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Outlet Type, Access to Alcohol, and Violent Crime

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Abstract

Background: While there is overwhelming data supporting the association between alcohol outlet density and violent crime, there remain conflicting findings about whether on- or off-premise outlets have a stronger association. This inconsistency may be in part a result of the methods used to calculate alcohol outlet density and violent crime. This analysis uses routine activity theory and spatial access methods to study the association between access to alcohol outlets and violent crime, including type of outlet and type of crime in Baltimore, Maryland.

Methods: The data in this analysis include alcohol outlets from 2016 (n=1,204), violent crimes from 2012–2016 (n=51,006), and markers of social disorganization, including owner-occupied housing, median annual household income, drug arrests, and population density. The analysis used linear regression to determine the association between access to alcohol outlets and violent crime exposure.

Results: Each 10% increase in alcohol outlet access was associated with a 4.2% increase in violent crime exposure (β=0.43, *95% CI* 0.33, 0.52, p<0.001). A 10% increase in access to off-premise outlets (4.4%, β=0.45, *95% CI* 0.33, 0.57, p<0.001) and LBD-7 outlets (combined off- and on-premise outlets) (4.2%, β=0.43, *95% CI* 0.33, 0.52, p<0.001) had a greater association with violent crime than on-premise outlets (3.0%, β=0.31, *95% CI* 0.20, 0.41, p<0.001).

Conclusions: Access to outlets that allow for off-site consumption had a greater association with violent crime than outlets that only permit on-site consumption. The lack of effective measures to keep order in and around off-premise outlets could attract or multiply violent crime.

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Keywords

Alcohol outlet density; violent crime; spatial access

Introduction

Alcohol-attributable violence is a significant public health problem. It is more common than drink driving crashes in the United States (US) (Wintemute, 2015). Every day, there are 43 homicides in the US, and excessive drinking (e.g., binge drinking, heavy drinking) is responsible for 20 of them (Centers for Disease Control and Prevention, 2015). Alcohol plays a role in both violence perpetration and victimization (Boles and Miotto, 2003, Rehm et al., 2009), likely through alcohol's disinhibiting effects that can make people more likely to perpetrate an attack as well as less physically or mentally capable of resisting an attack. Two out of five homicide victims test positive for alcohol (Naimi et al., 2016), and women who average six or more drinks per drinking day are more likely to become a sexual assault victim than women who did not drink (Bryan et al., 2016). Alcohol-attributable violence also carries a large price tag; crimes that resulted from excessive drinking cost the US $36.7 billion in 2010 (Sacks et al., 2015).

Research demonstrates that violent crimes are associated with greater access to alcohol outlets (Campbell et al., 2009b, Popova et al., 2009a), including a recent systematic review that only included time series studies of off-premise outlets (Sherk et al., 2018). However, the literature is not as conclusive on whether on-premise outlets (e.g., bars) or off-premise outlets (e.g., liquor stores) have a stronger association with violent outcomes. If the role of alcohol outlets in the generation of violent crime truly differs by outlet type, then local jurisdictions may want to tailor the rules for outlet locations and operations based on the type of outlet. The number of opportunities to regulate outlets also differs by outlet type. There are more opportunities to regulate on-premise outlets than off-premise outlets. Local jurisdictions can regulate staff service practices and settings in which patrons interact while they are consuming alcohol. In contrast, off-premise outlets tend to have a smaller staff and no control over environments where the drinking occurs. Routine activity theory may help researchers further understand the unique roles of on- and off-premise outlets in neighborhood-level violent crime,

Routine activity theory is an ecologic model that describes how places bring people together in ways that create or suppress opportunities for violent crime. The theory is based on the idea that crime occurs in times and locales where motivated offenders are in close proximity to susceptible targets and supervision is low (Felson, 2006). From this perspective, alcohol outlets are hypothesized to be associated with violent crime because they are often located in areas with reduced guardianship, like retail districts (Gruenewald et al., 2006). Specific neighborhood types may also be associated with violent crime, because socially disorganized neighborhoods rarely have responsible supervisors (Felson and Eckert, 2016). Markers of socially disorganized areas like abandoned buildings facilitate crime by providing settings for motivated offenders to meet and help each other escape after the crime. From this perspective, it is important to take levels of social disorganization and

social cohesion into account in studies of alcohol outlet access. Further, alcohol consumption can often be a “precriminal situation,” increasing both offender motivation and target susceptibility (Felson and Eckert, 2016, Freisthler et al., 2004, Gruenewald et al., 2006).

Alcohol outlets themselves may have criminogenic properties, and these properties may differ by outlet type. One way that outlet types could shape criminogenic properties is through the types of place managers they employ. Place managers prevent crime by controlling the physical environment (Felson and Eckert, 2016). They tend to be most effective when they are in close proximity to and have unobstructed view of potential offenders and have a sense of duty to maintain order in the establishment (Felson and Eckert, 2016). In on-premise establishments, waitresses, bartenders, bouncers, and disc jockeys can all serve as place managers, as these people tend to be in close proximity to patrons for the duration of the time that the patron drinks in the establishment (Livingston, 2011, Cunradi et al., 2011, Snowden, 2016). In such circumstances, outlet staff may use de-escalation techniques or ask patrons to leave if violence begins to spark. However, some on-premise outlets may serve as crime generators if they have staff or environments that make it easier for offenders to commit a crime, such as bartenders who serve alcohol to minors or serve past intoxication, bringing people together who otherwise would not interact, poor lighting, and/or locations in high-density areas that produce streams of suitable targets at closing time (Felson and Eckert, 2016).

Place managers in off-premise outlets (e.g., sales clerks) have a more limited role as they often only observe patrons briefly at the point of sale. Alcohol is also less expensive at off-premise outlets, and patrons can buy greater quantities (Schonlau et al., 2008, Connor et al., 2011, Livingston et al., 2008). The physical design of off-premise outlets can also limit place managers’ effectiveness, because these outlets often have plexiglass barriers separating place managers from patrons (Branas et al., 2009). In addition, off-premise outlets may be adjacent to alleys or parking lots that can also act as de facto bars/taverns without any place managers at all (Grubesic and Pridemore, 2011).

In line with these hypotheses, most cross-sectional studies that compare on- and off-premise outlets have found a stronger association between off-premise alcohol outlets and violent crime overall (i.e., homicide, aggravated assault, sexual assault, and robbery) (Gorman et al., 2005, Lipton et al., 2013), and separately, assault (Pridemore and Grubesic, 2012b, Grubesic et al., 2013, Gruenewald et al., 2006) and robbery (Snowden and Freiburger, 2015). Using cross-sectional data from Baltimore City, Jennings et al. (2014) found that each additional off-premise alcohol outlet in a census tract was associated with a larger increase in violent crime than on-premise outlets (Jennings et al., 2014). Pridemore & Grubesic (2012) in Cincinnati found stronger cross-sectional associations between violent crime and off-premise outlets compared to bar and restaurant availability (Pridemore and Grubesic, 2012a). In Philadelphia, the same authors found that off-premise outlets had a cross-sectional association six times stronger than the association with on-premise outlets on assaults (Grubesic et al., 2013).

The differences in location of consumption at on- and off-premise outlets present an inherent measurement problem in quantifying harms more broadly, and specifically, quantifying the association with violent crime. Harms tend to occur near the location of consumption. Patrons drink on-site in on-premise outlets. However, patrons of off-premise outlets may purchase alcohol, consume it at home or at some other location distant from the point of purchase, and then commit a violent act. Others may consume the alcohol close to the point of purchase and end up committing a violent act near the outlet (Grubesic and Pridemore, 2011). This is known as “diffusion bias,” and it suggests that researchers may need to use the most sensitive methods possible to detect the nuanced spatial relationships between alcohol outlets and related harms (Morrison et al., 2016, Cameron et al., 2016b).

Even if the associations tend to be larger for off-premise outlets overall, routine activity theory hypothesizes that some on-premise outlets contribute to violent crime, and the literature supports this. A cross-sectional study by Roncek & Maier (1991) investigated the role of one type of on-premise outlets - bars/taverns by city block in Cincinnati and found that each additional bar/tavern on a block was associated with a 17.4% increase in violent crime (Roncek and Maier, 1991). Further, a longitudinal study of the Buckhead area in Atlanta, Georgia found that decreases in on-premise alcohol outlet density were associated with proportional decreases in violent crime (Zhang et al., 2015).

It is possible that the studies finding a greater association between on-premise outlets and violent crime (Lipton and Gruenewald, 2002, Toomey et al., 2012, Morrison et al., 2016, Gruenewald et al., 2006, Mair et al., 2013, Gruenewald and Remer, 2006) suffer from methodological weaknesses. For example, two longitudinal studies (Mair et al., 2013, Gruenewald and Remer, 2006) and one cross-sectional study (Gruenewald et al., 2006) that concluded a stronger association between violent crime and on-premise outlets used the victim’s residential address instead of the location of the assault (Gruenewald et al., 2006, Mair et al., 2013, Gruenewald and Remer, 2006). Another cross-sectional study that failed to detect an association between off-premise outlet availability and violent crime may have been underpowered to detect off-premise associations because the study area had few off-premise outlets (Toomey et al., 2012). Lastly, the findings from a longitudinal study from the North Island of New Zealand demonstrated larger associations for bar and clubs than off-premise outlets might be attributable to the large unit of analysis – census area units – which have a maximum of 5,000 residents and approximately correspond to suburbs in urban areas (Cameron et al., 2016a).

In addition, all of these previous studies used count-based methods of measuring alcohol outlet availability, whether they were raw counts (Gruenewald and Remer, 2006) or weighted by population (Cameron et al., 2016a), area (Mair et al., 2013), or roadway miles (Lipton and Gruenewald, 2002, Toomey et al., 2012, Gruenewald et al., 2006). Recent guidance (Sacks et al., 2016) and analyses (Grubesic et al., 2016) highlight the limitations of count-based methods to measure spatial effects of alcohol outlets. In particular, counts are less sensitive (Grubesic et al., 2016), contain more systematic error than other methods (Trangenstein et al., 2018), and treat alcohol outlets as if they were evenly distributed within the geographic unit of analysis (Sacks et al., 2016). This assumption is problematic when investigating the role of alcohol outlets in violent crime, because alcohol outlets often

concentrate in clusters and clustering is associated with violence (Grubesic and Pridemore, 2011, Gorman et al., 2013, Zhang et al., 2015). Distance-based and spatial access methods are alternatives to count-based methods, and recent literature and guidance recommends spatial access methods to overcome these limitations (Sacks et al., 2016, Grubesic et al., 2016). Spatial access methods combine information about the number and locations of alcohol outlets to simultaneously measure availability and accessibility of alcohol outlets (Guagliardo, 2004). While spatial access methods encompass a broad set of tools, one common approach is to calculate a spatial accessibility index (SAI) by summing the inverse distances from a reference point to a set of alcohol outlets. This SAI can then be interpreted as a score that quantifies the access to alcohol outlets and discounts outlets that are farther away.

The objectives of this study were to determine 1) the overall association between alcohol outlet spatial access and violent crime in Baltimore City, Maryland from 2012–2016; 2) whether three specific types of alcohol outlets – on-premise, off-premise, and LBD-7 (outlets permitted to sell both on and off premise) – are associated with violent crime; and 3) whether specific outlet types are associated with specific types of crime including homicide, aggravated assault, sexual assault, and robbery. Based on routine activity theory, we hypothesize that greater exposure to off-premise outlets will have a stronger association with violent crime exposure than on-premise outlet exposure. This study uses spatial access methods to overcome common limitations of previous research. Of note, interpretations for spatial access methods are different from those for traditional count-based methods that model alcohol outlet availability and number of violent crimes or violent crime rates. In particular, our alcohol outlet variables measure alcohol outlet *access*, and our violent crime variables measure violent crime *exposure* in a CBG. In the final models, we controlled for neighborhood factors including percent African American, owner-occupied housing, median annual household income, population density, and drug arrests.

Materials and Methods

Geographic Unit of Analysis.

This analysis uses 2010 census block groups (CBGs) as the unit of analysis, which is the smallest geographical unit for which the United States Census Bureau publishes unrestricted data. Baltimore has 653 CBGs. Fifty-four (8.3%) CBGs did not have available income data due to the following: three (0.5%) had no residents and the other 51 (7.8%) were suppressed. The final study sample included 599 CBGs. The 599 CBGs ranged from 0.02 to 1.01 square miles (mean: 0.11 mi^2) and contained between 141 and 3,828 residents (mean: 983 residents).

Measures

Alcohol Outlets.—Data were obtained from the Board of Liquor License Commissioners for 1,218 licensed alcohol establishments as of June 4, 2016 (liquor licenses are valid from April to March each year). Maryland state law prevents alcohol outlets from being located within 300 to 500 feet (depending on the legislative district) from a church or a school (§9–204.3.) (Maryland Code). Recently approved regulations add that alcohol outlets may not

open or relocate within 300 feet of an existing alcohol outlet (except downtown) (§ 14–336) (City of Baltimore, 2017). Fourteen establishments (1%) were excluded due to limited days or hours of sale, including Pimlico Race Track (n=1), Baltimore Zoo (n=1), arenas (n=7), and municipal licenses (n=5). This resulted in a final list of 1,204 establishments: 519 (43%) on-premise outlets, 264 (22%) off-premise outlets, and 421 (35%) LBD-7 outlets. The last license type is unusual. The LBD-7 has the longest opening hours (6AM-2AM) and most days of sales (7), and license holders are permitted to both serve alcohol on premise and to sell package goods for off-premise consumption. It is the most common license type in Baltimore City (n=421). Table 1 summarizes the license types included in each of these four variables as well as the hours and days of sale for each license type. The addresses for these 1,204 outlets using an address locator in ArcGIS and StreetMap 2013. We were able to geocode 99% of the alcohol outlets.

Four spatial accessibility indices (SAIs) were calculated to measure the spatial access of alcohol outlets using an inverse distance total, including: 1) Total alcohol outlet spatial access, 2) On-premise outlet spatial access, 3) Off-premise outlet spatial access, and 4) LBD-7 outlet spatial access. Previous work found that a SAI choice set size of 10 outlets were able to detect clustering. Thus, we calculated each SAI by summing the inverse distance from each CBG centroid to the 10 nearest outlets (Sacks et al., 2016). We did not restrict distance to the CBG borders to find the 10 closest outlets, and a set size of 10 outlets will smooth over three CBGs on average (Trangenstein et al., 2018). The final SAIs measured the exposure of CBGs to alcohol outlets and weighted alcohol outlets that are located closer to the CBG centroid more heavily than those that were further away. The alcohol outlet SAIs were transformed using the natural logarithm in order to adjust for positive skew.

Violent Crime

We obtained victim-based violent crime, which includes the location of the crime for reported crimes, from the Baltimore Police Department. The violent crime data were from January 1, 2012 through December 31, 2016, and the drug arrest data were from January 1, 2016 through December 31, 2016. We used five years of violent crime data to ensure sufficiently large sample sizes to stratify the outcome by type of crime. Violent crime was defined using the Federal Bureau of Investigation (FBI's) Uniform Crime Reporting (UCR) definition: homicide, forcible sexual assault, aggravated assault, and robbery (Federal Bureau of Investigation, 2016). All of these crimes involve force or threat of force (Federal Bureau of Investigation, 2016).

We also created SAIs to generate an index of violent crime exposure. The ideal choice set sizes for violent crime were different than for alcohol outlets because there are more violent crimes than alcohol outlets in Baltimore CBGs. Previous research concluded that the choice set size for violent crimes should equal roughly the median number of crimes in the CBG (Trangenstein et al., 2018). The median CBG contained 62 violent crimes, 30 aggravated assaults, 1 sexual assault, 1 homicide, and 25 robberies. We increased the choice set sizes for sexual assault and homicide to 10 so the SAIs would be able to detect clustering. Thus, the final choice set sizes were 62 total violent crimes, 10 homicides, 30 aggravated assaults, 10

sexual assaults, and 25 robberies. Like the alcohol outlet SAIs, we calculated the violent crime SAIs by summing the network inverse distance from each CBG centroid to the N closest violent crime types, where N is the choice set size for the particular type of crime. All violent crime exposure SAIs and the drug arrest count variable were transformed using the natural logarithm to adjust for positive skew and mitigate the effect of outliers.

Covariates

We selected covariates using routine activity theory and previous empirical research. We had two sets of these contextualizing variables, including those for the bivariate analyses that examine the types of Baltimore neighborhoods that have higher access to alcohol outlets and regression coefficients that determine the association between alcohol outlet access and violent crime exposure. These variables included percent African American, median annual household income, percent female-headed households, percent of families living in poverty, percent owner-occupied housing, percent of adults with a college degree, percent owner-occupied housing, population density and drug arrest counts. Lower levels of owner-occupied housing are anticipated to increase the risk of violent crime because renters tend to be less invested in the social control of the neighborhood, which can undermine social cohesion (Felson, 2006). From a routine activity perspective, this means areas with more renters will have fewer invested place managers. In addition, areas with high population density and low median household incomes tend to have higher levels of violent crime and suffer greater effects of high concentrations of alcohol outlets (Mair et al., 2013). Lastly, we used percent African American, because African Americans tend to drink less than people of other races (Substance Abuse and Mental Health Administration, 2017). As it is important to account for social disorganization, four variables were combined into a social disadvantage index as follows:

([(% female-headed households/10) + (% families living in poverty/10)] – [(% owner-occupied housing/10) + (% adults aged 25 years or older with college degree/10)]) / 4

The social disadvantage index is designed so each unit increase corresponds to a 10% increase in the two disadvantage items (i.e., female-headed households and families living in poverty) and a 10% decrease in the two advantage items (i.e., owner-occupied housing and adults with college degree) (Ross and Mirowsky, 2001). Socio-demographic variables at the CBG level were obtained from the American Community Survey (ACS) 2016 five-year estimates and drug arrest counts were obtained from the BPD.

We used percent African American, income, and the social disadvantage index in the bivariate analyses, because these were anticipated to describe the community context for areas with higher or lower alcohol outlet access. Regression covariates included percent African American, percent owner-occupied housing, median annual household income, population density, and number of drug arrests. ACS censored median annual household income at $250,000 per year, and we scaled it so a one-unit increase represented an additional $10,000. We also scaled and log transformed the drug arrest variable so each unit increase represented the natural log of 10 drug arrests. The means, standard deviations, and minimum and maximum values are shown in Table 2.

Analyses.

As a part of exploratory analyses, we created choropleth maps to examine the distribution of alcohol outlet and violent crime exposure. Student t-tests with unequal variances were used to compare spatial access by outlet type and demographic characteristics to describe the types of neighborhoods that have higher or lower access to alcohol outlets. In particular, we compared areas of high African American populations (≥50% African American), low-income areas (<$25,000 median annual household income), high-income areas (≥$75,000 median annual household income), disadvantaged areas (social disadvantage <−3.77 [lowest quartile]), and advantaged areas (social disadvantage > 0 [upper quartile]).

Multiple linear regressions with robust standard errors were used to determine the association between spatial access of alcohol outlets and violent crime exposure at the CBG level. Model 1 included the total alcohol outlet SAI and the total violent crime SAI. Models 2 through 5 examined the association between total violent crime exposure and each outlet type, and models 6 through 9 tested the associations between all outlet types and homicide, aggravated assault, sexual assault, and robbery separately. All non-significant regression covariates were removed to yield the most parsimonious model. We assessed collinearity using correlations between regression coefficients and variance inflation factors. The three alcohol outlet SAIs were correlated, but all VIFs were less than three, indicating that they provided stable estimates.

We used Moran's Index (Moran's I) to measure spatial dependence among the violent crime exposure indices and as a diagnostic check for residual spatial variation. We added spatial lag terms for the alcohol outlet SAIs to see if they accounted for additional residual spatial variation and if the alcohol outlet spatial access in adjacent CBGs was associated with the violent crime exposure index. These terms did not account for any additional spatial dependence and were excluded from the final models. The residual spatial variation was small (Moran's I 0.04–0.15), and the regression coefficients for the alcohol outlet SAIs were highly significant. Thus, the results of this analysis are approximately correct. We used traditional diagnostic procedures during the regression fitting process, including leverage, Cook's distance, and studentized residuals. In the end, we concluded that no CBGs had an undue influence on the regression results, and all 599 CBGs remained in the analysis.

Results

Table 2 presents descriptive analyses for Baltimore City in 2016 by CBGs, and Figure 1 presents choropleth maps showing the distribution of alcohol outlet and violent crime exposure. Overall, a substantial number of CBGs, particularly those in north Baltimore and near city borders, had low spatial access of alcohol outlets and violent crime. Violent crime exposure tends to concentrate in downtown Baltimore City (near the city center); the highest violent crime exposures are in a band that extends 1.5 miles north and 2.5 miles to the east and west of downtown. When looking at specific types of violent crime, exposure to aggravated assaults (mean SAI=5,443.5) was notably higher than robberies (mean SAI=1,615.7), homicide (mean SAI=1,044.5), and sexual assault (mean SAI=44.84). Homicides concentrate along the edge of industrial areas in West Baltimore, particularly in CBGs approximately two miles west and northwest of downtown Baltimore. Aggravated

assault, sexual assault, and robbery exposure tend to concentrate in the city center, with aggravated assaults and sexual assaults having slightly higher exposure in South Baltimore and robbery having greater exposure along the Inner Harbor (an entertainment zone).

Spatial access of on-premise and LBD-7 outlets distributes similarly across Baltimore City. Spatial access of LBD-7 outlets (mean SAI=20.4) was slightly higher than spatial access of on-premise outlets (mean SAI=18.4) or off-premise outlets (mean SAI=18.9) overall. Spatial access of on-premise and LBD-7 outlets tended to cluster along the I-83 corridor (a highway that roughly separates east and west Baltimore) and Inner Harbor, though LBD-7 spatial access also extended into West Baltimore. The spatial access of on-premise (SAI 13.28 vs. 29.38, $p<0.001$) and LBD-7 outlets (SAI 16.80 vs. 28.01, $p<0.001$) was higher in areas where the residents were not predominantly African American (SAI 16.80 vs. 28.01, $p<0.001$ -- see Table 3). In contrast, off-premise outlet spatial access was high along the highway corridor that separates East and West Baltimore and two miles west of this corridor, and it was low along the Inner Harbor. These differences in how on-premise and LBD-7 outlets were distributed compared to off-premise outlets occurred along economic lines. On-premise (SAI 29.06 vs. 16.99, $p<0.001$) and LBD-7 outlets (SAI 32.12 vs. 18.79, $p=0.001$) had higher spatial access in high-income areas, while off-premise outlets had higher spatial access in low-income areas (SAI 23.84 vs. 17.82, $p<0.001$). On-premise and LBD-7 outlets were also less likely to have high access in areas of the most advantage or disadvantage. Of the four measures included in the social disadvantage index, on-premise outlets had higher access in areas with high education (SAI 25.25 vs. 11.15, $p<0.001$, data not shown), low poverty (SAI 24.38 vs. 16.47, $p<0.01$), and low percentages of female-headed households (SAI 33.11 vs. 13.80, $p<0.001$) but lower access in areas with high home ownership (SAI 13.77 vs. 20.04, $p<0.01$). LBD-7s had higher access in area with high education (SAI 23.19 vs. 14.88, $p<0.001$) and low percentages of female-headed households (SAI 29.61 vs. 17.34, $p<0.001$).

Table 4 presents results from the first linear regression model, which examined the association between access to all alcohol outlets and total violent crime exposure. In this regression, a 10% increase in the alcohol outlet SAI was associated with a 4.2% increase in total violent crime exposure ($\beta=0.43$, 95% CI 0.33, 0.52, $p<0.001$).

The results of models 2–4, which examined the association of types of outlets on total violent crime exposure, are presented in Table 5. Models 2–4 show that spatial access of the three types of alcohol outlets independently has a significant association with violent crime exposure. A 10% change in the on-premise SAI was associated with a 3.0% increase in total violent crime exposure ($\beta=0.31$, *95% CI* 0.20, 0.41, $p<0.001$). For off-premise outlets, a 10% increase in access was associated with a 4.4% increase in total violent crime exposure ($\beta=0.45$, *95% CI* 0.33, 0.57, $p<0.001$). A 10% increase in LBD-7 access was associated with a 4.2% ($\beta=0.43$, *95% CI* 0.33, 0.52, $p<0.001$) increase in total violent crime. Model 5 considers all three types of alcohol outlets simultaneously. In this model, only access to off-premise ($\beta=0.23$, *95 CI* 0.10, 0.37, $p<0.01$) and LBD-7 outlets ($\beta=0.36$, *95% CI* 0.21, 0.51, $p<0.001$) remained significant. After adjusting for off-premise and LBD-7 spatial access, on-premise spatial access no longer had a significant association with total violent crime exposure ($\beta=-0.05$, *95% CI* −0.22, 0.12, $p=0.57$).

Table 6 presents results for models 6–9, which measured the association between three types of outlets on each type of crime separately. Model 6 shows that greater levels of off-premise (β=0.30, *95% CI* 0.18, 0.41, p<0.001) and LBD-7 spatial access (β=0.29, *95% CI* 0.17, 0.41, p<0.001) are associated with increased exposure to homicide. However, greater on-premise spatial access is not associated with homicide exposure (β=−0.12, *95% CI* −0.28, 0.03, p=0.11). The results from model 7 follow the same trend as model 6; off-premise (β=0.25, *95% CI* 0.09, 0.41, p=0.01) and LBD-7 spatial access (β=0.41, *95 CI* 0.25, 0.58, p<0.001) are associated with increased exposure to aggravated assaults while on-premise spatial access (β=−0.17, *95% CI* −0.36, 0.02, p=0.08) had no association. Model 8 shows that greater access to on- and off-premise outlets is associated with greater sexual assault exposure (on-premise β=0.15, *95% CI* 0.04, 0.25, p=0.01, off-premise β=0.19, *95% CI* 0.06, 0.31, p<0.01) but greater access to LBD-7 outlets is not (β=0.13 *95% CI* −0.01, 0.27, p=0.06). The trends in model 9 mirrored those in models 6 and 7, with only off-premise (β=0.20, *95% CI* 0.06, 0.34, p=0.01) and LBD-7 spatial access (β=0.28, *95% CI* 0.12, 0.44, p<0.01) associated with greater exposure to robbery.

Discussion

Greater levels of spatial access to alcohol outlets in Baltimore City are significantly associated with increased exposure to violent crime, even after controlling for neighborhood contextual factors. This conclusion is consistent with the previous analysis of alcohol outlet availability in Baltimore City from 2005–2010 as well as the literature from other large (>200,00 residents) cities in the US (Branas et al., 2009, R. Britt et al., 2005, Zhu et al., 2006, Yu et al., 2008, Parker et al., 2011, Toomey et al., 2012, Snowden and Freiburger, 2015). In Baltimore, a 10% increase in alcohol outlet access was associated with a 4.2% in exposure to violent crime. Sensitivity analyses show this is roughly equivalent to an increase in one additional outlet in a CBG is associated with an increase in about 12 violent crimes.

The association between alcohol outlets and violent crime depended on the type of outlet and the type of crime. Generally, off-premise and LBD-7 outlets appear to have a stronger association with violent crime than on-premise outlets do. For total violent crime, a 10% increase in off-premise outlet (4.4%) and LBD-7 (4.2%) spatial access had a stronger association than a 10% increase in on-premise spatial access (3.0%). Not only do neighborhoods that are low-income have higher access to alcohol outlets, but they also have greater access to the type of outlets associated with the most harm. However, these trends in neighborhood context of alcohol outlet access in which alcohol outlets are located does not fully explain the associations between type of alcohol outlet and violent crime alone, because on-premise and LBD-7 outlet access tends to be higher in similar types of neighborhoods, but LBD-7s are associated with more types of violent crime than on-premise outlets are. This suggests that the role of alcohol outlets in violent crime is complex and likely involves a combination of contextualizing factors and outlet characteristics.

Routine activity theory may help to explain the relationship between specific types of alcohol outlets and specific types of violent crime. Routine activity theory argues that homicide is an outcome rather than a type of crime, so homicides and aggravated assaults should be interpreted similarly (Felson and Eckert, 2016). The results of this analysis

support this idea, because the trends in the associations between on-premise, off-premise, and LBD-7 outlets are similar for both aggravated assault and homicide. It is important to note that homicides and aggravated assaults do differ by choice of weapon. Eighty-three percent of the homicides during the study period were committed using a firearm (of the remaining homicides, 10% are committed with a knife and 7% with another type of weapon). In comparison, fewer aggravated assaults involve a firearm (28%). In these crimes, offenders also commonly use knives (24%), hands (12%), and other weapons (37%).

Distinguishing consensual and predatory crimes using routine activity theory may also help to explain the unique role of each type of alcohol outlet on violent crime exposure. Consensual crimes involve more than one offender (e.g., two young males who decide to fight each other), and predatory crimes involve a motivated offender who pursues a susceptible target (e.g., a teenager who snatches a passerby's purse). Aggravated assaults/homicides often have hallmarks of consensual crimes, while sexual assaults and robberies are generally predatory in nature. The mechanisms that promote and prevent consensual and predatory crimes differ. Place managers have a larger effect on preventing consensual crimes (Felson and Eckert, 2016). This is because offenders in consensual crimes may not be as concerned with witnesses so much as situational cues of order that signal whether they are likely to suffer consequences if they commit a crime.

The finding that off-premise and LBD-7 outlets are associated with aggravated assault/homicide may be the result of ineffective or lack of place managers at these outlets. Store clerks who oversee off-premise sales often work in solitary settings and may have an obstructed view of patrons, which decreases the chances of effective place management. People who purchase alcohol for off-premise consumption may then drink in public settings near the outlets (e.g., in abandoned lots or cars) where place managers are completely absent. In addition, the stronger associations with LBD-7s and total violent crime and aggravated assaults could stem from business hours; off-premise outlets must close by 12 midnight but LBD-7s can remain open until 2 AM. On the other hand, on-premise outlets often have several types of staff persons who can manage the environment and regulate patrons' consumption. In addition, on-premise outlets often regulate entrances with staff who check IDs, which can reduce the chances of motivated offenders entering the on-premise outlets in the first place.

In contrast, capable guardians can prevent predatory crimes (Felson and Eckert, 2016). In these situations, motivated offenders enter a space with a suitable target, but the crime doesn't occur until the potential guardians leave (Felson and Eckert, 2016). Routine activity theory suggests that the most common guardians are other people – they need not be security guards or police officers (Felson and Eckert, 2016). People often patronize off-premise outlets alone and pass through them quickly, decreasing the likelihood of encountering potential guardians. This lack of effective guardians could explain the finding that greater access to outlets that serve for off-premise consumption was associated with predatory crimes like sexual assaults (off-premise outlets only) and robberies (off-premise and LBD-7 outlets). Unlike off-premise outlets, people tend to patronize on-premise outlets in groups. This means there are more people who could serve as potential guardians, and this presence of guardians could explain why greater access to on-premise outlets was not associated with

increased exposure to robberies. There may also be fluidity in the guardian/offender role for sexual assaults, whereby known acquaintances who might guard against robberies might also perpetrate sexual assaults. Approximately 8 out of 10 sexual assault victims knew the perpetrator (Sinozich and Langton, 2014).

The primary contributions of this article are the novel application of routine activity theory and spatial access methods used to calculate alcohol outlet access and violent crime exposure. In particular, previous work by study authors and others has shown that spatial access methods are more sensitive, precise, and stable than commonly-used counts of alcohol outlets and crime (Grubesic et al., 2016, Trangenstein et al., 2018). Other strengths of this analysis are using CBGs as the unit of analysis instead of census tracts, which reduces aggregation bias by avoiding averaging across larger, more heterogeneous areas. In addition, this analysis coded off-premise and LBD-7 outlets separately to be able to tease apart the consequences associated with these distinct types of outlets. These methodological decisions all allowed the analysis to test different interpretations of routine activity theory.

The findings from this study are consistent with the majority of the literature that demonstrates a stronger association between off-premise outlets (compared to on-premise outlets) and violent crime (Pridemore and Grubesic, 2012b, Grubesic et al., 2013, Snowden and Freiburger, 2015, Lipton et al., 2013, Gorman et al., 2005, Gruenewald et al., 2006, Branas et al., 2009, Day et al., 2012, Snowden, 2016, Pridemore and Grubesic, 2013). However, some elements of this analysis differ from previous studies. Unlike Gorman, Zhu, & Horel and Lipton & Gruenewald, this study found that access to on-premise alcohol outlets was associated with increased violent crime after adjusting for drug arrests (Lipton et al., 2013, Gorman et al., 2005). This difference could be attributable to using more sensitive methods to measure alcohol outlet spatial access.

This analysis has several limitations. First, the data obtained from the Board of Liquor License Commissioners contained minimal information. Thus, the analysis was unable to differentiate subtypes (beyond license category) of alcohol outlets, using data like volume of sales, area of floor space, hours of operation, and/or presence of a kitchen. These differentiations could be important because bars and restaurants likely have different associations with violence (Sacks et al., 2016), and previous critiques emphasize the importance of isolating the effects of particular types of outlets (Holmes et al., 2014). To date, the study authors are only aware of one study that weighted alcohol outlet access by volume of sales, but this study only performed simple linear regressions to compare methods of measuring alcohol outlet access (Groff, 2014). Future research should test whether more granular classifications of outlet types or operational characteristics affect the association between alcohol outlet access and violent crime.

Studies that are specific to one city often suffer from edge effects. In this study, the level of violent crime in the CBGs located along the Baltimore City boundaries may be associated with the access to alcohol outlets located just over the border in Baltimore County. Indeed, CBGs that share a border with Baltimore County tended to have lower access to alcohol outlets (2.39 vs. 3.29, t=11.67, p<0.001) and exposure to violent crime (5.41 vs. 6.43, t=9.83, p<0.001). This could be the result of the alcohol environment in Baltimore County or

because the SAI must travel further distances to find the 10 nearest alcohol outlets when some distances are cutoff by city boundaries.

It is also possible that some outlets closed or relocated during the gap between data generation and analysis. Also, the BPD data only include crimes that were reported to the police. Greater percentages of robberies (62%) and aggravated assaults (62%) are reported to police than sexual assaults (32%) (Truman and Morgan, 2016). Thus, it is possible that there is underreporting in the dataset. In addition, the SAIs used for both alcohol outlets and violent crime used the geometric centroid of the CBG. Future research should consider whether using population-weighted centroids improves the performance of these measures.

Finally, this is an ecological, cross-sectional study and cannot determine causality in isolation. One must consider the ecological fallacy, which states that findings at the population level might not generalize to the individual level. It is also possible that there are potential unmeasured confounder(s) that explain the association between alcohol outlet access and violent crime, although the analysis tried to incorporate commonly hypothesized ones such as income and social disadvantage. Similarly, these data may contain residual confounders despite our efforts to control for environmental context. It is also possible that areas that have more crime attract alcohol outlets, a relationship that cannot be tested cross-sectionally.

Previous research concludes that limiting alcohol outlet density may prevent related harms (Campbell et al., 2009b). The results of this analysis using routine activity theory suggest several options that may hold crime prevention potential like limiting access to alcohol outlets, increasing the number of trained place managers, greater oversight of alcohol outlet operations coupled with penalties for violating rules, streamlined monitoring of alcohol outlets located near high volumes of crime, and linking liquor licensing fees to alcohol outlets' operational conduct and/or proximity to violent crime. Of these options, reducing the number of alcohol outlets has the strongest evidence base (Popova et al., 2009b, Campbell et al., 2009a, Sherk et al., 2018), and the present analysis uses spatial access methods to pinpoint the types of outlets that should be considered for tighter regulations – outlets that sell alcohol for off-site consumption. This option is also cost-effective and sustainable. While grounded in theory, relying on trained place managers or enforcement staff may not be sustainable unless it can be linked with a revenue stream like increased liquor license fees. One innovative approach in this area was the use of deemed approved ordinances in California (Mosher and Treffers, 2013). Under this model, alcohol outlets paid an annual fee that funded compliance monitoring, and they could lose their liquor license if strict operational standards were not met (Mosher and Treffers, 2013).

From a routine activity perspective, minimizing the impact of crime multipliers like alcohol outlets may have an exponential effect. Routine activity theory argues that criminal acts are themselves often crime multipliers because each crime requires, advertises, or escalates into another crime (Felson and Eckert, 2016). This means that communities hold the power to prevent crime by making criminal act more difficult, more risky, or less rewarding (Felson and Eckert, 2016). In the end, each prevented crime could translate into a series of prevented

crimes. Future research should determine whether limiting alcohol outlet access provide communities with multiplicative effects.

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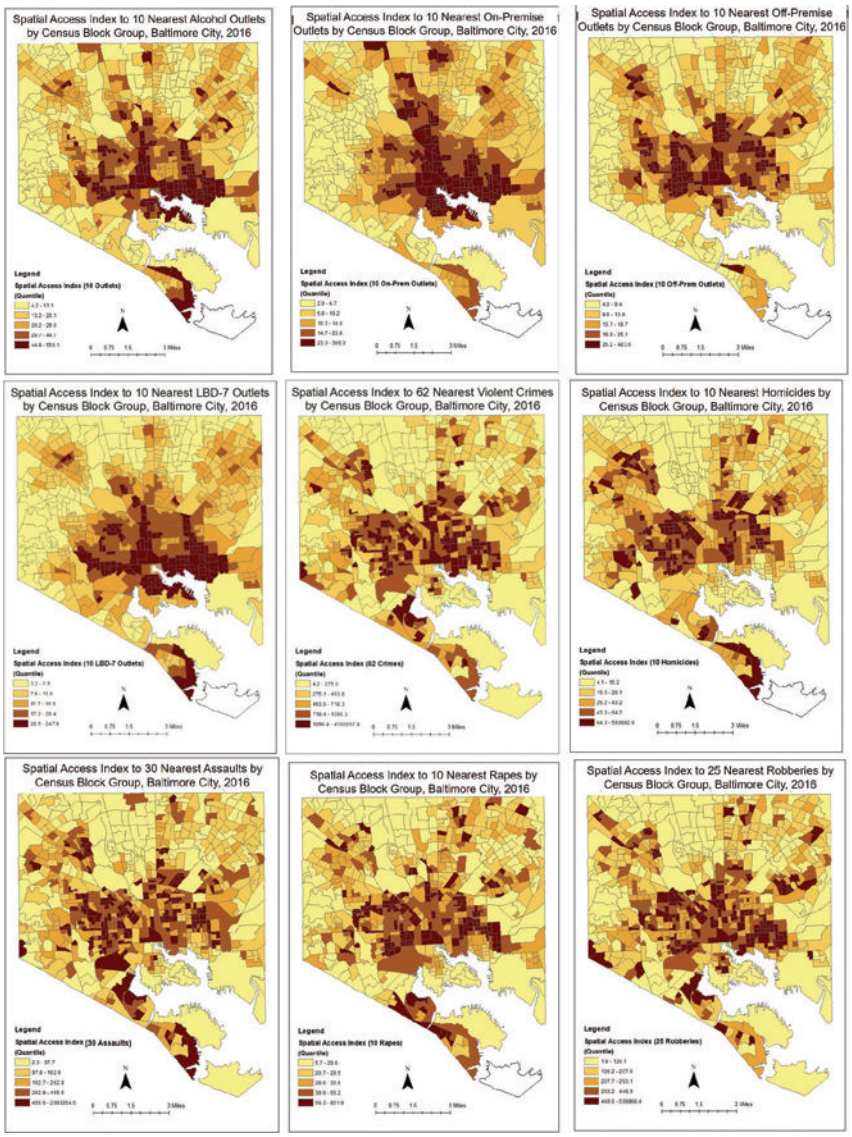

Figure 1.
Distribution of Exposure to Alcohol Outlets and Violent Crime in Baltimore

Table 1.

Alcohol Outlet License Types in Baltimore City, June 2016

License Type	Description	Days	Hours	Count
On-Premise				
AE	Adult entertainment	7	6 AM-2 AM	25
D	Breweries	Limited	Limited	3
LB	Beer/wine/liquor restaurant	7	6 AM - 2 AM	298
LBHM	Hotel/motel	7	6 AM - 2 AM	25
LC	Beer/wine/liquor private/non-profit clubs	7	6 AM - 2 AM	47
LD	Beer/wine/liquor bar/tavern	7	6 AM - 2 AM	51
WB	Beer/wine restaurants	7	6 AM - 2 AM	14
WC	Beer/wine private/non-profit clubs	7	6 AM - 2 AM	13
WD	Beer/wine taverns	7	6 AM - 1 AM	43
Off-Premise				
WA	Beer/wine package stores	6	6 AM - 12 midnight	30
LA	Beer/wine/liquor package stores	6	6 AM - 12 midnight	234
LBD-7 (Both On- and Off-Premise)				
LBD-7	Beer/wine/liquor bar/tavern with packagestores	7	6 AM - 2 AM	421

Table 2.

Descriptive Statistics by Census Block Group, Baltimore City, 2016 (n=599)

Variable	Mean	SD	Min	Max
Violent Crime SAI				
Total Crime[a]	8,152.63	171,413.20	53.99	4,190,958.00
Homicide[b]	1,044.54	24,460.19	4.11	598,692.00
Aggravated Assault[c]	5,443.50	122,308.40	15.11	2,99,335.00
Sexual assault[d]	44.84	56.97	5.73	851.88
Robbery[e]	1,615.66	25,285.34	26.89	98,860.40
Alcohol Outlet SAI				
All Outlets[f]	33.34	36.85	4.20	556.11
On-Premise Outlets[g]	18.44	22.03	2.94	305.26
Off-Premise Outlets[h]	18.88	21.49	3.95	483.56
LBD-7 Outlets[i]	20.39	19.67	3.32	148.09
Drug Arrests	11.6	18.3	0.0	183.0
Percent African American	66.0%	35.3%	0.0%	100.0%
Median annual household income[j]	$47,786.48	$29,056.48	$8,281.00	$250,000.00
Population density[j]	13,935	9,041	306.52	57,500
Percent owner-occupied housing	0.49	0.25	0.00	100.00
Social disadvantage index[k]	−1.76	3.01	−10.77	8.79

SD = Standard deviation of the mean; Min = Minimum value; Max = Maximum value; SAI = Spatial accessibility index

[a]Calculated as the sum of the inverse distance to the 62 nearest violent crimes.

[b]Calculated as the sum of the inverse distance to the 10 nearest homicides.

[c]Calculated as the sum of the inverse distance to the 30 nearest aggravated assaults.

[d]Calculated as the sum of the inverse distance to the 10 nearest sexual assaults.

[e]Calculated as the sum of the inverse distance to the 25 nearest robberies.

[f]Calculated as the sum of the inverse distance to the 10 alcohol outlets nearest to the CBG centroid.

[g]Calculated as the sum of the inverse distance to the 10 on-premise outlets nearest to the CBG centroid.

[h]Calculated as the sum of the inverse distance to the 10 off-premise outlets nearest to the CBG centroid.

[i]Calculated as the sum of the inverse distance to the 10 LBD-7 outlets nearest to the CBG centroid. LBD-7 outlets are bars/taverns that are permitted to sell alcohol for on- and off-premise consumption.

[i]Median annual household income is censored at $250,000.

[j]Measured as people per square mile.

[k] Calculated as *([(% female-headed households/10) + (% families living in poverty/10)] – [(% owner-occupied housing/10) + (% adults with college degree/10)]) / 4*

Table 3.

Distribution of Spatial Accessibility Index of Alcohol Outlets by Community Demographics, Baltimore City, 2016 (n=599)

	On Premise[a]		Off Premise[b]		LBD-7[c]	
	Mean	**t**	**Mean**	**t**	**Mean**	**t**
African American						
50% or more (n=407)	13.28	6.66***	18.70	0.22	16.80	5.36***
Less than 50% (n=192)	29.38		19.26		28.01	
Low Income						
Less than $25,000 (n=105)	18.81	−0.23	23.84	−4.11***	22.55	−1.70
$25,000 or more (n=494)	18.36		17.82		19.94	
High Income						
$75,000 or more (n=126)	29.06	−3.79***	15.50	2.78**	32.12	−3.64***
Less than $75,000 (n=527)	16.99		19.34		18.79	
High Advantage on Index (<−3.77)						
Lowest quartile of index (n=151)	13.62	2.82**	16.54	2.65*	15.69	4.43***
Not lowest quartile of index (n=448)	20.06		19.67		21.98	
Low Advantage on Index						
Index at least 0 (n=152)	28.46	−5.30***	21.74	−1.19	26.21	−3.52***
Index less than 0 (n=447)	15.03		17.91		18.42	

[a]Calculated as the sum of the inverse distance to the 10 on-premise outlets nearest to the CBG centroid.

[b]Calculated as the sum of the inverse distance to the 10 off-premise outlets nearest to the CBG centroid.

[c]Calculated as the sum of the inverse distance to the 10 LBD-7 outlets nearest to the CBG centroid. LBD-7 outlets are bars/taverns that are permitted to sell alcohol for on- and off-premise consumption.

Table 4.

Linear Regression Results for Violent Crime Exposure[a] by Total Alcohol Outlet Spatial Access

Variable	Model 1		
	β	95% CI	P Value
Total alcohol outlet SAI[b]	**0.43**	0.33, 0.52	<0.001
Drug arrests	**0.07**	0.01, 0.13	0.02
Percent African American	**0.61**	0.41, 0.82	<0.001
Median annual household income	**−0.03**	−0.05, −0.01	0.01
Owner-occupied housing	**−0.04**	−0.07, −0.02	<0.01
Population density	**0.03**	0.02, 0.03	<0.001
Moran's I	**0.06**		0.01

SAI Spatial accessibility index; SE Standard error; Moran's I Moran's Index

[a]Calculated as the sum of the inverse distance to the 62 violent crimes nearest to the CBG centroid.

[b]Calculated as the sum of the inverse distance to the 10 alcohol outlets nearest to the CBG centroid.

Table 5.

Linear Regression Results for Violent Crime Exposure[a] by Type of Alcohol Outlet Spatial Access, Baltimore City (n=599)

Variable	Model 2 On-Premise Outlets			Model 3 Off-Premise Outlets			Model 4 LBD-7 Outlets			Model 5 All Outlets		
	β	95% CI	P Value	β	95% CI	P Value	β	95% CI	P Value	β	95% CI	P Value
On-premise SAI[b]	**0.31**	0.20, 0.41	<0.001							−0.05	−0.22, 0.12	0.57
Off-premise SAI[c]				**0.45**	0.33, 0.57	<0.001				**0.23**	0.10, 0.37	<0.01
LBD-7 SAI[d]							**0.43**	0.33, 0.52	<0.001	**0.36**	0.21, 0.51	<0.001
Drug arrests	**0.11**	0.05, 0.17	<0.001	**0.08**	0.02, 0.15	<0.01	**0.07**	0.01, 0.13	0.02	**0.05**	−0.01, 0.11	0.09
Percent African American	**0.60**	0.37, 0.83	<0.001	**0.27**	0.08, 0.46	<0.01	**0.66**	0.44, 0.89	<0.001	**0.55**	0.33, 0.76	<0.001
Median annual household income	**−0.03**	−0.06, −0.01	0.02	**−0.04**	−0.06, −0.01	<0.01	**−0.03**	−0.05, −0.01	0.02	**−0.03**	−0.05, −0.01	0.01
Owner-occupied Housing	**−0.05**	−0.08, −0.02	<0.001	**−0.04**	−0.07, −0.01	<0.01	**−0.05**	−0.07, −0.02	<0.001	**−0.04**	−0.06, −0.01	<0.01
Population density	**0.03**	0.02, 0.04	<0.001	**0.03**	0.02, 0.04	<0.001	**0.03**	0.02, 0.03	<0.001	**0.02**	0.02, 0.03	<0.001
Moran's I	**0.07**		<0.01	**0.05**		0.01	**0.06**		0.01	**0.06**		0.01

SAI Spatial accessibility index; SE Standard error; Moran's I Moran's Index

[a]Calculated as the sum of the inverse distance to the 62 violent crimes nearest to the CBG centroid.

[b]Calculated as the sum of the inverse distance to the 10 on-premise outlets nearest to the CBG centroid.

[c]Calculated as the sum of the inverse distance to the 10 off-premise outlets nearest to the CBG centroid.

[d]Calculated as the sum of the inverse distance to the 10 LBD-7 outlets nearest to the CBG centroid. LBD-7 outlets are bars/taverns that are permitted to sell alcohol for on- and off-premise consumption.

Table 6.

Linear Regression Results for Violent Crime Exposure by Alcohol Outlet Spatial Access and Type of Outlet

Variable	Model 6 Homicide[a]			Model 7 Aggravated Assault[b]			Model 8 Sexual assault[c]			Model 9 Robbery[d]		
	β	95% CI	P Value	β	95% CI	P Value	β	95% CI	P Value	β	95% CI	P Value
On-premise SAI[e]	−0.12	−0.28, 0.03	0.11	−0.17	−0.36, 0.02	0.08	**0.15**	0.04, 0.25	0.01	0.07	−0.11, 0.25	0.46
Off-premise SAI[f]	**0.30**	0.18, 0.41	<0.001	**0.25**	0.09, 0.41	<0.01	**0.19**	0.06, 0.31	<0.01	**0.20**	0.06, 0.34	0.01
LBD-7 SAI[g]	**0.29**	0.17, 0.41	<0.001	**0.41**	0.25, 0.58	<0.001	0.13	−0.01, 0.27	0.06	**0.28**	0.12, 0.44	<0.01
Drug arrests	**0.08**	0.04, 0.13	<0.001	**0.07**	0.01, 0.14	0.03	0.04	−0.01, 0.08	0.06	0.03	−0.05, 0.09	0.44
Percent African American	**1.11**	0.93, 1.28	<0.001	**0.73**	0.50, 0.95	<0.001	**0.31**	0.15, 0.48	<0.001	**0.32**	0.07, 0.56	0.01
Median annual household Income	−0.01	−0.03, 0.01	0.42	**−0.04**	−0.06, −0.01	<0.01	**−0.04**	−0.06, −0.02	<0.01	**−0.03**	−0.05, −0.01	0.03
Owner-occupied housing	**−0.06**	−0.07, −0.03	<0.001	**−0.06**	−0.08, −0.03	<0.001	**−0.03**	−0.05, −0.01	<0.01	−0.01	−0.04, 0.02	0.37
Population density	**0.02**	0.01, 0.02	<0.001	**0.03**	0.02, 0.03	<0.001	**0.01**	0.01, 0.02	<0.001	**0.02**	0.02, 0.03	<0.001
Moran's I	**0.07**		0.01	0.04		0.05	**0.11**		<0.001	**0.08**		<0.01

SAI Spatial accessibility index; SE Standard error; Moran's I Moran's Index

[a]Calculated as the sum of the inverse distance to the 10 homicides nearest to the CBG centroid.

[b]Calculated as the sum of the inverse distance to the 30 aggravated assaults nearest to the CBG centroid.

[c]Calculated as the sum of the inverse distance to the 10 sexual assaults nearest to the CBG centroid.

[d]Calculated as the sum of the inverse distance to the 25 robberies nearest to the CBG centroid.

[e]Calculated as the sum of the inverse distance to the 10 on-premise outlets nearest to the CBG centroid.

[f]Calculated as the sum of the inverse distance to the 10 off-premise outlets nearest to the CBG centroid.

[g]Calculated as the sum of the inverse distance to the 10 LBD-7 outlets nearest to the CBG centroid. LBD-7 outlets are bars/taverns that are permitted to sell alcohol for on- and off-premise consumption.