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Article

The Negative Effects of Alcohol Establishment Size and Proximity on the Frequency of Violent and Disorder Crime across Block Groups of Victoria, British Columbia

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Abstract: Multiple studies have associated the density of alcohol establishments with crime. What is not well understood is the influence of establishment patron capacity on the magnitude of crime in an area, or how the spacing of liquor primary establishments impacts crime levels. Using a Poisson spatial lag model, we estimated how patron capacity of on-premises licenses and the total number of off-premises licenses were associated with the frequency of violent and disorder crime occurring on Friday and Saturday nights in Victoria, British Columbia. To identify how the distance between bars and pubs was associated with the frequency of crime within 200 m of each establishment, we applied bivariate curve fitting and change detection techniques. Our model explained 76% percent of the variance in crime frequencies. Bars and pubs within block groups, and in neighboring block groups, had a significant positive association ($p < 0.05$) with the frequency of crime compared to other on-premises licenses (e.g., restaurants, theatres, clubs, hotels), and off-premises liquor stores. For every additional 1111 bar or pub patron seats the crime frequency per block group is expected to double over a 17 month period (factor of 1.0009 per patron seat). Crime frequency significantly dropped ($p < 0.05$) around (200 m) bars and pubs that are spaced greater than 300 m apart. Our results provide the first evidenced-based information for evaluating the size and spacing of on-premises licenses in Canada.

Keywords: alcohol establishment; crime; violent; disorder; spatial lag; distance; off-premises; on-premises

1. Introduction

Greater access to alcohol contributes to higher rates of intoxication, and subsequent harm, including violent [1–4] and disorder crime [5–10]. In particular, researchers have linked a higher density of on (bars, clubs, pubs) and off (liquor store, ubrews) premises alcohol establishments to the escalation of crime across multiple regions using various spatial and temporal units of analysis (e.g., census tracts, see [10,11] for review). Patterns of use indicate that alcohol consumption and crime reach their highest levels during the operating hours (weekend-nights) of on-premises drinking establishments [4,12–15].

Intoxication is one cumulative factor that can influence the relationship between alcohol and crime [16]. This is such that the consumption of alcohol leads to impaired judgment [17] and the

escalation of aggression in some individuals [18]. As alcohol access increases (more establishments, more patron seats), consumption follows, and the likelihood of harm escalates [19]. However, the effects of alcohol establishments on crime are not uniform in all areas. Differences in the influence of on versus off premises alcohol establishments on crime are documented [20–24]. Particular bars are thought to attract risk-taking groups of people; thereby, increasing the potential for crime in those areas [25]. On-premises licenses with loud music, dance floors, liberal serving practices, and high patron capacity also have a disproportionate amount of crime around their establishments [26–28].

What is not well understood are the varying effects of different types of on-premises alcohol establishment types, and their patron capacities on crime [10,11,29,30]. Many studies combined alcohol license types (on and off) and use large (census tracts, postal codes) regional units to provide information on the association. These limitations make it hard to distinguish individual establishment effects [31–39]. Other studies separate establishment types (on versus off premises), but do not differentiate between establishment size [2,3,22,23,40–45]. One study represents on-premises alcohol licenses by size (patron seats), but uses a hypothetical change in alcohol establishment locations to indicate rises in crime [46]. The effects of proximity between alcohol licenses on crime have also not been established.

A small body of literature documents that specific on-premise drinking establishments disproportionately contribute to local crime. The concentration amounts to more than 50% of crimes happening around the establishments [22–24,28,47], and crime clustering within 152 m or 5000 ft of the premises [22]. Alarming, bars within economically deprived areas can double crime occurrence rates [2]. In order to reduce alcohol-associated crime, policy makers may benefit from consistent evidenced-based information where they can attribute crime to the type, patron capacity, and distance between establishments (factor increase). This is particularly true in Canada where the lack of crime statistics available at detailed spatial locations (x,y coordinates or blocks) has limited the ability to test how the type, size, and placement of alcohol establishment is associated with crime levels [29].

The goals of our research were to identify the association between different license types and on-premises patron seat capacity, on the count of violent and disorder crimes in Victoria, British Columbia block groups (census dissemination areas) using a Poisson Generalized Linear Model (GLM) with spatial effects. Secondly, we quantify the effects of on-premises establishment proximity on the count of crime around establishments using change point analysis. Both objectives provide evidence-based information for establishment size limits and licenses proximity restrictions. Further, no studies have been published that model the effects of alcohol establishments on crime in Victoria, British Columbia.

2. Materials and Methods

2.1. Study Area

Victoria is the capital city of British Columbia, and is located on the southern tip of Vancouver Island. It is world renowned for spectacular gardens and heritage buildings, drawing over three million visitors each year [48]. There are 118 off-premises, and 124 on-premises alcohol establishment licenses within Victoria (Figure 1) to serve a metropolitan area of 360,000 people, and a residential population of 80,017 people, according to the 2011 census.

When making decisions about new liquor licenses (i.e., establishments) it is important to understand the factors that lead to increased risk of crime for the surrounding community and how far these effects extend around the venue [49]. To date, no provincial or federal laws are mandated about the allowable density or proximity of establishments in Canada [50]. Based on limited amounts of evidence-based information, municipalities have developed their own policies and restrictions. Municipal governments have set minimum distance allowances of 50 to 500 m between establishments [51]. In Victoria there is an ad hoc 100 to 500 m radius restriction (land use dependent) on the approval of new establishment liquor licenses [52].

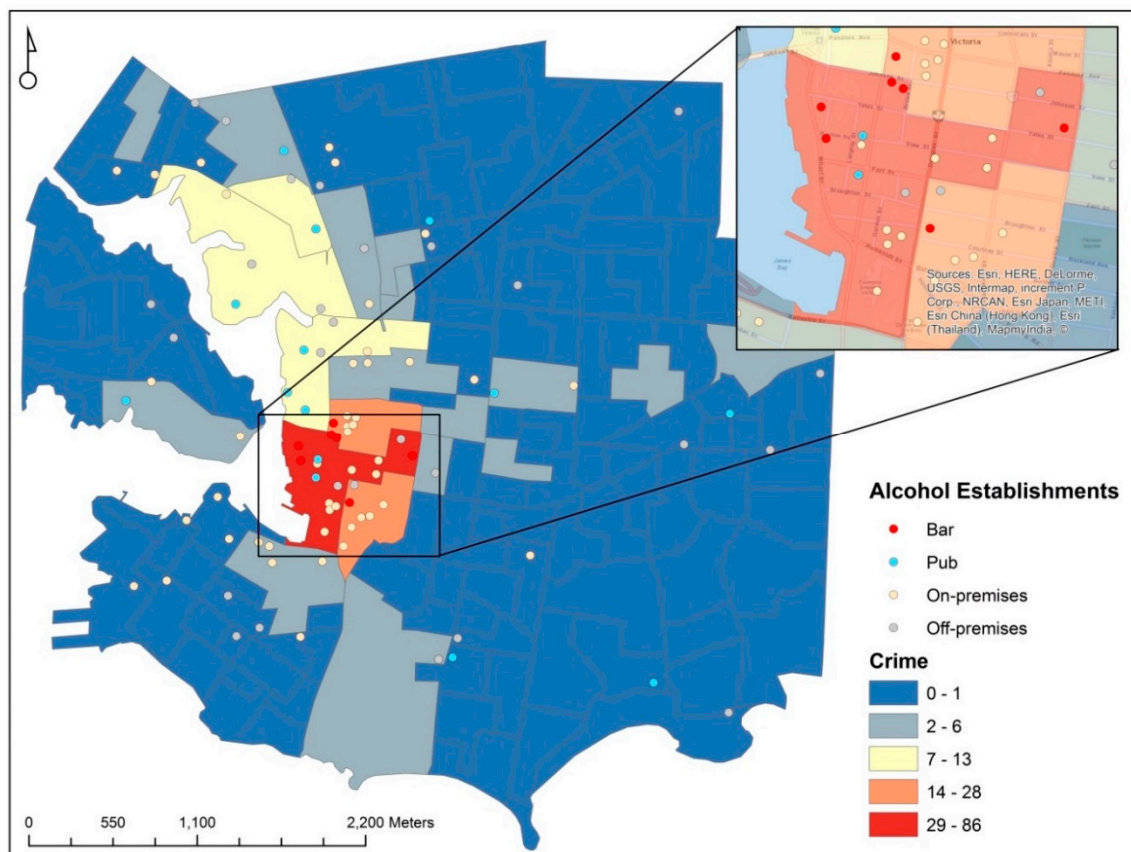


Figure 1. Victoria study area displaying the spatial distribution of crime and alcohol establishments. Off-premises licenses include government and independent retail liquor stores, and ubrews. On-premises licenses include establishments where drinking is the primary activity (bars and pubs), and where drinking is a subsidiary activity in restaurants, lounges, theatres, clubs, and hotels (on-premises). For mapping purposes, we differentiated bars as primary drinking establishments with a dance floor.

2.2. Data and Research Design

To estimate the effects of the type of alcohol establishments, and size of on-premises licenses on violent and disorder crime across Victoria BC we used estimated crime counts and covariate data aggregated to dissemination area (DA) units (Table 1). DAs are census geographical units composed of small adjacent block groups with a residential population between 400 and 700 persons [53]. Victoria is composed of 138 dissemination units with an average footprint of 0.14 km². These units provide a detailed spatial scale for analysis, which includes approximately eight city blocks in each unit. Since the units were not uniform in shape or size, we incorporated the square area as a control variable within our estimation model [54].

2.3. Covariates

Violent (assaults, and assaults with a deadly weapon) and disorder crime reports were downloaded from the Victoria Police Department website (crimereports.com), and include all incidence reports occurring in the Victoria area between 16 January 2015 and 29 May 2016. We excluded data before 2014, as liquor licensing laws for on-premises establishments changed to increase the length of happy hours [59]. Drink specials that are offered at limited times of the day are known to increase alcohol-attributable crime [60]. Downloaded offence attributes included: crime type, the probable time of occurrence, date, incident ID, and 100 block address. A 100 block address is a generalized

address location. For example, in the police reporting system, a house number of 823 would be converted to 800 for anonymity. To flag alcohol-attributable crime, we selected assault and disorder crimes occurring between 7:00 p.m. and 4:00 a.m. on Friday and Saturday nights, and counted the frequency of crime over the time period by hour. Multiple studies have suggested stratifying crime reports to strengthen model or analysis results [1,4,15,23,24,61–63], since consumption increases during the weekend nights [64]. Disorder and assaults were chosen as the focus crime types such that alcohol is known to increase aggression [18] and cause impaired judgment [17] that can lead to violent and disorderly behavior. Crime occurrences were geo-coded to 100 block address at a 98% match success rate, with an average of 97% accuracy. The remaining 2% were manually geo-coded to street segments using an open street map. The minor inaccuracies in the geocoding occurred due to the generalization of the 100 block address which, in some cases, did not register a house number. For modeling, violent and disorder crime points were summarized into a count per DA.

Table 1. Summary of covariates used to model and predict violent and disorder crimes across the 138 dissemination areas.

Covariate	Code	Rationale
Square meter of each DA (census dissemination areas)	Area	Area accounts for the varying sizes and shapes of DAs.
Count of off-premises licenses per DA	ct_off	Off-premises are hypothesized to attract clientele that may be vulnerable targets of crime, or who may commit crime around the establishments [25,55].
Total patron capacity of bars and pubs per DA	sd_bp	
Total patron capacity of bars and pubs in neighboring DAs (lag)	l_sd_bp	On-premises licenses provide both accesses to alcohol and group at-risk populations together, which can increase the probability of crime within and around these establishments such that intoxication increases aggression, and impairs judgment [25,55].
Total patron capacity of hotels, sports clubs, restaurants, theatres, and lounge liquor licenses per DAs (lag)	sd_on	
Total patron capacity of hotels, sports clubs, restaurants, theatres, and lounge liquor licenses in neighboring DA (lag)	l_sd_on	
Count of 2011 census population per DA	Pop	Crime is known to occur at a higher frequency in areas with higher populations [56]. We accounted for both residential and dynamic population distributions across DAs.
Count of the closest 2015 bike count collected between 3:00 p.m. and 7:00 p.m. per DA	bike_t	
Count of males between 19 and 24 years old per DA	M1924	Young males are documented to drink a larger amount alcohol than their female counterparts [57].
Count of no-child households per DA	NoChild	Locations with lower socio-economic status are found to have lower collective efficacy, and therefore crime tends to occur at a higher frequency in these areas. These areas have a perceived lawlessness (broken windows) and inability to resist venues that attract crime (alcohol establishments).
Average amount of children per family per DA	AvgChild	
Number other primary languages spoken per DA	Lang	
Count of needle exchanges per DA	Needle	Needle exchanges attract clientele who are prone to criminal behavior [58].
Count of lighting structures per DA	Lights	Lighting accounts for conspicuousness of an area and night-time population distribution. A greater amount of lights are needed for a larger population.
Dominant land use zone per DA	Zone	Industrial and commercial areas influence crime by providing areas with lower “guardianship” [41].

Alcohol establishments locations (x,y coordinates) including on and off premises, were downloaded from the Ministry of Justice BC Liquor control and licensing branch [65]. All addresses were geo-coded with an average match score of 92% and 99% accuracy. Unmatched addresses were manually geo-referenced to address locations using an open street map. Unmatched addresses were caused by unit numbers that were too detailed for the address locator to geo-locate. Alcohol outlet types were separated into three classes, as previous research documents variable effects by license type [40,66–68]. We created one category for off-premises licenses that included government and independent retail liquor stores, and brews. On-premises licenses were separated into two categories that distinguished between establishments where drinking is the primary activity (bars and pubs), and where drinking is a subsidiary activity (restaurants, lounges, theatres, clubs, and hotels).

For modeling purposes we counted the amount of off-sale licenses per DA. On-premises licenses were counted as the patron capacity for bars and pubs, and a second category as the patron capacity for hotels, sports clubs, theatres, and lounges per DA. Using patron counts is advantageous in situations where regions have a similar amount of establishments, but different capacities to hold clientele. By using patron capacity, we were able to distinguish how each seat was associated with the regional assault and disorder crime level. However, patron capacity is only a proxy for patronage. Data on patron use of each establishment were not available. In addition to DA counts, we created spatial lagged covariates that counted the total patron capacity of on-premises alcohol establishments in neighboring DAs (contiguous blocks). We incorporated spatially adjacent DA units in our lagged spatial counts such that persons drinking in a bar or pub may commit an assault or disorder crime in neighboring blocks rather than the focal DA [3]. To negate any edge effects when calculating our lagged covariates, we included the patron capacity of alcohol establishments in neighboring DA units that touched the boundary of the analysis units, but were outside of the study area boundary (i.e., Saanich, British Columbia, Canada).

In order to represent the effects of place-based attributes on assault and disorder crime we mapped the location of needle exchanges. The needle exchange services on Pandora St., in the downtown periphery of Victoria, is a long standing hot spot of crime [58]. We geo-coded addresses of needle sites provided by the Vancouver Island Health Authority [69]. Six needle exchanges were geo-located at 100% accuracy, and were counted per DA unit for the estimation model.

To control for the increase of crime in highly populated areas [56], we used 2011 census information to count the total residential population per DA. A proxy estimate was also used to represent the dynamic population distribution between DAs during the night time hours. These are people who are visiting an area, but who live in another location. Dynamic population estimates are known to shift the hot spots of crime across cities [70]. By separating the population estimates into multiple control variables, we were able to establish whether the dynamic population had a stronger association with assault and disorder crime compared to the residential population. To estimate the distribution of the dynamic population on the weekend nights, we used 2015 bike counts collected between 3:00 p.m. and 7:00 p.m. by the Capital Regional District of Victoria. These counts included cyclists that were entering the city center. We believe cyclists counts were a suitable proxy variable for the dynamic population, since a large portion of Victoria's population (~10%) commutes using bicycles, especially the younger demographic that are expected to frequent bars and clubs [71]. The spatial pattern of bike counts also correlated with traffic volumes in Victoria (higher density in downtown), but provides population estimates at night compared to 24 hr traffic counts (see traffic count data [72] and bike count maps [73]). To calculate the variable, each DA was attributed the closest bike count to the region. The spatial pattern showed a higher distribution of population in the downtown center. We also used the 2011 census count of males between 19 and 24 years old, and the median age per DA to signify populations at risk of alcohol attributable-crime. Young males are documented to consume more alcohol [57], and have a higher probability of experiencing harms such as violence while intoxicated [18,74–76].

Areas of lower socio-economic status, and higher ethnic diversity moderate the alcohol-crime relationship, and tend to experience a greater frequency of crime occurrences [20,37,77–79].

Communities with less capital, or collective efficacy (e.g., diffuse residential population) are vulnerable to the inclusion of venues (drinking establishments, and needle exchanges) that attract criminal activity in their neighborhoods [80]. A high ethnic diversity may represent a stratified population unable to group against crime [81]. To represent multi-cultural communities that may have lower collective efficacy, we used census data on the amount of other official languages spoken per DA. To indicate demographic variance, we used 2011 census data to count the number of childless households per DA, and the average number of children per family per DA to show the variability between the downtown core and the periphery family neighborhoods.

Crime occurs more often in commercial and industrial areas where there is a decrease in the amount of witnesses [82], and there is a greater number of venues that attract crime (e.g., alcohol outlets [41]). Structural characteristics of the city were represented with lighting fixtures and zoning information. Using Victoria zoning data from the Victoria Open Data Catalog we stratified zones into five categories (commercial, residential, industrial, service, and other), then mapped the dominant land use category per DA. Using light pole and structure information from the Victoria Open Data Catalog, we also counted the amount of light structures per DA to represent night-time visibility, and provided a proxy that represented the night-time population distribution.

2.4. Analysis Methods

To estimate the effects of off-premises establishments and patron seat capacity of on-premises alcohol establishments on the frequency of violent crime (assaults) and disorder counts, we applied a Poisson generalized linear model with spatial lag effect [54]. The GLM used a linear combination of covariates to estimate and predict violent and disorder crime counts. Lag models were an extension of GLMs that include covariates that are spatially structured so that information from neighboring analysis units were used to predict the focal DA's assault and disorder crime count [83], and have been applied in multiple alcohol establishment-crime studies [1,41,77,84,85]. We mapped the observed and predicted assault and disorder crime counts per DA using a natural break classification scheme that ensured similarity in crime counts within groups, and largest change in crime counts between. Exponents of the coefficients were calculated to indicate the unit factor increase for each variable.

Prior to modeling we produced a Spearman's correlation matrix to ensure independence between our variables. Once estimation was complete, we summarized the predicted errors from our model and calculated a McFadden pseudo r-squared value, which is recommended for multinomial models to indicate the variance explained [86]. To ensure independence in errors (residuals) between spatial units we ran a lag 1 (adjacent DAs) Moran's I cluster analysis [87]. Moran's I calculates the spatial autocorrelation (similarity in error values between spatial units) across spatial units within a spatial neighborhood (focal DAs and adjacent DAs). By calculating a global "I" value, we determined if residuals within DAs and adjacent DAs were clustered, and extreme (low, high, low-high, high-low) relative to the mean error [88]. The "I" value was compared to a spatial pattern of residuals distributed under complete spatial randomness, and it was determined if the pattern was significantly clustered, random, or dispersed. To indicate the fit of our model, we ran a goodness of variance fit test between the model deviance and an "ideal" saturated model where the predicted values are identical to the observed.

Drawing from change-point time-series modeling and semi-variogram techniques, we conducted a bivariate analysis to identify if the spacing (distance) between alcohol establishments was associated with the frequency of assault and disorder crime around establishments. We focused our analysis on bar and pubs, because the results of our Poisson GLM model indicated that the seating capacity of these establishments was significantly associated with the frequency of assault and disorder crimes per DA in Victoria ($p < 0.05$). At the location of each bar and pub we delineated a 200 m radius buffer and counted the amount of assault and disorder crime that fell within each establishment buffer. Since each city block was between 150 m to 200 m long, the 200 m buffer represented the 100 block address accuracy of the assault and disorder crime locations. Next we calculated the distance between a bar

or pub, and the closest bar or pub to that location. Using a scatter plot, we graphed the distance between the establishment and the nearest bar and pub (x-axis), against the count of violent and disorder around (200 m) each bar and pub (y-axis). From the association, we calculated a distance decay function (curve) to model the expected increase of assault and disorder crimes for every meter of distance between alcohol establishments (3rd order polynomial) [89]. The model fit was evaluated by the R^2 value, and standard error.

To identify a low-risk threshold for the proximity of bars and pubs we applied a change-point analysis on the establishment distance function to determine the threshold at which the count of assault and disorder crime around establishments significantly decreased (software: <http://www.variation.com/cpa/>). Other alcohol-crime research have used change-point regression to determine the distance at which crime no longer clusters around alcohol establishments [23]. Changes in crime frequency with distance between establishments were determined using a cumulative sum method. A significant change was flagged by comparing the cumulative sum of the difference between the assault and disorder crime frequencies at each distance lag compared to the average assault and disorder crime frequency around pubs and bars. Only large changes in assault and disorder crime frequencies with a probability of greater than 99% percent confidence of occurrence were identified. Significance was determined by performing 1000 bootstrap iterations of the assault and disorder crime frequency per establishment without replacement and recalculating the cumulative sum difference [90].

3. Results

3.1. Crime in Victoria

From 16 January 2015 to 29 May, 91 assaults and 158 disorder crimes occurred on Friday and Saturday nights. Crime peaked at 2:00 a.m. over Friday and Saturday (Figure 2), with the majority of violent and disorder crime located in the one downtown block group that is bordered by Belleville St. and Johnson St. and is south of Douglas St., encompassing the Wharf St. area (Figure 1). This block group has the highest density of bars in the area ($n = 5$), compared to all other block groups with a maximum of one bar. The spatial pattern of assault and disorder crime dissipated from the downtown center (Figure 1). The disproportionate amount of assault and disorder crime in the downtown area was likely influenced by the greater amount of bars and pubs and population in that area during the evening on the weekend.

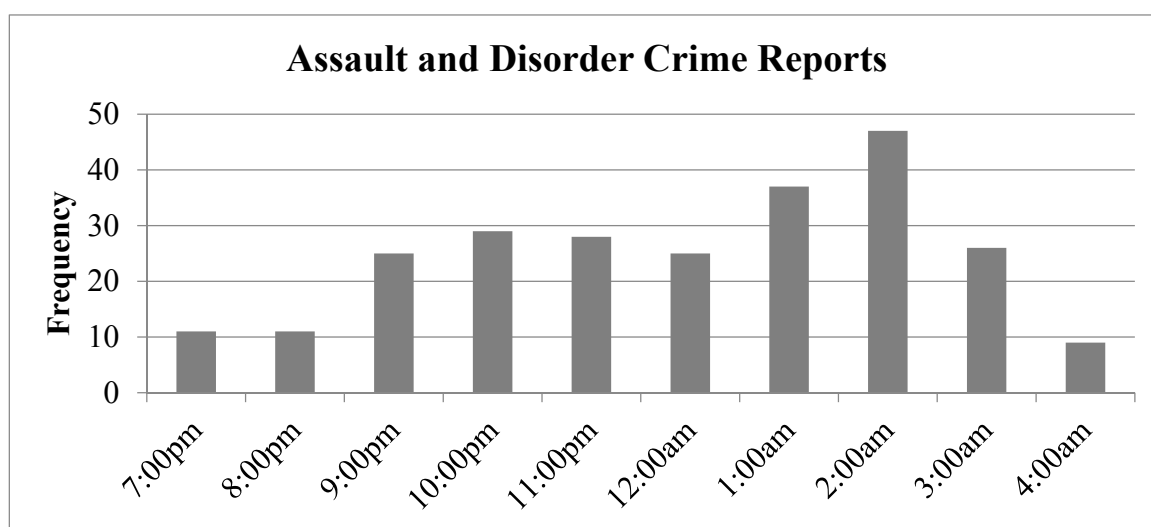


Figure 2. Frequency of violent and disorder crime reports between 7:00 p.m. and 4:00 a.m., Friday and Saturday nights from 16 January 2015 to 29 May 2016.

3.2. Model Validation

Our Spearman's rank correlation matrix indicated independence between the covariates used to estimate and predict alcohol-associated assault and disorder crimes. The highest correlation coefficient observed was 0.59 ($p < 0.05$) between no-child households and census total population; all other correlation coefficients were lower than 0.55, with the majority below 0.30. The results from our Poisson spatial lag model indicate that 76% of the variation in violent and disorder spatial distribution was explained by alcohol establishments and other covariates (See Figure 3 for a visual between the observed and predicted values). The chi-square goodness of fit test found no significant statistical difference between the deviance of our model and the maximum deviance of the ideal model where there is no difference between observed and predicted values ($p > 0.05$), indicating a good fit. Model errors had a median of zero a minimum error of -1.3 and a maximum error of 5. Residuals were randomly spatially distributed ($p < 0.05$), and therefore meet the aspatial and spatial independence criteria [83].

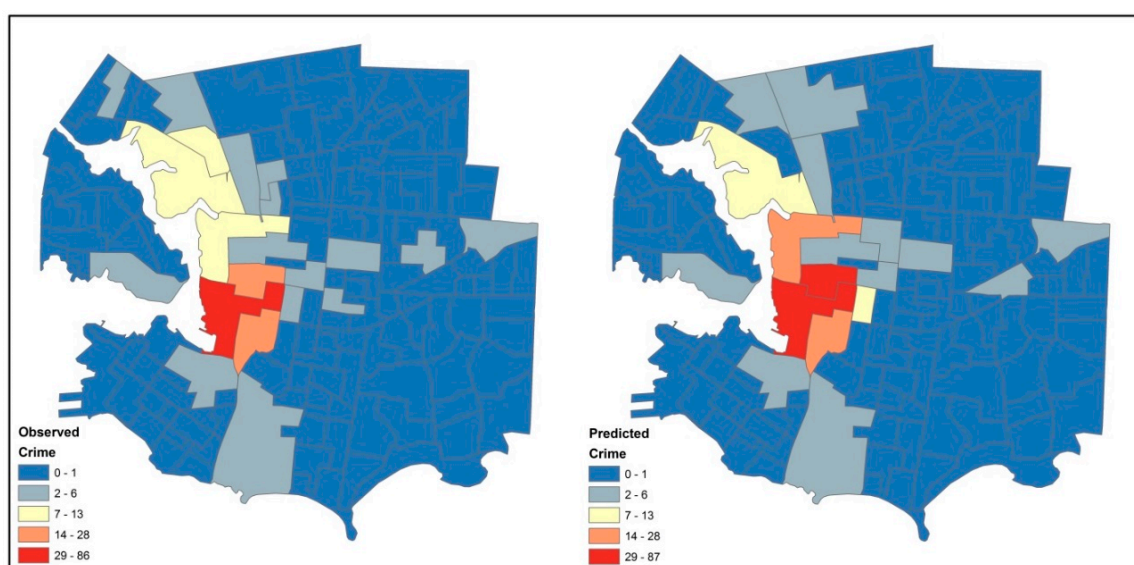


Figure 3. Observed and predicted counts of assault and disorder crime reports on Friday and Saturday nights, between 7:00 p.m. and 4:00 a.m. from 16 January 2015 to 29 May 2016.

3.3. Estimation Results

The seat density of bars and pubs within dissemination areas and in neighboring areas had a significant positive association with the count of assault and disorder crimes ($p < 0.05$, Table 2). Bars and pubs were found to increase assault and disorder crime by a factor of 1.0009 per patron seat. For every additional 1111 seats the assault and disorder crime frequency per block group would double over a 17 month period, holding all other variables constant (the average capacity for a bar or pub in Victoria is 219 patron seats). Bars and pubs in neighboring communities also increased the frequency of crime assault and disorder by a factor of 1.0007 ($p < 0.05$). Other significant ($p < 0.05$) contributing factors included the presence of needle exchange (1.9052), higher total bike commuters (1.0007), lower median age (0.9676), and a greater number of spoken languages (1.0099).

3.4. Distance Analysis

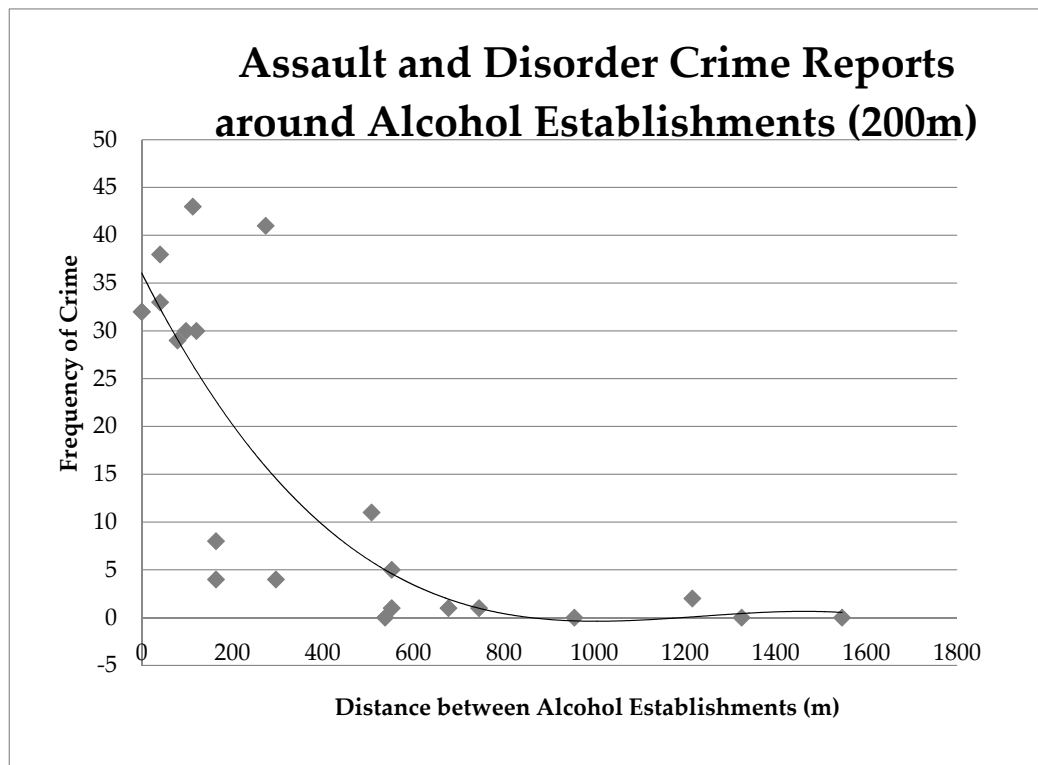
Distinguishing the association of bar and pub establishment proximity (x-axis) on assault and disorder crime within 200 m of each venue (y-axis) we identified a cubic function (Figure 4) as:

$$y = 3.060E + 001 + -8.080E - 002x + -8.080E - 002x^2 + -1.630E - 008x^3 \quad (1)$$

Table 2. Model estimates from the Poisson spatial lag model. Coefficients were evaluated at the $p < 0.05$ level.

Model Results						
	Estimate	Factor	Std. Error	z Value	α	Sig. Code
Intercept	0.6280	1.8739	0.83	0.75	0.45	
Lagged seat density of bars and pubs	0.0007	1.0007	0.00	4.94	0.00	***
Needle exchange locations	0.6446	1.9052	0.18	3.59	0.00	***
Total cyclists	0.0007	1.0007	0.00	3.06	0.00	**
Seat density of bars and pubs	0.0009	1.0009	0.00	1.96	0.05	*
Median age	-0.0330	0.9676	0.01	-2.29	0.02	*
Count of languages spoken	0.0098	1.0099	0.00	1.99	0.05	*
DA area	0.0000	1.0000	0.00	2.21	0.03	*
Seat density of on-premises licenses	0.0002	1.0002	0.00	1.65	0.10	
Lagged seat density of on-premises licenses	0.0000	1.0000	0.00	-1.76	0.08	
Count of off-premises licenses	0.1424	1.1530	0.13	1.11	0.27	
Population of 19 year-old to 24 year-old males	-0.0035	0.9965	0.01	-0.34	0.72	
Number of no-child households	0.0052	1.0052	0.01	1.02	0.31	
Average family size	-0.1053	0.9000	0.49	-0.21	0.83	
Count of street lights	-0.0023	0.9977	0.00	-1.32	0.19	
Zoning code	-0.1181	0.8886	0.14	-0.87	0.38	
Total census population	-0.0019	0.9981	0.00	-1.37	0.17	

Significance codes: 0 '***' 0.001 '**' 0.01 '*'.

**Figure 4.** Influence of bar and pub proximity (distance in meter) on the frequency of assault and disorder crime around bars and pubs.

Assault and disorder crime exponentially increased with the decrease in proximity to other establishments. The fitted curve explains 74% variance in crime frequencies around venues with a standard error of 11.63. Errors were larger at short distance between establishments, indicating a variance in crime around different establishments. Running change detection analysis, we found that overall bars and pubs that were within 300 m of each other had significantly more crime than establishments spaced greater than 300 m apart ($p < 0.05$). When bars and pubs were within 300 m, there were 29 crime incidents over a 17 month period, compared to two incidents when establishments were further apart.

4. Discussion

Our model contributes a greater level of detail than previous cross-sectional studies quantifying the connection between alcohol establishments and crime over multiple spatial units. While many other studies combined alcohol establishments types, conduct analysis over large spatial units, or count all establishments as having an equal influence on crime [10,29], we separate establishment categories, represent the variance in establishment size through patron capacity, and consider the spacing of alcohol establishments on assault and disorder crime potential. We provide the first low-risk threshold for allowable patron capacity of on-premises alcohol establishments, and the minimum spacing of venues to reduce alcohol-attributable assault and disorder crime.

We were able to distinguish variable effects between the count of off-premises, and the patron capacity of on-premises, establishment types. Between our off premises counts and on-premises patron capacity, we calculated an insignificant ($p > 0.05$), and low correlation (<0.30 correlation coefficient). These results show that congruent with other studies, our GLM model showed that bars and pubs have a greater factor increase on assault and disorder crime compared to off-premises licenses or other on-premises establishments [2,3,22,23,40,42–45]. The locations of bars and pubs within DAs, and in neighboring DAs units (lag), had a significant association with ($p < 0.05$) assault and disorder crime counts. In comparison, off-premises licenses and less risk on-premises licenses such as hotels, lounges, theatres, and sports clubs where drinking is not the primary activity, had no significant association (Table 2).

Accounting for varying sizes of on-premises venues, our model provides the expected factor increase in assault and disorder crime for every additional patron seat. The results indicate that an increase of 1111 seats would double assault and disorder crime rate within a DA, if other environmental factors remained constant. With an average patron capacity of 250, an additional four to five establishments could double assault and disorder crime in Victoria; therefore, policy officials should be cautious when allocating any new licenses. The addition of a multi-use alcohol establishment that houses a bar, nightclub, and dance floor with more than 1000 seats would cause a considerable spike (double) in assault and disorder crime.

Analyzing the effects of bars and pubs within DAs, our bivariate analysis indicated that on-premises establishments should be spaced greater than 300 m apart to reduce assault and disorder crime. This radius is larger than previous calculated thresholds at 152 m [22], and expands on the point of level crime-establishment studies [21–24] to quantifying the functional association between establishment proximity and crime frequency around venues. The equation can be extrapolated to predict how assault and disorder crime will increase over a 17 month period if a new liquor license is situated at a distance between 0 and 1500 m from another license.

Our results also support general crime potential theory, asserting that crime is a function of both population and place characteristics across spatial units [2]. In line with social disorganization theory, and previous alcohol establishment and crime research, we found that higher populated areas with lower socio-economic status moderate the crime-alcohol relationship [2,33,41,67,68,84,91,92]. Victoria DAs with lower median age, higher amount of languages spoken, and higher total population were significantly associated with the count of violent and disorder reports (Table 2). Total commuter count was also a significant predictor of assault and disorder crime compared to census residential

population count. This finding continues to support the use of dynamic over residential population counts when predicting crime [70].

We acknowledge some limitations with the present study. Research indicates that crime patterns are generally stable [93]; however, as place-characteristics that link crime to locations change, crime has the potential to shift over space and time. Our model provides a cross-sectional assessment of night-time assault and disorder crime after alcohol policy reform in Victoria British Columbia. To ensure results are robust, future analysis should incorporate data over a longer time-scale and see if the spatial and temporal distribution of assault and disorder crime remains consistent in the downtown core where alcohol establishments are at their highest density to show greater support for the negative association on-premises venues have with crime. A longer time frame, and therefore a larger sample, may allow assault and disorder crimes to be modeled separately, informing alcohol access policy on each.

It should also be noted that our model used patron capacity as a proxy for patronage. Patronage, however, is a multifaceted. We know from previous literature that crime occurs at a higher frequency inside and around certain alcohol establishments, more than others [22–24,28,47]. As such, the factor increase we calculated for bars and pubs (1.0009) within DAs, and bars and pubs in neighboring DAs (1.0007), may not stay constant in all regions. For example, the addition of an alcohol outlet in a region with a low density of establishments may cause overcrowding of patrons, whereas the addition of an outlet in a high density area may distribute the patron use, and effectively reduce crime risk by spacing people. Another factor to consider is the spacing of establishments. We know from our curve fitting procedure that larger errors in the amount of assault and disorder crime were found around establishments spaced less than 300 m apart (Figure 4). Errors indicate that some establishments in the bar and pub category presented a greater frequency of crime around their establishments than others. Therefore, studies that address the differences in the characteristics of bars and pubs, and patron use, on crime are still needed.

The quality of establishment distance analysis and modeling could also be improved by a greater accuracy in the location of crime reports. Assault and disorder crime reports were downloaded with a 100 block address limiting placement accuracy, and in turn limiting the size of the spatial units that we could use for modeling. Since the average 100 block in Victoria is 200 m long, we were limited in presenting any higher spatial accuracy. If assault and disorder crime were located at the x.y coordinate we could have predicted the crime across blocks, and may have had a greater confidence in allocating crime to each on-premises alcohol establishment when quantifying our low-risk distance threshold between establishments.

5. Conclusions

Crime followed an expected pattern where reports of violent and disorder offences peaked during the closing of on-premises locations (2:00 a.m.) and downtown blocks had the highest frequency of assault and disorder crime, which coincided with the highest number of bars per DA region. Bars and pubs were identified as the locations of assault and disorder risk. Both our spatial lag model and distance analysis found violence and disorder to increase around bars and pubs, especially when spaced less than 300 m from each other. Our coefficients (1.0009 and 1.0007) also indicated that the size of bars and pubs has an adverse effect on the level of assault and disorder crimes within DAs. To date, our study is the first to evaluate the association between assault and disorder crime and establishment patron capacity offering a fine level of spatial detail for evidenced-based alcohol license decision making at a time when alcohol policy reform is prioritized by British Columbia government. We offer low-risk guidelines (less than 1111 seats, and spaced greater than 300 m apart) for the evaluation of new alcohol establishment licenses in Victoria, and similar sized cities. Further studies are needed to validate the size and distance thresholds presented in this study. What we offer is information to support policy evaluation at a time when Canada has no official density limitations [50], and where municipal governments are left to make decisions about the placement of new liquor licenses.

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