zealand Health Survey Produces the High-Quality and Robust Data Expected of Official Statistics. Available from: https://www.health.govt.nz/publication/methodology-report-2016-17-new-zealand-health-survey.

Ministry of Health, 2018. New Zealand Health Survey 2016/17 Annual Data Explorer Wellington. Minsitry of Health. Available from: https://minhealthnz.shinyapps.io/nz-health-survey-2016-17-annual-data-explorer/_w_c13033de/#!/explore-indicators.

Ministry of Transport, 2016. Alcohol and Drugs Crash Facts Wellington. Ministry of Transport [Available from: https://www.transport.govt.nz/mot-resources/road-safety-resources/crashfacts/alcohol-and-drugs/.

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

Pridemore, W.A., Grubesic, T.H., 2011. Alcohol outlets and community levels of interpersonal violence: spatial density, outlet type, and seriousness of assault. J. Res. Crime Delinquen. 50 (1), 132–159.

Rehm, J., Gmel, G.E., Sr, Gmel, G., Hasan, O.S.M., Imtiaz, S., Popova, S., et al., 2017. The relationship between different dimensions of alcohol use and the burden of disease-an update. Addiction 112 (6), 968–1001.

Schonlau, M., Scribner, R., Farley, T.A., Theall, K., Bluthenthal, R.N., Scott, M., et al., 2008. Alcohol outlet density and alcohol consumption in Los Angeles county and southern Louisiana. Geospatial health 3 (1), 91–101.

Sherk, A., Stockwell, T., Chikritzhs, T., Andreasson, S., Angus, C., Gripenberg, J., et al., 2018. Alcohol consumption and the physical availability of take-away alcohol: systematic reviews and meta-analyses of the days and hours of sale and outlet density. J. Stud. Alcohol Drugs 79 (1), 58–67.

Sparks, A.L., Bania, N., Leete, L., 2011. Comparative approaches to measuring food access in urban areas: the case of Portland. Oregon. Urban studies (Edinburgh, Scotland) 48 (8), 1715–1737.

Statistics New Zealand, 2018. Statistical Standard for Meshblock Wellington. Statistics New Zealand. Available from: http://archive.stats.govt.nz/methods/classifications-and-standards/classification-related-stats-standards/meshblock/definition.aspx.

Statistics New Zealand, 2019. Statistical Standard for Geographic Areas 2018: New Standard Released Wellington. Statistics New Zealand. Available from: http://archive.stats.govt.nz/methods/classifications-and-standards/current-classifications-and-standards-review/review-geographic.aspx.

Steinberg, L., 2008. A social neuroscience perspective on adolescent risk-taking. Dev. Rev. 28 (1), 78–106.

Trangenstein, P.J., Curriero, F.C., Webster, D., Jennings, J.M., Latkin, C., Eck, R., et al., 2018. Outlet type, access to alcohol, and violent crime. Alcohol Clin. Exp. Res. 42 (11), 2234–2245.

World health Organisation (Who), 2019. AUDIT : the Alcohol Use Disorders Identification Test : Guidelines for Use in Primary Health Care. WHO, Geneva.

Yu, Q., Li, B., Scribner, R.A., 2009. Hierarchical additive modeling of nonlinear association with spatial correlations–an application to relate alcohol outlet density and neighborhood assault rates. Stat. Med. 28 (14), 1896–1912.