The Violence Prevention Potential of Reducing Alcohol Outlet Access in Baltimore, Maryland

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ABSTRACT. Objective: There are few cost-effectiveness analyses that model alcohol outlet zoning policies. This study determines the potential decreases in homicides, disability-adjusted life years (DALYs), and victim and criminal justice costs associated with four policy options that would reduce the alcohol outlet access in Baltimore. **Method:** This cost-effectiveness analysis used associations between on-premise (incidence rate ratio [IRR] = 1.41), off-premise (IRR = 1.76), and combined on- and off-premise outlet density (IRR = 1.07) and homicide in Baltimore. We determined the potential change in the level of homicide that could occur with changes in the density of alcohol outlets, assuming that 50% of the association was causal. **Results:** Reducing alcohol outlet density in Baltimore City by one quintile was associated with decreases of 51 homicides per year, $63.7 million, and 764 DALYs. Removing liquor stores in residential zones was associated with 22 fewer homicides, which would cost $27.5 million and lead to 391 DALYs. Removing bars/taverns operating as liquor stores was associated with a decrease of one homicide, $1.2 million, and 17 DALYs. Removing both the liquor stores in residential zones and the bars/taverns operating as liquor stores was associated with 23 fewer homicides, which translated to $28.7 million and 409 DALYs. **Conclusions:** For preventing homicides, the strategy of removing liquor stores in residential zones was preferred because it was associated with substantial reductions in homicides without closing unacceptably high numbers of outlets. It is possible that policies that close the bars/taverns operating as liquor stores would be associated with decreases in other types of violent crime. (*J. Stud. Alcohol Drugs, 81,* 24–33, 2020)

GREATER ALCOHOL OUTLET DENSITY (i.e., the number and configuration of alcohol outlets in a geographic location) is associated with increased rates of violence (Campbell et al., 2009; Popova et al., 2009; Sherk et al., 2018). Researchers have consistently demonstrated the link between greater alcohol outlet density and higher rates of violent crime in cities and suburban areas across the United States, as well as abroad (Branas et al., 2009; Franklin et al., 2010; Jennings et al., 2014; Toomey et al., 2012; Yu et al., 2008, 2009; Zhang et al., 2015). Three systematic reviews have documented the consistency of these associations (Campbell et al., 2009; Popova et al., 2009; Sherk et al., 2018). In addition, several studies have used longitudinal designs and natural experiments that establish temporality. For example, a recent study found that violent crime decreased twice as much in parts of Atlanta, Georgia, that reduced alcohol outlet density by 3% relative to areas where alcohol outlet density increased (Zhang et al., 2015). An analysis of the 1992 Los Angeles riots found that census tracts where alcohol outlets were burned during the rioting experienced reductions in violent crime, and those reductions were proportional to the number of alcohol outlets lost, which demonstrates a dose-response association (Yu et al., 2009).

Alcohol outlets may lead to increased crime through several pathways. First, availability theory asserts that greater access to alcohol outlets expands physical availability, which can decrease the "full price" (i.e., the combination of the real cost and the convenience cost for accessing alcohol) by mak-

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ing it easier to get alcohol (Stockwell & Gruenewald, 2004). As argued by Stockwell and Gruenewald, these changes in the availability of alcohol will lead to changes in related harms when they alter “routine drinking activities” (i.e., behaviors that drinkers engage in while they are drinking alcohol) (Stockwell & Gruenewald, 2004). Second, social disorganization theory argues that alcohol outlets may undermine a neighborhood’s ability to regulate and prevent violent crime. This theory suggests that alcohol outlets attract people who establish an atmosphere of immoral or illegal behavior, as well as young males (who are more prone to violence), regardless of whether those people are drinking (McCord & Ratcliffe, 2007; Parker, 2004). Last, routine activity theory asserts that alcohol outlets could have an environmental effect on the level of violence in a place by bringing high-risk drinkers together and fostering opportunities for violence (Campbell et al., 2009; Roncek & Maier, 1991). Taken together, these theories establish the strong association between alcohol outlet access and violent crime, suggesting that strategies to limit access to alcohol outlets may reduce alcohol-related harms.

Cost, cost-effectiveness, and cost-threshold analyses convert health-related events into dollar values. Once policies are converted to a fiscal scale, researchers can model and compare the anticipated outcomes associated with different policy options. To date, the authors are only aware of one analysis that applied cost-effectiveness ideas to compare consequences of different alcohol outlet zoning policies, although it did not model costs. Ahern et al. (2013) modeled how different alcohol outlet zoning policies would change levels of binge drinking (i.e., consuming four or more drinks in 2 hours for males or five or more drinks in 2 hours for females) in New York City. The authors concluded that limiting alcohol outlet availability to 70 outlets per square mile would decrease binge drinking by 0.7% (Ahern et al., 2013).

Baltimore, MD, initiated a zoning recode called “TransForm Baltimore” in 2007 that ended a 35-year stretch during which its zoning laws remained unchanged (Baltimore Department of Planning, 2018). The final bill included three provisions related to alcohol outlet zoning: (a) require liquor stores located in residential zones to amortize (i.e., relocate or change the nature of their business) over a 2-year period; (b) require bars/taverns, which function as both on- and off-premise outlets (i.e., LBD-7s [7-day beer, wine, and liquor licenses]), which are the most common license type in Baltimore, to demonstrate substantial floor space and sales devoted to onsite consumption; and (c) ban new liquor stores from opening within 300 feet of existing liquor stores (except downtown, which is largely commercial and focuses on tourism and entertainment) (Baltimore City Department of Legislative Reference, 2019).

The present study aims to model the estimated consequences of various zoning policies that are based on the recent TransForm Baltimore initiative in Baltimore, MD. The present ecologic analysis compares four policy options to reduce alcohol outlet access: (a) reduce alcohol outlet density to the quintile below it; (b) close the 80 liquor stores in residential zones; (c) close 117 “sham” bars/taverns (i.e., alcohol outlets with a LBD-7 bar/tavern license that operate as liquor stores); and (d) close both the 80 nonconforming liquor stores and the 117 sham bars/taverns.

Method

Measures

All measures are described in detail in the supplemental appendix. (Supplemental material appears as an online-only addendum to the article on the journal’s website.)

Geographic units. U.S. census block groups (CBGs) were used as the primary geographical unit of analysis in this study. There are 653 CBGs in Baltimore. The population in Baltimore CBGs ranges from 0 to 4,828 people, and there are on average three CBGs per census tract.

Homicide. Victim-based violent crime incident data were obtained from the Baltimore City Police Department via OpenBaltimore (City of Baltimore, 2019). We selected homicide for this analysis because it is part of the Federal Bureau of Investigation Uniform Crime Reporting definition (Federal Bureau of Investigation, 2016), and it is the most serious type of violent crime. In addition, the number of homicides increased by 56.1% (from 205 to 320) in 2015, and Baltimore has seen at least 300 homicides per year since that time, suggesting that Baltimore is experiencing a homicide epidemic (*The Baltimore Sun,* n.d.). This analysis pooled homicide data over 5 years (2012–2016) to have the statistical power to limit the outcome to homicide. There were 1,322 homicides in 2012–2016, and 318 of these were in 2016.

Alcohol outlets. Liquor license information, including license type and address, was obtained from the Board of Liquor License Commissioners for Baltimore City as of June 2016. In 2016, there were 1,218 licensed alcohol outlets in Baltimore City, 1,204 of which were included in this analysis. There were 14 license types (see Table A-1 in the supplemental material for further detail). Eleven of these license types were for on-premise consumption (e.g., adult entertainment, brewery, restaurant, and bar/tavern). Two license types were for off-premise sales: LA/LA-2 (package stores beer/wine/liquor) and WA (package stores beer/wine). The last license type, known as LBD-7, was the most common license type in Baltimore City (n = 421). LBD-7 license holders are permitted to both serve alcohol on-premise and to sell package goods for off-premise consumption. This license type had the longest opening hours (6 A.M.–2 A.M.) and most days of sales (7 days).

We quantified alcohol outlet density using two methods: kernel density estimation (KDE) and a spatial accessibility index (SAI). KDE uses a nonparametric moving window to measure the intensity of alcohol outlets (i.e., the average number of alcohol outlets per measure of area). SAIs are another nonparametric method that uses inverse distances to quantify the clustering of alcohol outlets (i.e., the tendency for alcohol outlets to be located near other outlets). Specifically, the SAI was the sum of the inverse network (road-based) distances to a set of seven nearest alcohol outlets (Centers for Disease Control and Prevention, 2017). Because homicide perpetrators and potential victims can move through space, we also calculated spatial lags for the KDE and SAI measures, which were defined as the average level of alcohol outlet density/clustering in adjacent CBGs (Waller & Gotway, 2004). We forced all four types of alcohol outlet density variables (i.e., KDE, KDE lag, SAI, and SAI lag) into the models.

Nonconforming liquor stores. Nonconforming liquor stores were off-premise alcohol outlets with license types LA, LA-2, and WA located in residential neighborhoods. The Citizen's Planning and Housing Association (2013) identified 105 nonconforming liquor stores in 2013, and 95 of these remained in 2016. During the TransForm Baltimore discussions, 19 nonconforming liquor stores were rezoned, meaning they will not need to relocate under the new zoning code. We obtained information for 15 of these 19 outlets, and the cost-effectiveness analyses did not amortize these known spot-zoned outlets. Thus, there were 80 nonconforming liquor stores included in the cost-effectiveness analysis (Figure 1). We calculated values for the off-premise KDE and SAI variables with and without these 80 outlets.

Sham bars/taverns. Sham bars/taverns are alcohol outlets with an LBD-7 (bar/tavern) license operating as an off-premise outlet. This is problematic because LBD-7 licenses have more lenient operating hours/days than off-premise licenses. TransForm Baltimore mandated all alcohol outlets with an LBD-7 license to devote at least 50% of their sales floor and sales to on-premise consumption to ensure they are not operating as an extended-hours liquor store (Baltimore City Department of Legislative Reference, 2019). Sham LBD-7s were identified by another research team using an alcohol outlet assessment tool (methods are documented elsewhere; Milam et al., 2014), which documented the percentage of the sales floor devoted to on-premise consumption; data on volume of sales were unavailable. Alcohol outlets with an LBD-7 license and less than 50% of the sales floor devoted to on-premise consumption were designated as sham bars/taverns. There were 117 sham bars/taverns in 2016 (Figure 1). We also calculated the LBD-7 KDE and SAI variables with and without these 117 sham bars/taverns.

Statistical analyses

All statistical analyses are described in full detail in the supplemental appendix.

Negative binomial regressions. We used a series of negative binomial regressions to measure the association between the count of homicides and alcohol outlet density and clustering. Our final covariates included alcohol outlet clusters, demographics (e.g., population density), socioeconomic status (e.g., median household income), residential instability (e.g., percent renter-occupied housing), and social disorganization (e.g., drug arrests). We transformed the KDE and SAI variables using the natural logarithm to meet the constant multiplicative assumption of negative binomial regression.

We conducted three negative binomial regressions, where there was one regression for each type of alcohol outlet (on-premise, off-premise, and combined on-/off-premise outlets). A 1-unit increase in the natural log of the on- and off-premise SAIs were associated with a 41.3% (incidence rate ratio [IRR] = 1.41, 95% CI [1.03, 1.53]) and 75.5% (IRR = 1.76, 95% CI [1.41, 2.19]) increase in the number of homicides over 5 years, respectively. In addition, a 1-unit increase in the natural logarithm of the LBD-7 KDE was associated with a 7.67% (IRR = 1.07, 95% CI [1.02, 1.12]) increase in the number of homicides in a CBG over 5 years (see Table A-4 in the supplemental material for further details).

Spatial analyses. We calculated Moran's Index on homicide and regression standardized residuals using a first-order Queen adjacency matrix requiring at least two adjacent sides to determine whether our units of analysis were spatially dependent. The regression covariates explained all the spatial dependence in the outcomes, thereby meeting the assumption of independence made by ordinary least squares regression. We calculated spatial lags as the mean of the focal variable (e.g., alcohol outlet density, drug arrests) in the neighboring CBGs as defined by the adjacency matrix (Waller & Gotway, 2004). The final models included lagged versions of the alcohol outlet KDE/SAI and drug SAI variables. None of the other spatial lag variables improved the inference, so they were not retained in the final models.

Cost-effectiveness analysis. We used a cost-effectiveness approach to model the potential decreases in homicides that would be associated with alcohol outlet access zoning changes over 1 year. To do so, we first determined the natural log of the KDE (for LBD-7 outlets) or SAI (for on- and off-premise outlets) for each CBG at baseline for each policy. We then determined the natural log of the KDE and SAI that would exist under the new policy. These methods varied by policy, as described below.

To determine the size of the decrease in homicides that would be associated with the four policies, we first obtained a linear prediction using the actual 2016 values for alcohol outlet density. We then calculated the number of homicides that would be associated with the new policy using linear predictions from the negative binomial regressions, changing values only for the regression alcohol outlet density terms that reached statistical significance. These associations are given by the following formulas:

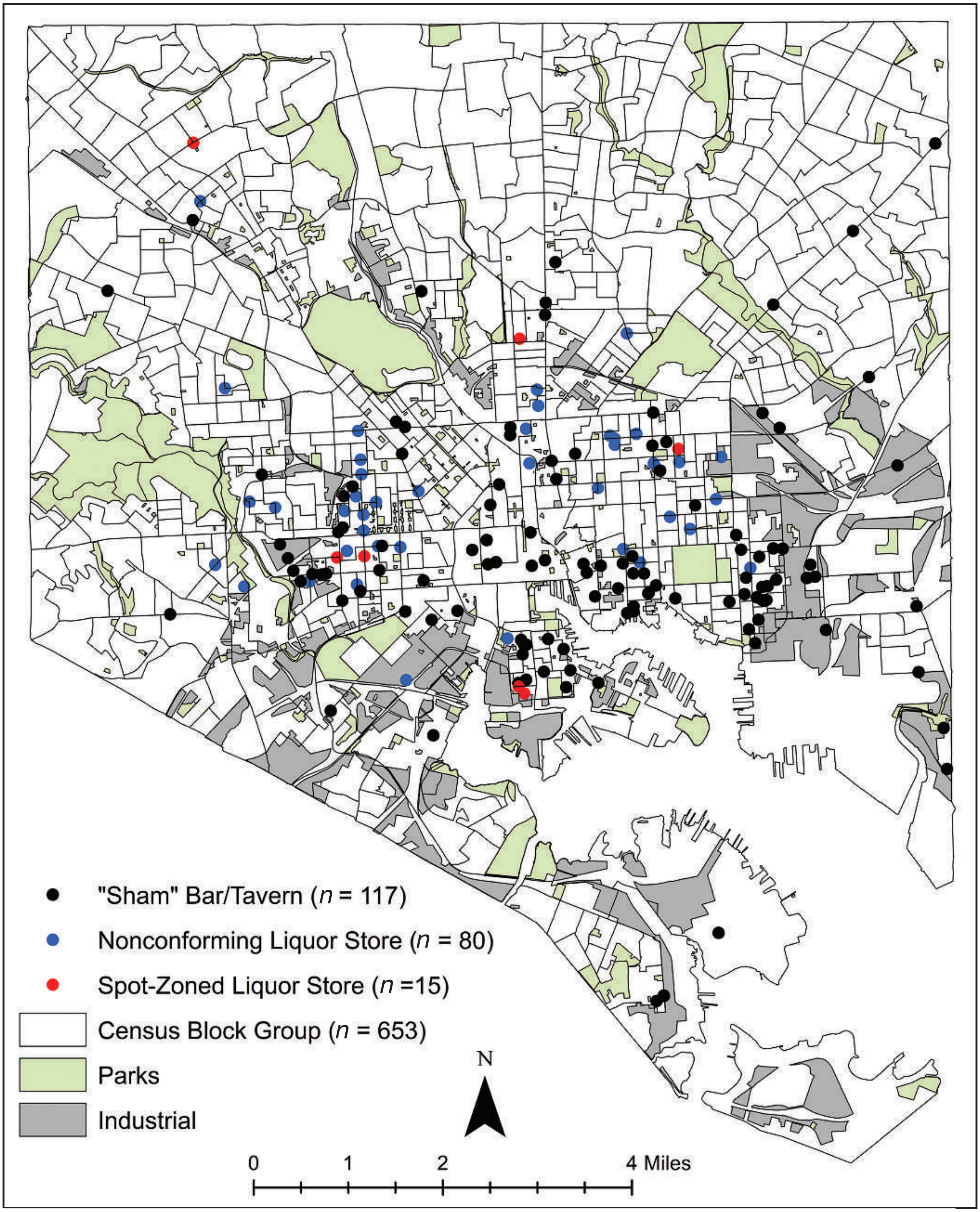

FIGURE 1. Map of Baltimore showing the locations of sham bars/taverns, nonconforming liquor stores in residential zones, and spot-zoned liquor stores in residential zones, 2016

$$\text{On-premise outlets: } (\beta_0 + 1.41(\text{SAI}) + \theta) / A$$

$$\text{Off-premise outlets: } (\beta_0 + 1.76(\text{SAI}) + \theta) / A$$

$$\text{LBD-7 outlets: } (\beta_0 + 1.07(\text{KDE}) + \theta) / A,$$

where β_0 is the intercept, θ is a string of covariates, and A is the natural log of the CBG area in square feet. We then subtracted the predicted number of homicides that would exist using the hypothetical KDE and SAI values for each policy scenario. Last, we divided these estimates by five, because we pooled data over 5 years in order to obtain stable estimates for the association between homicide and specific types of alcohol outlets. This process was repeated using a slightly different method depending on the policy, as outlined below.

Policy 1: Quintiles. Reducing on-premise, off-premise, and LBD-7 alcohol outlet density by one quintile was calculated by dividing the CBGs into quintiles for each alcohol outlet type and setting the level of density in each CBG to the current mean of the quintile below it. This policy was selected as an example of a comprehensive approach that would affect all three types of outlets equally. We first divided the logged KDEs and SAIs into quintiles and determined the mean of the natural log-transformed KDE/SAI for each quintile. For CBGs that had LBD-7 KDE or on-/off-premise SAIs that fell in Quintiles 2–5, we set the natural log of the KDE/SAI that would exist under Policy 1 equal to the value of the mean in the quintile below it. We did not change the natural log of the KDEs/SAIs for CBGs with KDEs/SAIs in the quintile with the lowest alcohol outlet density.

Policy 2: Amortize nonconforming liquor stores. For Policy 2, we calculated the natural log of the SAI that would exist under Policy 2 by removing the 80 nonconforming liquor stores from the network data set. We then calculated the SAIs as the sum of the inverse distance (d) between each CBG centroid and the seven closest alcohol outlets (d_{ij}) using the remaining 1,124 outlets: $\ln\left(\Sigma_1^7 \frac{1}{d_{ij}}\right)$ among 1,124 outlets.

Policy 3: Amortize sham bars/taverns. Policy 3 amortized the 117 sham bars/taverns. For this policy, we first removed the 117 sham bars/taverns from the network data set. We then recalculated the natural log of the KDEs that would exist under Policy 3 using the remaining 1,087 outlets.

Policy 4: Amortize nonconforming liquor stores and sham bars/taverns. Policy 4 combined Policies 2 and 3. It amortized the 80 nonconforming liquor stores and 117 sham bars/taverns simultaneously. In this approach, we added the results of Policies 2 and 3 to determine changes associated with this combined policy.

Direct costs per homicide ($1,129,869) were derived from McCollister et al. (2010) (Table 1). In brief, the authors used a two-step approach to determine the cost-per-crime using a societal perspective that combined cost-of-illness and jury compensation methods. The costs included victim costs (i.e., medical costs, property/cash losses, and lost earnings), criminal justice system costs (i.e., police costs, adjudication costs, and corrections costs), and career crime costs (i.e., lost earnings for perpetrators). We excluded costs for career crime and for pain and suffering. One limitation of these data is that they were from 2008 (McCollister et al., 2010); therefore, we adjusted them to 2016 dollars using the Consumer Price Index (CPI = 1.106). The final cost per homicide used in the analyses was $1,249,635.

The disability-adjusted life years (DALY) per homicide were derived from Dolan et al. (2005) as a measure of intangible costs. The authors used the Global Burden of Disease Study (Murray et al., 1996) to determine the years of life lost from homicide, using a 3.5% discounting rate. They concluded that each homicide was associated with 17.79 DALYs.

Adjustments for potential biases. The major threats to validity are sampling bias, misclassification bias, and unknown/unmeasured confounding. We concluded that sampling bias was not a concern in this study (see supplemental appendix), but there was the potential for misclassification bias and residual confounding; therefore, we conducted two sensitivity analyses to examine these threats empirically. Previous research found that up to 6% of active licenses might be non-operational or closed (Ponicki et al., 2013; Trangenstein et al., 2017), which suggests that our alcohol outlet data may contain false positives. Given this, we drew and removed random samples of 6% of the alcohol outlets on the 2016 license list 1,000 times to determine the consequences on our measures of alcohol outlet density. On average, this adjustment resulted in a decrease of one additional homicide per alcohol outlet density zoning policy. The presented results include this adjustment.

We also calculated an E-value, which tested how strongly an unmeasured confounder would need to be associated with outlet density and homicide in order to fully explain our reported measures of association (VanderWeele & Ding, 2017). E-values range from 1 to infinity. The E-values were 1.08 (95% CI [1.00, 2.53]) for on-premise outlets, 2.10 (95% CI [1.08, 4.45]) for off-premise outlets, and 1.00 (95% CI [1.00, 1.00]) for LBD-7 outlets. To explain the association between off-premise outlets and homicide, the unmeasured confounder would need to double the homicide rate after adjusting for our range of covariates. Because the 95% CI for two of the E-values included 1, it is possible that an unmeasured confounder could explain our measures of association for on-premise and LBD-7 outlets.

The E-value used strength of the association as a measure of causality, and the extant literature established that the magnitude of the effect of alcohol outlet density on violent crime is small to moderate (Livingston, 2008). In light of this, we divided our measures of association by two to account for residual measurement error that may result from using proxies for some covariates (e.g., drug arrests as a measure or drug use). Although this value is not based on

TABLE 1. Available cost of homicide estimates since 2000

Lead author	Year of data	Type of costs	Location	Study pop.	Method: Willingness to pay	Method: Jury award	Method: DALY	Method: Bottom-up	Data: Admin.	Data: Survey or interview	Costs: Direct	Costs: Indirect	Costs: Total
Smith[a]	2010	Societal	Australia	National				X	X		AUD $1,900,000	AUD $299,800,000	AUD $301,700,000
McCollister	2008	Societal	U.S.	National	X	X			X	X	USD $1,285,146	USD $8,442,000	USD $9,727,146
Roman	2008	Societal	U.S.	Subsample (n = 12,918)		X					USD $6,900,000	–	USD $6,900,000
DeLisi	2008	Societal	U.S.	Subsample (n = 654)					X	X	–	–	USD $17,252,656
Rollings	2005	Societal	Australia	National					X		AUD $8,600,000	AUD $719,000,000	AUD $727,600,000
Czabanski	2003	Societal	Poland	National			X			X			PLN 8,195,000
Dubourg	2003	Societal	U.K.	National					X		£201,000,000	£618,000,000	£819,000,000
DeLisi	2002	Societal	U.S.	Subsample (n = 500)					X	X	USD $16,811	USD $425,768	USD $442,579
Mayhew[a]	2001–2002	Societal	Australia	National					X		AUD $4,500,000	AUD $700,000,000	AUD $704,500,000
Dolan	2001	Victim	U.K.	National		X	X		X		–	£100,000,000	£100,000,000

Notes: Pop. = population; DALY = disability-adjusted life year; admin. = administrative; U.S. = United States; U.K. = United Kingdom. [a]Costs are calculated in Australian dollars.

Table 2. Reductions in homicides, costs, and DALYs associated with policies over 1 year

	Homicides prevented									
	On-premise		Off-premise		LBD-7		Costs saved (millions)		DALYs prevented	
Variable	*n*	[95% CI]	*n*	[95% CI]	*n*	[95% CI]	$	[95% CI]	*n*	[95% CI]
Quintiles	15	[0, 65]	22	[6, 56]	14	[5, 15]	$63.7	[$13.7, $170.0]	764	[195, 2,419]
Liquor stores in residential zones			22	[7, 52]			$27.5	[$8.7, $65.0]	391	[124, 925]
"Sham" bars/taverns					1	[0, 4]	$1.2	[$0, $5.0]	17	[0, 71]
Combined strategy			22	[7, 52]	1	[0, 4]	$28.7	[$8.7, $70.0]	409	[124, 996]

Notes: DALY = disability-adjusted life year; LBD-7 = 7-day beer, wine, and liquor license for on- and off-premise outlets; CI = confidence interval.

empirical data, we believe that discounting our measure of association by half is better than the alternative of assuming the entire measure of association was causal. We also compared our adjusted measures of association to reported measures of association from longitudinal studies, and we concluded that our estimates were within a reasonable range (see the supplemental appendix, Section 7.0).

Results

The quintiles policy (i.e., reducing alcohol access by one quintile) was associated with a decrease of 51 homicides (95% CI [11, 136]), $63.7 million from a societal perspective (95% CI [$12.7m, $170.0m]), and 764 DALYs (95% CI [195, 2,419]) (Table 2). Closing nonconforming liquor stores (i.e., those located in residential neighborhoods) was associated with 22 fewer homicides (95% CI [7, 52]). These crimes would cost $27.5 million dollars (95% CI [$8.7m, $65.0m]) and lead to 391 DALYs (95% CI [124, 925]). Closing the sham bars/taverns was associated with a reduction of 1 homicide (95% CI [0, 4]), $1.2 million (95% CI [$0m, $5.0m]), and 17 DALYs (95% CI [0, 17]). The combined policy of closing both the nonconforming liquor stores and the sham bars/taverns was associated with decreases of 23 homicides (95% CI [7, 56]), $28.7 million (95% CI [$8.7m, $70.0m]), and 409 DALYs (95% CI [124, 996]).

Discussion

The findings suggested that the quintile policy may achieve the largest reductions in homicide; however, it may not be feasible to implement. To achieve reductions of the magnitude that are modeled in the quintile policy, Baltimore would need to close large numbers of alcohol outlets. As a consequence, the quintile policy may be viewed as "anti-business." Among the remaining policy options examined, the policy that closed liquor stores in residential areas was the preferred approach. It was associated with a reduction of 22 homicides in 1 year. Although previous research concluded that clustering of LBD-7 outlets was strongly associated with clustering of violent crimes (Trangenstein et al., 2018), closing the sham bars/taverns was not associated with substantially fewer homicides in this analysis. There is an ongoing violence epidemic in Baltimore, with recent years breaking records for number of homicides (342 in 2017, 318 in 2016, and 342 in 2015) (*The Baltimore Sun,* n.d.). This study suggests that there is potential to prevent violent crimes by reducing alcohol outlet density in Baltimore City.

These estimates were conservative in many ways. The main analysis assumed that 50% of the direct association between alcohol outlet access and violent crime was attributable to the outlets. The initial regressions accounted for neighborhood context (e.g., income level, race/ethnicity, and drug arrests) as well as spatial autocorrelation across CBGs. The regression models did not have any residual spatial dependence, which suggested that there were no omitted variables that contained spatial patterning. Also, the cost estimates excluded the victim's pain and suffering as well as costs borne by persons other than the victim (e.g., friends and family). In addition, all estimates were rounded down to the nearest number to avoid potentially overstating the problem. Thus, the true financial impact of alcohol outlet access reduction could be larger than the models that we presented here.

This study has several limitations. We were unable to model relocating the nonconforming liquor stores and sham bars/taverns because we were unsure where or whether they will reopen. In this sense, the analysis may have overestimated the potential results of alcohol outlet zoning. These models also assumed that all outlets will close at one point in time. The implementation of the policies included in the analysis would likely take a phased approach, and the results would therefore accrue more slowly over time. In addition, it is possible that amortizing the nonconforming liquor stores and sham bars/taverns might actually increase the disparities (Hippensteel et al., 2019). Alcohol outlets tend to cluster in low-income and minority neighborhoods (Morrison et al., 2016; Trangenstein et al., 2019), and alcohol outlet density zoning would ideally aim to reduce the concentration of outlets in these neighborhoods. Outside of the padlock law (which allows the city to temporarily close businesses with two or more violent acts on the premises in a 2-year period), Baltimore is legally unable to revoke a liquor license because it is private property. Therefore, TransForm Baltimore will relocate instead of close alcohol outlets. However, many available, affordable buildings are in low-income, high-minority neighborhoods (Hippensteel et al., 2019). Incentivizing relocating displaced outlets to low-density, low-crime neighborhoods may prevent increasing physical availability of alcohol in already disadvantaged neighborhoods.

This study used cost data that are almost 10 years old. Although the analysis used CPIs to adjust the estimates for inflation, it is possible that the cost structure of violent crime has evolved during the past decade. Further, it is unclear whether the costs associated with violent crime in the United States and Baltimore are similar. Baltimore's ongoing violence epidemic could have changed the costs associated with violent crime.

In addition, Baltimore has unique demographics that could also influence crime costs. For example, Baltimore has a much larger African American population (63% vs. 13%) and lower median annual household income ($47,350 vs. $57,617) than the United States overall (United States Census Bureau, 2018). Unfortunately, we are unaware of any comprehensive local estimates of the cost of violent crime in Baltimore, so we were unable to determine the similarity of these costs across the national and local levels. However, the national cost estimates that we used also had strengths. Specifically, they were calculated using rigorous methods and did not include costs associated with pain and suffering, which are often subjective. Accurate cost estimates can be used to demonstrate the disproportionate burden of alcohol-related harms to inform the development and implementation of prevention strategies (Domínguez & Raphael, 2015; Hahn et al., 2012). Therefore, future research could be conducted to update estimates of costs of violent crime from a societal perspective.

Last, the DALY estimates were from a 2005 study in the United Kingdom. Although the authors of this study used more rigorous methods to generate these DALY estimates, it is possible that frequency and years of life lost from homicide differ in the United States and the United Kingdom. Therefore, researchers could also aim to update estimates of DALYs for violent crime to facilitate comparisons of policy proposals across public health domains.

Still, this analysis demonstrates the potential opportunities to prevent violent crimes inherent in alcohol outlet density zoning policies. In the United States, there is an emergent trend in which individual states (e.g., privatizing alcohol sales in Washington in 2011) and local jurisdictions (e.g., Lubbock, TX, adding 140 off-premise alcohol outlets in 2009) are rolling back regulations on alcohol outlet access. Although retrospective analyses document the public health consequences of these decisions (Gorman et al., 2018; Tabb et al., 2016), using cost-effectiveness analysis to quantify potential burdens and benefits could support evidence-based policy decisions prospectively.

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