

# The Association Between Density of Alcohol Establishments and Violent Crime Within Urban Neighborhoods

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**Background:** Numerous studies have found that areas with higher alcohol establishment density are more likely to have higher violent crime rates, but many of these studies did not assess the differential effects of type of establishments or the effects on multiple categories of crime. In this study, we assess whether alcohol establishment density is associated with 4 categories of violent crime and whether the strength of the associations varies by type of violent crime and by on-premise establishments (e.g., bars, restaurants) versus off-premise establishments (e.g., liquor and convenience stores).

**Methods:** Data come from the city of Minneapolis, Minnesota in 2009 and were aggregated and analyzed at the neighborhood level. Across the 83 neighborhoods in Minneapolis, we examined 4 categories of violent crime: assault, rape, robbery, and total violent crime. We used a Bayesian hierarchical inference approach to model the data, accounting for spatial auto-correlation and controlling for relevant neighborhood demographics. Models were estimated for total alcohol establishment density as well as separately for on-premise establishments and off-premise establishments.

**Results:** Positive, statistically significant associations were observed for total alcohol establishment density and each of the violent crime outcomes. We estimate that a 3.9 to 4.3% increase across crime categories would result from a 20% increase in neighborhood establishment density. The associations between on-premise density and each of the individual violent crime outcomes were also all positive and significant and similar in strength as for total establishment density. The relationships between off-premise density and the crime outcomes were all positive but not significant for rape or total violent crime, and the strength of the associations was weaker than those for total and on-premise density.

**Conclusions:** Results of this study, combined with earlier findings, provide more evidence that community leaders should be cautious about increasing the density of alcohol establishments within their neighborhoods.

**Key Words:** Alcohol Outlets, Violent Crime, Neighborhood.

NUMEROUS STUDIES HAVE assessed the relationship between the density of alcohol establishments and rates of violent crime with most finding that areas with higher alcohol establishment densities are more likely to have higher violent crime rates (e.g., Gorman et al., 2005; Gruenewald et al., 2010; Scribner et al., 2010). Many of these studies examined the combined effects of all types of alcohol establishments including on-premise establishments (e.g., bars, restaurants) and off-premise establishments (e.g., liquor

stores, grocery stores) (Britt et al., 2005; Gyimah-Brempong and Racine, 2006; Nielsen et al., 2005; Reid et al., 2003; Zhu et al., 2006), and most examined a single type of crime (e.g., assaults; Gruenewald et al., 2006; Liang and Chikritzhs, 2011; Livingston, 2008a,b; Nielsen et al., 2005) or total violent crime rather than individual types of crime (e.g., Britt et al., 2005; Gorman et al., 2001, 2005; Zhu et al., 2004, 2006).

One conceptual framework that has been used to explain the observed positive association between alcohol establishment density and violence is availability theory (Bruun et al., 1975; Gruenewald, 2007), which assumes that as alcohol becomes more available (i.e., another alcohol establishment is added to a census block, neighborhood, etc.), alcohol consumption increases with a subsequent rise in alcohol-related violence. Based on this theory, we would expect that both an increase in on-premise and off-premise establishments will lead to an increase in consumption and related violence because both would represent an increase in alcohol availability.

Gruenewald (2007) drew from several other theories to hypothesize an alternative mechanism that could explain the observed association between density of bars and violence. He hypothesized that a greater number of establishments within a small geographic area leads to more competition; and as a result, there is an increase in niche marketing where

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establishments specialize and cater to specific types of customers. Specific segments of customers are attracted to these different types of establishments (e.g., sports bars, wine bars, bars that play country music, etc.), resulting in a more homogenous clientele within establishments. An addition of establishments that appeal to primarily heavy drinking customers could lead to hot spots—in other words, establishments that contribute significantly to alcohol-related crime in the area surrounding it. If the increase in crime is a result of this segmentation of the customers rather than simply an increase in alcohol availability, we might expect to see a greater increase in crime resulting from a higher density of on-premise establishments—especially from a higher density of bars—than a higher density of off-premise establishments.

Although there may be differential effects by on-premise and off-premise density, only about half of the previous studies assessed effects of on-premise versus off-premise establishments separately and these have found inconsistent results. Of those examining the relationship between density of *on-premise* alcohol establishments and violent crime, about half found a positive relationship (Liang and Chikritzhs, 2011; Livingston, 2008a, 2011; Scribner et al., 2010) and the rest found no relationship (Franklin et al., 2010; Gorman et al., 2005; Livingston, 2008b; Scribner et al., 1999; Zhu et al., 2004). Consistent with the niche theory (Gruenewald, 2007), a few studies that examined effects of bar and restaurant density separately observed a positive association for *bar density* and violent crime (Gruenewald and Remer, 2006; Gruenewald et al., 2010; Lipton and Gruenewald, 2002); however, no studies found a positive association between *restaurant density* and violent crime (Gruenewald and Remer, 2006; Gruenewald et al., 2006, 2010; Lipton and Gruenewald, 2002). Similar to on-premise establishments, about half of the analyses examining the association between *off-premise* alcohol establishments and violent crime identified a positive association (Alaniz et al., 1998; Gorman et al., 2005; Gruenewald and Remer, 2006; Gruenewald et al., 2006, 2010; Livingston, 2008b, 2011; Scribner et al., 1999) and the remaining analyses found no relationship (Franklin et al., 2010; Liang and Chikritzhs, 2011; Lipton and Gruenewald, 2002; Livingston, 2008a; Scribner et al., 2010; Zhu et al., 2004).

In addition to assessing differences in associations by on-premise and off-premise density, it may also be important to assess differences across different types of crime. If establishment density increases crime through an increase in consumption resulting from greater alcohol availability, then we should expect to see comparable associations between alcohol establishment density and all types of alcohol-related crime. However, if the effect of establishment density is a result of segmentation of customers with the potential congregation of heavy drinking customers in certain establishments, we might expect to see higher associations between types of violent crime that are more likely to occur in and immediately surrounding these establishments (e.g., assaults) than other types of violent crime (e.g., rapes). Most of the

published studies, however, have focused on the association between establishment density and a single violent crime outcome, preventing this type of comparison (e.g., Gruenewald et al., 2006; Liang and Chikritzhs, 2011; Livingston, 2008a). In the current study, we assessed the association between establishment density (total, on-premise, and off-premise density) and multiple violent crime outcomes within the same city, enabling us to make comparisons of associations across different types of crime.

Along with assessing differential associations by on-premise and off-premise density and including multiple types of violent crime, this study also builds upon and expands the current research literature in several other ways. First, most of the previous studies used census blocks/tracts as units of analysis. Census blocks/tracts are small enough geographic areas that they can capture the variability in establishment density across communities and provide greater statistical power; however, few individuals identify with and organize at a census block/tract level. Within at least some cities, individuals identify with and gather at the neighborhood level to influence community policies that affect their neighborhoods (Lenk et al., 2002; Swindell, 2000). Hence, in this study, we use neighborhood as the unit of analyses. Only 1 previous study (Britt et al., 2005) used neighborhood as the unit of analysis. Second, unlike some of the earlier studies, we controlled for spatial autocorrelation. Geographic units, such as neighborhoods, may contribute to crime occurring in nearby units; thus, these geographic units may not be independent (Banerjee, 2004; Cliff and Ord, 1981). Failing to control for this spatial correlation could lead to a Type I error (i.e., erroneously concluding there is a statistically significant association). Third, this study was conducted in Minnesota, being one of the few alcohol density studies conducted in the Midwestern section of the United States (Britt et al., 2005; Gyimah-Brempong and Racine, 2006; Reid et al., 2003).

## MATERIALS AND METHODS

This 2-year study examined the associations between alcohol establishment density and multiple types of violent crime in neighborhoods in Minneapolis, Minnesota.

### *Neighborhoods*

We used neighborhood, as designated by the city of Minneapolis, as the geographic unit of analysis. Minneapolis has 87 neighborhoods as defined by the City. We included all of the neighborhoods except 4. Three neighborhoods were excluded because they were industrial areas with no residents. We also excluded 1 neighborhood that had a 96% decline in its population between 1990 and 2000 resulting from an urban renewal project, leaving 83 neighborhoods that we used in our analyses. Population size across these 83 neighborhoods ranged from 128 to 15,247 (mean = 4,607), with the percentage of the neighborhood population that is Caucasian ranging from 15.0 to 94.9%.

### *Alcohol Establishments*

In 2009, we obtained a list of 663 licensed alcohol establishments from the Minneapolis Department of Regulatory Services. We

identified and removed 40 duplicates, resulting in a final list of 623 establishments (503 on-premise establishments and 120 off-premise establishments). We geocoded addresses for the alcohol establishments using an address locator in ArcGIS and 2009 street address data from the Twin Cities Metropolitan Council; establishments were then assigned to neighborhood. Fourteen of the addresses did not have a 100% accuracy score; for these addresses, we used other sources (i.e., Google Maps, Bing Maps, etc.) to confirm the accuracy of the address and assign each establishment to a neighborhood.

We developed 3 alcohol establishment density measures: (i) total establishment density, (ii) on-premise establishment density, and (iii) off-premise establishment density. Because people move through their neighborhoods on roadway systems, we characterized alcohol establishment density based on these functional paths people take in their community—we calculated density as the number of establishments per roadway mile (Gruenewald et al., 1996; Lipton and Gruenewald, 2002). Our first step in calculating roadway miles was to remove alleys and freeway on/off ramps. Second, if a regular undivided road was on the border of 2 neighborhoods, we assigned the road equally to both neighborhoods. In our calculations, highways, freeways, and other divided roads were not double counted—in other words, they were treated the same way as undivided roads. For roads that crossed neighborhood boundaries, we assigned the part of the road that fell within a given neighborhood to that neighborhood. We obtained information about roadway miles from the Minnesota Population Center at the University of Minnesota.

### Crime

We obtained Uniform Crime Report Part I and Part II crime data from the Minneapolis Police Department (MPD) for the time period from October 1, 2008 to September 30, 2009 (the most recent data available at the time of data collection). This data set included the primary offense for each incident. We checked the accuracy of the address coordinates indicating the crime locations (e.g., latitude/longitude) by geocoding a subset of the crime incidents using an address locator in ArcGIS and 2009 street/address data from the Twin Cities Metropolitan Council. Because we found that the MPD address coordinates had a high level of accuracy (each coordinate was within 36 yards), we used these coordinates to assign crime incidents to the appropriate neighborhood when available. If a reported crime did not include coordinate information, we geocoded the address using the ArcGIS address locator. If an address for a crime fell outside the boundaries of Minneapolis, it was deleted from our final data set. Ninety-nine percent of the crime incidents were successfully mapped and assigned to a Minneapolis neighborhood. Crime incidents that fell on neighborhood boundaries were randomly distributed into neighborhoods that shared the boundary (1.04%).

For these analyses, we included 4 violent crime categories that previous research has shown to commonly be alcohol related (Markowitz, 2000; Martin, 2001): assault, rape, robbery, and a combination of Part I and Part II violent crime that includes homicide, assault, rape, robbery, malicious punishment of a child, sexual molestation, and abuse of a vulnerable adult. We considered assessing the association between alcohol establishment density and other specific crime categories (e.g., homicide) separately; however, the incidence was low (e.g., there were only 24 homicides in Minneapolis during that year and 75% of the neighborhoods did not have any homicides). Although we could not perform formal analyses on the association between homicide and alcohol establishment density, interestingly, many of the neighborhoods that had high homicide rates had fairly low alcohol establishment density (not controlling for any other measures).

### Neighborhood Demographics

Based on the work of previous studies (Kikuchi and Desmond, 2010; Morenoff et al., 2001), we created an index measuring neighborhood-level economic and racial characteristics that was based on composite measures used in similar studies. This composite index included 7 U.S. 2000 Census measures (we obtained all Census data from the City of Minneapolis at <http://www.ci.minneapolis.mn.us/citywork/planning/census2000/>): (i) percent female-headed households; (ii) percent rental housing units; (iii) percent of families below poverty; (iv) percent unemployment; (v) median household income; (vi) median home value; and (vii) percent white. These 7 variables were standardized (mean = 0, standard deviation = 1) and summed to create the index (range of index values: -13.14 to 10.688). The index had a high internal consistency, with an alpha coefficient of 0.87. We also included 2 other neighborhood demographic variables in our analyses: total persons aged 15 to 24 years and population density (total population divided by roadway miles). Percentage of males was also considered, but showed very little variability across neighborhoods and was not included in these analyses. A limitation of the study is that 2000 Census data were the best available at the time of our analyses.

When using neighborhood-level Census data, it is important to determine the level of misalignment between the boundaries of neighborhoods and Census block groups. We calculated this misalignment using ArcMap spatial analysis tools and found that most of the misalignment occurred primarily in industrial areas that did not have residents. Excluding these areas, we found misalignment in <1% of residential areas, suggesting there is negligible bias in our census estimates resulting from misalignment.

### Analyses

We used a Bayesian hierarchical inference approach to model the data using the OpenBUGS software package, Version 3.1.1 (Lunn et al., 2009). Unlike in a frequentist approach where model parameters are viewed as fixed but unknown values, the Bayesian approach views model parameters as random variables having prior distributions that reflect any preexisting information. Inferences are then based on the posterior distribution of all parameters, obtained by multiplying the prior by the data likelihood and restandardizing, a result known as Bayes' Rule. While in our analyses, we used only noninformative priors that permit the present data to fully determine the posterior, the Bayesian approach remains particularly well-suited here for properly acknowledging all sources of uncertainty (both spatial and nonspatial) in our hierarchical Poisson random effects model. For an overview on Bayesian statistical methods, see Carlin and Louis (2009).

We modeled crime counts from each neighborhood using a Poisson likelihood, where the expected number of crime incidents in the  $i$ th neighborhood is  $E_i \exp(\mathbf{x}_i' \boldsymbol{\beta} + \theta_i + \phi_i)$  where  $E_i$  is the number of crime incidents we would see in the  $i$ th neighborhood if crime was uniformly distributed across the city, calculated by multiplying the number of roadway miles in the neighborhood by the city-wide crime per roadway mile rate. In addition,  $\mathbf{x}_i$  denotes the vector of neighborhood-specific covariates,  $\boldsymbol{\beta}$  is a corresponding vector of coefficients, and  $\theta_i$  represents random (nonspatial) error. By contrast,  $\phi_i$  are random effects that capture the spatial autocorrelation between the neighborhoods using the conditionally autoregressive (CAR) model first used in this context by Besag and colleagues (1991).

We compared several modifications of our baseline model using the Deviance Information Criterion (DIC; Spiegelhalter et al., 2002), a hierarchical models generalization of the familiar Akaike Information Criterion (AIC). Like AIC, DIC is made up of 2 terms, one capturing model fit and the other a penalty for model complexity. Smaller DIC scores indicate preferred models, with

differences of more than 3 to 5 points normally thought of as indicating meaningful differences (Spiegelhalter et al., 2002). In our case, our spatial model had nearly the same DIC score as that of the standard nonspatial model, suggesting that statistically there was not an advantage of one model over the other. Given previous work in this area, however, we prefer the additional spatial smoothing provided by the spatial CAR model, which we adopt in all subsequent analyses.

Because the  $\beta$  coefficients can be challenging to interpret, we also calculated the percent increase in model-predicted violent crime associated with a 20% increase in alcohol density in a neighborhood of average establishment density. The densities in our model were first standardized to have mean 0 and standard deviation 1 and thus, we compute this percentage as 100 times the quantity:

$$\exp\left(\frac{0.2 \times \text{Mean (Density)}}{\text{SD (Density)}}\beta\right) - 1.$$

This is also the percent increase in crime that would be predicted to result from an increase in alcohol density in *any* neighborhood by 20% of the average alcohol density; that is, all that matters is the size of the increase, not the baseline rate. We also remark that these values vary widely across the total (mean 0.577, SD 0.925), on-premise (mean 0.471, SD 0.862), and off-premise (mean 0.106, SD 0.127) cases, because of the comparative rarity of off-premise establishments in our study area.

## RESULTS

Frequencies for alcohol establishments, crime incidents, and neighborhood demographics are shown in Table 1. On-premise establishments were more frequent and dense than off-premise establishments. Some neighborhoods had no establishments, several neighborhoods had more than 20 establishments, but the majority had between 1 and 20 establishments. Assaults and robberies were more common than rapes. Crime frequencies ranged widely by type of crime and across neighborhoods. Additionally, we saw a wide range of differences in demographic characteristics across neighborhoods.

Estimates and credible intervals for establishment density and each crime outcome are shown in Table 2. Positive, statistically significant associations were observed for total alcohol establishment density and each of the violent crime outcomes. Results were similar for estimates of the percent increase in each of the crime types resulting from a 20% increase in establishment density in a neighborhood with an average density, ranging from 3.9 to 4.3%. The estimated percent increase in crime was lower for violent crime combined (3.4%), although the relationship with this outcome and total alcohol establishment density was still statistically significant.

The associations between on-premise density and each of the individual violent crime outcomes were also all positive and statistically significant (Table 2). The strength of the associations across crime outcomes was very similar to those between total establishment density and each of the crime outcomes. Estimates for the percent increase in crime for a 20% increase in on-premise establishment density were

**Table 1.** Descriptive Statistics of Minneapolis Neighborhoods ( $n = 83$ )

	Mean (range) per neighborhood
<b>Number of crime incidents</b>	
Assault	21 (0–128)
Rape	4 (0–34)
Robbery	19 (0–97)
Total crime	53 (0–272)
<b>Number of alcohol establishments</b>	
On-premise	6 (0–118)
Off-premise	1 (0–9)
Total	7 (0–124)
<b>Density of alcohol establishments (per roadway mile)</b>	
On-premise	0.46 (0–5.5)
Off-premise	0.11 (0–0.57)
Total	0.56 (0–5.8)
<b>Neighborhood demographics</b>	
Female-headed households (%)	8% (0–27%)
Rental housing units (%)	41% (0–89%)
Families below poverty (%)	12% (0–43%)
Unemployment (%)	6% (1–27%)
White (%)	69% (15–95%)
Median household income	\$43K (12–103K)
Median home value	\$147K (59–563K)
Aged 15–24	817 (10–5,034)
Population density (population/roadway miles)	325 (16–784)

**Table 2.** Associations Between Alcohol Establishment Density and Violent Crime (Estimates and 95% Credible Intervals)

Crime outcomes	Alcohol establishment density	Increase <sup>a</sup> (%)
<b>Total establishments</b>		
Rape	<b>0.31 (0.16, 0.46)</b>	3.9
Robbery	<b>0.32 (0.17, 0.46)</b>	4.1
Assault	<b>0.34 (0.21, 0.47)</b>	4.3
Combined crime	<b>0.27 (0.16, 0.38)</b>	3.4
<b>On-premise establishments</b>		
Rape	<b>0.31 (0.16, 0.46)</b>	3.4
Robbery	<b>0.30 (0.16, 0.44)</b>	3.3
Assault	<b>0.34 (0.22, 0.47)</b>	3.8
Combined crime	<b>0.27 (0.16, 0.38)</b>	3.0
<b>Off-premise establishments</b>		
Rape	0.15 (–0.04, 0.33)	2.5
Robbery	<b>0.19 (0.04, 0.35)</b>	3.2
Assault	<b>0.17 (0.03, 0.31)</b>	2.9
Combined crime	0.11 (0.00, 0.23)	1.9

Control variables included in each model: population density, economic/racial index, and persons aged 15 to 24; Bold text, statistically significant at the  $p < 0.05$  level.

<sup>a</sup>Percent increases corresponding to a 20% increase in density in a neighborhood with average density.

slightly lower than for total establishment density (3.3 to 3.8%). Again, the association between on-premise density and all violent crime combined was slightly lower than for the individual crime types, but still statistically significant.

The relationships between off-premise density and the individual crime outcomes were all positive, but they were not all statistically significant (Table 2). The association was not statistically significant for rape or the combined violent crime outcome. The strength of the associations for robbery and assault was weaker than the associations between these

outcomes and total establishment density and on-premise density.

## DISCUSSION

We found that overall alcohol establishment density was positively associated with violent crime, indicating that neighborhoods with more alcohol establishments tend to have more assault, rape, robbery, and overall violent crime than neighborhoods with fewer alcohol establishments. The association between establishment density and violent crime was stronger and more consistent for on-premise establishments than off-premise establishments. And we found similar results for total alcohol establishment density and on-premise establishment density, which may not be surprising given that most establishments in this city are on-premise rather off-premise establishments. Our findings are similar to those from several earlier studies (e.g., Franklin et al., 2010; Gorman et al., 2005; Gyimah-Brempong and Racine, 2006; Livingston, 2008a,b).

A higher density of alcohol establishments means more availability of alcohol. Many studies show that as we increase availability of alcohol (e.g., through an increase in the hours that alcohol can legally be sold, a decrease in the price of alcohol, etc.), we see an increase in crime and other alcohol-related problems (Babor et al., 2003; Elder et al., 2010; Middleton et al., 2010). However, the stronger and more consistent associations between on-premise establishment density and violent crime provide support for the niche theory (Gruenewald, 2007) that the association between alcohol establishment density and crime may not be driven simply by the increased availability of alcohol in a neighborhood, but rather the specialization of on-premise establishments and subsequent segmentation of customers.

Further supporting the niche theory (Gruenewald, 2007), although the strength of the associations was fairly similar across crime categories within the stratum (on-premise, off-premise, total establishment density), the association was consistently highest between establishment density and assaults. Assaults may be more likely than other types of violent crime to occur in and near establishments.

The results of this study contribute to the growing literature on the relationship between alcohol establishment density and crime. The Task Force on Community Preventive Services (<http://www.thecommunityguide.org/alcohol/outletdensity.html>) has recommended "...the use of regulatory authority (e.g., through licensing and zoning) to limit alcohol outlet density on the basis of sufficient evidence of a positive association between outlet density and excessive alcohol consumption and related harms." The results of this study suggest that a greater density of either on-premise or off-premise establishments is associated with higher levels of at least some types of violent crime. However, neighborhood leaders may need to be especially cognizant of the potential risks of adding on-premise alcohol establishments within their neighborhoods. Assuming the observed associations are primarily

the result of the specialization of alcohol establishments and the resulting segmentation of customers, more research is needed to determine what specific types of establishments provide the greatest risk for increasing violence when added to a neighborhood.

Given that this was a cross-sectional study and the fact that the time periods for the alcohol establishment data and the crime data did not completely overlap, we cannot conclude that an increase in alcohol establishment density in a neighborhood will lead to an increase in violent crime; it is possible that there is another, unidentified neighborhood characteristic that confounds this association. Another limitation of this study is that the police report data only included incidents of crime that were reported to police and only the primary offenses were included in the database. Both of these limitations could lead to an underestimation of crime across neighborhoods; however, it is unlikely that these underestimations differ substantially across neighborhoods. Additionally, not all of the crime incidents involved alcohol; inclusion of crime incidents that are not alcohol involved may reduce the observed association between crime and alcohol establishment density. Because the study was conducted in only 1 metropolitan area and at the neighborhood level, generalizability of study findings may be limited. However, many previous studies also have been conducted in 1 metropolitan area using various units of analysis (e.g., Franklin et al., 2010; Gorman et al., 2005; Scribner et al., 1999) and the combined results across these different regions provide confidence that the results can be generalized to other geographic areas. Finally, we did not control for potential edge effects of alcohol establishments located in other communities near the Minneapolis border; however, this is likely not a significant limitation because of a limited number of alcohol establishments near Minneapolis borders.

Despite these limitations, this study contributes to the research literature assessing the association between alcohol establishment density and violent crime. Similar to other studies, we observed a positive association between total establishment and on-premise density and multiple violent-crime outcomes. Results were less consistent for off-premise density. This study builds on previous studies by including several violent crime outcomes, assessing on- versus off-premise and total establishment density, controlling for geospatial autocorrelation, and using advanced Bayesian analytical methods. Results of this study, combined with earlier findings, provide more evidence that community leaders should be cautious about increasing the density of alcohol establishments within their neighborhoods.

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