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Neighborhood Alcohol Outlets and the Association with Violent Crime in One Mid-Atlantic City: The Implications for Zoning Policy

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ABSTRACT *Violent crime such as homicide causes significant excess morbidity and mortality in US urban areas. A health impact assessment (HIA) identified zoning policy related to alcohol outlets as one way to decrease violent crime. The objectives were to determine the relationship between alcohol outlets including off-premise alcohol outlets and violent crime in one urban area to provide local public health evidence to inform a zoning code rewrite. An ecologic analysis of census tracts in Baltimore City was conducted from 2011 to 2012. The data included violent crimes (n=51,942) from 2006 to 2010, licensed alcohol outlets establishments (n=1,327) from 2005 to 2006, and data on neighborhood disadvantage, percent minority, percent occupancy, and drug arrests from 2005 to 2009. Negative binomial regression models were used to determine the relationship between the counts of alcohol outlets and violent crimes controlling for other factors. Spatial correlation was assessed and regression inference adjusted accordingly. Each one-unit increase in the number of alcohol outlets was associated with a 2.2 % increase in the count of violent crimes adjusting for neighborhood disadvantage, percent minority, percent occupancy, drug arrests, and spatial dependence (IRR=1.022, 95 % CI=1.015, 1.028). Off-premise alcohol outlets were significantly associated with violent crime in the adjusted model (IRR=1.048, 95 % CI=1.035, 1.061). Generating Baltimore-specific estimates of the relationship between alcohol outlets and violent crime has been central to supporting the incorporation of alcohol outlet policies in the zoning code rewrite being conducted in Baltimore City.*

KEYWORDS *Crime, Alcohol, Policy-making, Health policy, Crime, Health impact assessment*

INTRODUCTION

Zoning policy is recognized by modern public health practitioners as a potentially relevant structural intervention strategy for health promotio.[1,2] Zoning policy is an

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urban planning tool used by local governments for land use planning. Zoning assigns uses (e.g., residential, commercial, and industrial) to land areas or districts within a municipal boundary. Zoning directly impacts the neighborhoods that residents live, work, and play in. In addition, zoning code rewrites are conducted in US cities on a cyclical basis and, therefore, they present ongoing opportunities to impact neighborhoods and learn from these impacts. While zoning has some historical roots in promoting public health, its use and acceptability as a method to promote and protect health in a contemporary setting is still in a nascent state.[1,3–5] In part, this is because the current use of zoning for the promotion of public health is controversial because of past exclusionary impacts, such as preventing people from living in certain residential districts based on race or class.[6]

The Centers for Disease Control and Prevention Task Force on Community Preventive Services specifically recommends using zoning to limit alcohol outlet density to prevent alcohol-related harms[7] and improve public health.[8] This recommendation is consistent with a body of public health research, for example, showing an association between alcohol outlet density and violent crime.[9–13] Despite the recommendations and research, zoning code changes aimed at decreasing alcohol outlet density have not been proposed or successfully incorporated into a rewrite previously in the US.[14,15] Baltimore City leaders in public health, planning, and law were willing to support zoning policy aimed at decreasing alcohol outlets; however, they felt that they needed local evidence to convince leaders in government and constituents across the city about the potential positive health impact of the zoning policy.

The objective of this manuscript was to determine the relationship between alcohol outlets and violent crime among census tracts in Baltimore. Our hypothesis was that increased numbers of alcohol outlets would be associated with increased violent crime. The zoning policy changes focused on off-premise alcohol outlets; as such, analyses were stratified by off- and on-premise outlets to determine their independent associations with violent crime. Off-premise alcohol outlets (e.g., liquor stores and convenience stores) are outlets where alcohol can be purchased and then consumed off site as compared to on-premise alcohol outlets where alcohol is purchased and consumed at the same location (e.g., bars and restaurants). In final models, we controlled for neighborhood compositional factors including neighborhood disadvantage, percent minority, percent occupancy, drug arrests, and spatial dependence to determine the independent relationship between alcohol outlets and violent crime.

METHODS

Overview

An ecologic analyses of census tracts in one city was conducted utilizing multiple sources of publicly available data. The data from Baltimore City included information on violent crimes (n=51,942) from 2006 to 2010 from the Police Department, all alcohol outlets establishments (n=1,327) from 2005 to 2006 from the Board of Liquor License Commissioners, and data on neighborhood disadvantage, percent minority, percent occupancy, and drug arrests from the 2005 to 2009 American Community Survey (ACS).

Setting

The setting for the current study presents a unique opportunity to investigate the study objective. The study was conducted in Baltimore City, Maryland, which is located in the

Mid-Atlantic US with a 2010 population of 620,961.[16] Baltimore has a long history of violent crime. In 2010, for example, Baltimore had the fifth highest rate of violent crime among US cities with population counts of 250,000 or greater.[17] While the population of Baltimore has declined since its peak in 1,950 and there has been a moratorium on new liquor licenses since 1968, the city has more than twice the number of outlets per capita as mandated by Maryland state law (i.e., approximately 1,330 licenses exist, though the city should only have 630 based on population).[18]

Measures

Geographic Units US census tracts are the geographic units used in this investigation. Census tracts are relatively permanent subdivisions of counties generally with 2,500 to 8,000 residents.[16] Census tracts are designed to be homogenous in terms of population characteristics, economic characteristics, and living conditions.[16] There are 200 census tracts in Baltimore City with total population ranging from seven to 8,521 (M=3,197; SD=1,548, median=2,949). There is one census tract that is mainly water, with a total population of seven. This census tract was excluded due to the low number of residents.

Violent Crimes Data on violent crimes from 2006 to 2010 were obtained from the Baltimore City Police Department. The data included the address that the violent crime occurred, the date, and the description of the crime. Violent crimes include rape, aggravated assault, homicide/manslaughter, and robbery. Over the 5-year period, there were 51,942 violent crimes. Ninety-nine percent (n=51,472) of the violent crime data were geocoded in ArcMap (ArcMap v9.3, ESRI, Redlands, CA, USA), including 28,800 aggravated assault, 1,250 homicides/manslaughter, 708 rapes, and 20,714 robberies (Fig. 1).

Alcohol Outlets Data on 1,327 alcohol outlets was obtained from the Board of Liquor License Commissioners. The data included address and license type of all establishments licensed to sell alcohol in Baltimore from 2005 to 2006. There are 14 license classes. Studies generally find that off-premise outlets are better predictors of crime than on-premise alcohol outlets.[10,13,19,20] Unlike bars and restaurants, off-premise alcohol outlets can sell alcoholic beverages in large quantities, which can be consumed in uncontrolled environments (e.g., motor vehicles, outside the outlet, and home).[20] In bars and restaurants, servers control how much patrons receive and can stop serving patrons if they appear intoxicated. The uncontrolled environment associated with consumption of alcohol from off-premise outlets coupled with the potential to purchase large quantities can lead to excessive consumption and injuries. Of the 1,327 alcohol outlets, 1,324 were geocoded (99.8 %) including 803 off-premise alcohol outlets and 521 on-premise alcohol outlets.

Control Variables In final regression models, four census tract-level contextual and/or compositional factors based on theoretical and empirical evidence were controlled for. A neighborhood disadvantage index used was used to characterize and control for the larger community context.[21,22] LaVeist and Wallace found that alcohol outlets are disproportionately located in predominantly African American census tracts, even after controlling for socioeconomic status.[20] The index was created using the 2005 to 2009 ACS.[16] The index includes the percent adults 25 and older with a college degree, percent owner-occupied housing, percent of families living in poverty, and percent of female-headed households. Each of the four items

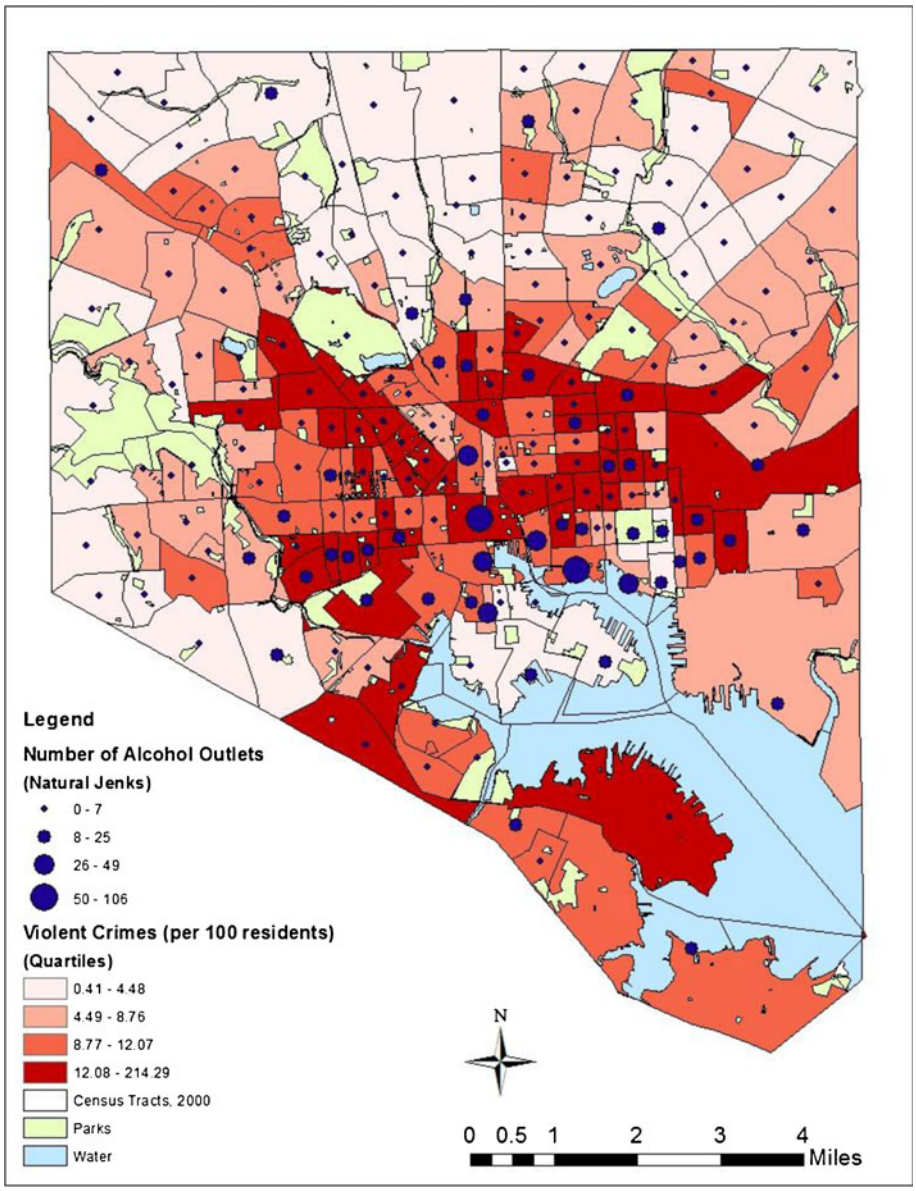

FIGURE 1. Violent crimes (per 100 residents) per census tract, Baltimore City, 2006 to 2010.

described above was then divided by ten. The percent owner-occupied housing was added to the percent of adults with college degrees; this was subtracted from the sum female-headed households and families living in poverty. The resulting value was divided by four. Each unit increase in the disadvantage index is equivalent to a 10 % increase in each item of the index.[21]

We controlled for percent occupancy per census tract, a contextual factor, because social disorganization theory suggests that places with less occupancy or more vacant houses may be more likely to lack guardianship such as police presence and, thus, are places with a greater likelihood for violent crime. We controlled for a compositional factor, percent minority (i.e., percent African American) population

because social normative theories and theories of social disorganization suggest that among minority populations, normative constraints against illegal activities such as drug market activity may be difficult to establish and maintain.[23,24] These two variables were obtained from the 2005 to 2009 ACS. In addition, we controlled for drug arrest counts per census tract because social disorganization theory suggests that drug arrests may indicate areas where there are congregations of individuals practicing illegal activities and police presence and/or control is less. Drug arrests are defined as any arrest for drug-related offenses. The data (n=73,246) from 2004 to 2005 was obtained from the Baltimore City Police Department. Duplicate arrest records, defined as records with the same arrest date, offender's date of birth, offender's home address, and arrest location, were excluded (n=31). The remaining drug arrests were geocoded to a street location. Of the total drug arrests, 93.4 % (n=68,412) were successfully geocoded and aggregated to their associated census tract. Drug arrests that occurred on highways (n=182) were excluded, leaving 68,230 drug arrests for final analyses.

Statistical Analysis

Negative binomial regression models were used to assess the relationship between the count of alcohol outlets and the count of violent crimes in each census tract. Negative binomial regression derives as an alternative to Poisson regression (most natural for analyzing count data) that accommodates overdispersion. The analyses were stratified by alcohol outlet type as follows: on-premise and off-premise alcohol outlets. In addition analyses were stratified by each type of violent crime to ascertain the independent relationship with alcohol outlets. Census tract-specific total population was used as a regression offset to adjust population size differences. Incident rate ratios (IRR) were calculated to convey the strength of association and significant findings were reported for alpha levels below 0.05. Moran's I statistic was used to assess spatial correlation, both in the outcome violent crime and regression residuals, as a diagnostic check on the regression assumption of independence.[25,26] All statistical analysis including descriptive statistics and negative binomial regression analyses were performed using Stata (Stata v12, StataCorp, College Station, TX, USA), GeoDa (GeoDa v0.9.3, Tempe, AZ, USA), and the R Project for Statistical Computing (R Development Core Team 2011).

RESULTS

Descriptive statistics are provided in Table 1. In the unadjusted negative binomial regression models, there was a statistically significant relationship between alcohol outlets and violent crime (Table 2, unadjusted models). For each unit increase in alcohol outlets, the count of violent crime increased by 1.5 % (IRR=1.015, 95 % confidence interval (CI)=1.007, 1.023). Community disadvantage and percent African American were also significantly associated with violent crime (IRR=1.373, 95 % CI=1.294, 1.457; IRR=1.005, 95 % CI=1.003, 1.008, respectively). There was a statistically significant inverse relationship between percent occupied housing and violent crime (IRR=0.970, 95 % CI=0.964, 0.977). The rate of drug arrests (per 100 residents) was also positively associated with the count of violent crime (IRR=1.073, 95 % CI=1.058, 1.089).

Alcohol outlets remained associated with violent crime after adjusting for community disadvantage, percent African American, percent occupied housing, and drug arrests. Each increase in the number of alcohol outlets was associated with a 2.2 % increase in the count of violent crime in the adjusted model (IRR=1.022,

TABLE 1 Descriptive characteristics including violent crime count, alcohol outlet count, and potential confounders by census tract, Baltimore City ($n=199$)

Census tract level	Mean	SD	Min	Max
Violent crime count	259	179	13	1,834
Aggravated assault count	145	100	5	836
Homicide count	6	5	0	25
Rape count	4	3	9	19
Robbery count	104	86	8	961
Alcohol outlet count	7	11	0	106
Off-premise alcohol outlet count	4	5	0	55
Total population count	3,213	1,535	380	8,521
African American population count	2,069	1,509	0	6,566
Drug arrest count	121	141	1	801
Occupied housing count	1,195	610	0	3,541
Neighborhood disadvantage index	0.22	1.39	−2.85	4.09

SD standard deviation

95 % CI=1.015, 1.028) (Table 2, adjusted model 1). The potential confounders remained significantly associated with violent crime, except drug arrests (IRR=1.014, 95 % CI=0.997, 1.031).

The Moran's *I* for violent crime was positive and statistically significant (0.232, $p<0.001$). This suggests that violent crimes in adjacent census tracts are more similar than those that are not adjacent (i.e., spatial correlation). In addition, the Moran's *I* for the adjusted model regression residuals also exhibited significant positive spatial correlation (0.223, $p<0.001$). Although the spatial correlation was reduced, since the included covariates accounted for some of this variability, this still violates the independence assumption of the regression analysis. Effort was made to further reduce residual spatial correlation to avoid potentially biasing the regression inference. Twelve census tracts with high regression residuals (|residual|>2) were identified, and these were mainly due to low population and low counts of violent crime. After removal of these 12 census tracts and inclusion of census tract centroid coordinates as additional regression covariates, the Moran's *I* for the regression residuals was further reduced, although it remained significant (0.107; $p=0.016$). The negative binomial regression model already includes a component to account for overdispersion as well as inferential procedures based on quasilikelihood methods; hence, effects of potential bias due to this remaining spatial correlation is minimal and assumed to be noninfluential. The removal of these 12 census tracts (Table 2, model 2) did not alter the significance and direction of the results; however, the magnitude of the associations were reduced. Among the remaining 187 census tracts, in the adjusted model, alcohol outlets remained associated with violent crime (IRR=1.019, 95 % CI=1.014, 1.024). In a final model, additionally controlling for spatial dependence by adding the tract centroid coordinates as a covariate, alcohol outlets remained associated with violent crime after adjusting for the potential confounders (IRR=1.019, 95 % CI=1.015, 1.023) (data not shown).

In independent stratified analyses controlling for spatial dependence, for each unit increase in *off-premise* alcohol and *on-premise* outlets, the count of violent crime increased by 3.0 % (IRR=1.030, 95 % CI=1.014, 1.046) and 1.6 % (IRR=1.016, 95 % CI=1.004, 1.028), respectively (data not shown in table). In the adjusted model, each increase in the number of off- and on-premise alcohol outlets was

TABLE 2 Unadjusted and adjusted incidence rate ratios (IRR) of the association between violent crime (outcome) and alcohol outlets, Baltimore City

	Unadjusted models ($n=199$)			Adjusted model 1 ($n=199$)			Adjusted model 2 ($n=187$)[b]		
Variables	IRR	95 % CI	*p*	IRR	95 % CI	*p*	IRR	95 % CI	*p*
Alcohol outlet count	1.015	1.007–1.023	<0.001	1.022	1.015–1.028	<0.001	1.019	1.014–1.024	<0.001
Neighborhood Disadvantage Index[a]	1.373	1.294–1.457	<0.001	1.225	1.145–1.310	<0.001	1.223	1.163–1.288	<0.001
African American population count	1.005	1.003–1.008	<0.001	1.000	1.000–1.001	0.027	1.000	1.000–1.000	0.484
Occupied housing count[a]	0.970	0.964–0.977	<0.001	0.987	0.980–0.994	<0.001	0.982	0.977–0.988	<0.001
Drug arrest count[a]	1.073	1.058–1.089	<0.001	1.014	0.997–1.031	0.099	1.008	0.996–1.020	0.211

95 % CI 95 % confidence interval, *p* indicates *p* value

[a]Each covariate is per 100 residents

[b]Model excluding low population and low counts of violent crime census tracts

associated with an increase, 4.8 % and 3.3 %, in the count of violent crime (IRR = 1.048, 95 % CI = 1.035, 1.061; IRR = 1.033, 95 % CI = 1.023, 1.044, respectively). The other variables had similar associations to the models with off- and on-premise alcohol outlets, except in the adjusted model for on-premise alcohol outlets, the count of drug arrests remained significantly associated with violent crimes (IRR = 1.020, 95 % CI = 1.004, 1.037). In adjusted analyses separating out each of the four types of violent crime, alcohol outlets were statistically associated with the count of homicides (IRR = 1.016, 95 % CI = 1.008, 1.025), forcible rapes (IRR = 1.015, 95 % CI = 1.007, 1.022), robberies (IRR = 1.024, 95 % CI = 1.016, 1.031), and aggravated assaults IRR = 1.020, 95 % CI = 1.013, 1.026).

DISCUSSION

The objective of this manuscript was to determine the relationship between alcohol outlets and violent crime among census tracts in Baltimore to provide local public health evidence to inform the alcohol-related elements of the zoning code rewrite. Our findings suggest that there is a relationship between alcohol outlets and violent crime during the study period (2005–2010) in Baltimore City after adjusting for neighborhood factors. Each increase in the number of alcohol outlets was associated with a 2.1 % increase in the count of violent crimes in the adjusted model. These findings are consistent with a body of research that has shown that the presence and density of alcohol outlets are associated with violent crime in cities with a population 200,000 or greater in the US.[9,10,14,27–33] For example, a study in Washington DC found that community-level liquor outlet density was significantly associated with violent crimes, independent of other neighborhood factors including violent crime, and the prevalence of weapons and illicit drugs.[21] Another study in Los Angeles, found that the total liquor outlet density was positively related to the assault rate (one type of violent crime) over the study period.[12] The temporary reduction of 250 outlets and permanent loss of 150 outlets over a 9-year period corresponded with a statistically significant drop in assaultive violence.

Our findings related to off-premise alcohol outlets are also consistent with the evidence. We found that off-premise alcohol outlets is associated with violent crime. Evidence suggests that off-premise alcohol outlets double the risk of violent crime and are specifically associated with increased homicide rates.[9,13,21,29] A study in Philadelphia demonstrated that being in an area of high density off-premise liquor outlets significantly increased the risk of being shot twofold.[9]

The 2011 National Prevention Strategy issued by the US Surgeon General's Office highlights the importance of including health considerations in decision-making across multiple sectors in order to achieve healthier and safer community environments.[6] Policy-making, such as zoning code policy, is driven by a combination of scientific evidence, political realities, and policy considerations. This manuscript provides public health evidence to one jurisdiction regarding the link between zoning policy and health. As a complement to the existing peer-reviewed research, these analyses seek to inform an ongoing zoning code rewrite with a specific opportunity to affect alcohol outlets in residential areas in one US urban area. As such, it represents an important contribution to the existing literature and suggests a model for providing local analyses to support the translation of public health research to inform policy-making processes in a meaningful and time-sensitive way.

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