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ARTICLE

Understanding the relationship between alcohol outlet density and life expectancy in Baltimore City: The role of community violence and community disadvantage

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Abstract

This research investigated the relationship between alcohol outlet density (AOD) and life expectancy, as mediated by community violence and community disadvantage. We used linear regression models to assess bivariate and multivariate relationships. There was a negative bivariate association between liquor store density and average life expectancy ($\beta = -7.3370$, $p < 0.001$). This relationship was partially attenuated when controlling for community disadvantage and fully attenuated when controlling for community violence. Bars/taverns (i.e., on-premise) were not associated with average life expectancy ($\beta = -0.589$, $p = 0.220$). Liquor store density is associated with higher levels of community disadvantage and higher rates of violence, both of which are associated with lower life expectancies. Future research, potential intervention, and current related policies are discussed.

1 | INTRODUCTION

Research has found that alcohol outlet density (AOD), defined as the "number of physical locations in which alcoholic beverages are available for purchase either per area or per population" (Campbell et al., 2009, p. 556), can contribute to morbidity, increased alcohol consumption, shorter life expectancy, and mortality (Gonzales et al., 2014; Major et al., 2014; Richardson, Hill, Mitchell, Pearce, & Shortt, 2015). High AOD has been associated with a variety of public health concerns, including increased violence, crime, traffic accidents, injuries, and driving after drinking (Campbell et al., 2009; Popova, Giesbrecht, Bekmuradov, & Patra, 2009). Although research on AOD and public health outcomes has had some inconsistency (Cunradi, Mair, Ponicki, & Remer, 2012; Kelleher, Pope, Kirby, & Rickert, 1996; Lipton & Gruenewald, 2002; Schonlau et al., 2008; Pollack, Cubbin, Ah, & Winkleby, 2015), meta-analyses have found sufficient

evidence to recommend alcohol outlet density regulation as a potential public health tool (Campbell et al., 2009); further, the World Health Organization has also advocated the use of AOD regulation and restriction to mitigate alcohol-related harms.

The spacing and placing of alcohol outlets also has significant racial and class consequences. Low-income, majority–minority communities have been found to have higher concentrations of alcohol outlets than wealthier areas (LaVeist & Wallace, 2000; Hay et al., 2009). In addition, the negative effects of alcohol outlets are amplified in these communities as compared to higher income ones (Mair et al., 2013). As such, distressed neighborhoods often suffer the greatest public health consequences of alcohol outlet oversaturation. Given the inherent issues of racial and class equity surrounding the placement of these outlets, some inconsistency in the literature, the potential for AOD regulation and reduction to increase social health, and the advocacy of experts and health organizations to limit AOD, studies examining the affect these outlets have on health have never been more important or timely.

Baltimore City has long considered AOD to be a major concern. In 1968, the Balitmore City Liquor Board issued a moratorium on new liquor licenses, and in 1971, the zoning code disallowed off-premise outlets in residential areas (Thornton, Greiner, & Jennings, 2013), although currently existing outlets were allowed to remain and labeled as "nonconforming." As recently as 2011, residents in 50% of Baltimore City Council districts identified AOD as one of the primary neighborhood health concerns (Baltimore City Health Department, 2011), and in 2017, the first zoning code rewrite in 30 years went into effect, creating additional regulations on alcohol outlets within the city (TransForm Baltimore, 2016). Further, despite some of the inconsistency in the literature at large, research from Baltimore City has been more consistent; the negative effects of liquor stores in Baltimore neighborhoods have been especially salient and damaging to community health and safety (Furr-Holden et al., 2016; Jennings et al., 2013).

Although alcohol outlet density has been linked to alcohol-related mortality (Kanny et al., 2015; Richardson et al., 2015; Zhao et al., 2013), little is known about its relationship to all-cause mortality (Matheson, Creatore, Gozdyra, Park, & Ray, 2014; Spoerri, Zwahlen, Panczak, Egger, & Huss, 2013). However, there is reason to suspect that the effect of alcohol outlets on mortality extends beyond alcohol consumption. Consumption patterns alone cannot adequately explain the wide discrepancy in all-cause mortality and alcohol-related harms between communities with high AOD and those with lower AOD (LaVeist & Wallace, 2000; Pollack, Cubbin, Ahn, & Winkleby, 2005).

Cities such as Baltimore suffer from large variations in life expectancy by neighborhood (Baltimore Neighborhood Indicators Alliance, 2016; Murray et al., 2006), with a more than 20-year gap between the healthiest and unhealthiest neighborhoods, despite only a 3-mile distance (4.8 km) between the two communities (Baltimore Neighborhood Indicators Alliance, 2016). This discrepancy has been attributed to the distribution of social (Cornwell & Cornwell, 2008) and health resources (Cooper, Bossak, Tempalski, Friedman, & Des Jarlais, 2009; Sarrazin, Campbell, Richardson, & Rosenthal, 2009) across communities. Alcohol outlets, along with check cashing establishments (Matheson et al., 2014), drug treatment centers, corner stores (Furr-Holden et al., 2014), and a host of other potentially predatory businesses have been identified as locations that disrupt and damage the social infrastructure of a community (Laviest & Wallace, 2000). Further, not only are alcohol outlets, specifically, forms of physical disorder (Bennet et al., 1996) in and of themselves, but they also shape the ecology of the neighborhoods and communities and may disrupt the distribution of these resources.

By better understanding the effects of structural and built environmental influences on these health disparities, scholars may be able to identify effective strategies for reducing differential health outcomes. This research investigates the role of alcohol outlets in contributing to the health and all-cause mortality disparities in Baltimore, Maryland.

2 | BACKGROUND

Alcohol outlets can be either on-premise, where alcohol is purchased and consumed at the same location (such as bars, taverns, and restaurants), or off-premise, where alcohol is purchased in one location but consumed in another (such as grocery stores or liquor stores; Campbell et al., 2009; Milam, Furr-Holden, Cooley-Strickland, Bradshaw, & Leaf, 2014). Research has found that both on-premise and off-premise outlets have different effects on their communities.

High off-premise AOD has been found to increase problematic drinking behaviors (Ahren et al., 2013), increase suicide (Escobedo & Ortiz, 2002), increase alcohol-related motor vehicle accidents (Gruenewald et al., 2010), increase community crime (Jennings et al., 2014; Pridemore & Grubesic, 2013) and increase local violence (Parket et al., 2011; Livingston, 2011). The research on on-premise outlets has been less robust but suggests that these outlets may increase violence (Franklin, Laveist, Webster, & Pan, 2010), increase the frequency of alcohol consumption (Gruenewald, Remer, & LaScala, 2014), increase the volume of alcohol consumption (Gruenewald et al., 2014), and increase traffic accidents (Gruenewald et al., 2010; Treno et al., 2007).

The relationship between high AOD and violence is especially salient and enduring (Branas, Elliott, Richmond, Culhane, & Wiebe, 2009; Branas, Richmond, Ten Have, & Wiebe, 2011; Franklin et al., 2010; Jennings et al., 2014; Furr-Holden et al., 2016). In Baltimore, Jennings et al. (2014) found that each addition liquor store was associated with a 2.2% increase in violent crime. A Washington, D.C., study found a positive relationship between AOD and robbery, aggravated assault, and sexual violence (Franklin et al., 2010). Branas and colleagues' (2009, 2011) found positive relationships between AOD and self-inflicted gun would as well as risk of being assaulted with a gun. One explanation for the relationship between AOD and violence is that alcohol outlets, along with a host of other predatory businesses, can cause disruption to the social infrastructure (Wallace & LaVeist, 2000) of a community.

Alcohol outlets, however, have a particularly large effect on the communities and neighborhood they are in. In one study, Furr-Holden and colleagues (2015) found that, even when compared directly to convenience stores, drug treatment centers, and corner stores, liquor stores were more strongly associated with violent crime, suggesting that the presence of alcohol outlets in a community has a particular effect on the ecology of that neighborhood. This suggests that alcohol outlets may have a unique, health-harming effect on their communities that other businesses may not. Despite these findings surrounding alcohol density and violence, the pathways through which violence and other important community characteristics might link alcohol availability to increased risk for mortality are largely unexplored (LaVeist & Wallace, 2000; Pollack et al., 2005).

The evidence that community disadvantage affects life expectancy is overwhelming–often referred to as the social determinants of health. Although the research on how community affects life expectancy is large and complex, Braveman and Gottlieb (2014), in their broad review, highlight the importance of chronic stress of poverty, low-quality housing, and the exposure to violence as having long-term detrimental effects on physical health. Children born into families at or below the poverty level are significantly more likely to have problematic health (Braveman & Gottlieb, 2014), and adults with less than a high school education are significantly more likely to be in poor or fair health than their higher educated peers (Bravement & Gottlieb, 2014). Alcohol outlets tend to cluster in poor, majority–minority communities (LaVeist & Wallace, 2000; Morrison, 2015; Rossheim, Thombs, Wagenaar, Xuan, & Aryal, 2015) and are overwhelmingly represented in Black communities, even after controlling for socioeconomic status (LaVeist & Wallace, 2000).

Some research suggests that high AOD may also directly impede economic growth and community development. Areas with high rates of community violence and high AOD may be less attractive locations to other businesses, including businesses that fill vital community needs such as grocery stores and laundry mats (Theall et al., 2009), and ultimately inhibiting the community's ability to increase local collective efficacy. This in turn can increase, cause, or perpetuate community disadvantage. This is particularly concerning because it suggests that the communities least equipped to handle the public health burden of high AOD are those with the highest concentration of alcohol outlets.

Finally, both location and density of alcohol outlets also are associated with physical health consequences. Studies have shown that living within 1,000 meters of an alcohol outlet increases alcohol-related mortality for both men and women (Spoerri et al., 2013), and an increase in AOD significantly increased alcohol-related death in communities (Stockwell et al., 2011). Higher community AOD is associated with higher rates of consumption (Popova, 2009), which is associated with increased alcohol morbidity, such as liver disease (Jiang et al., 2014). However, AOD has also been linked to nonalcohol-related mortality outcomes. One study found that an increase in AOD was associated with male all-cause mortality (but not with female all-cause mortality; Livingston & Wilkinson, 2013), while another found a

positive relationship between AOD and premature mortality, even after controlling for poverty (Matheson et al., 2014). This research, however, has not consistently controlled for community disadvantage or violence and has been largely conducted outside of the United States.

2.1 | Current study

The current investigation uses an ecological framework to examine the relationship between AOD and all-cause mortality in Baltimore City, Maryland. We have two hypotheses: first, that there is a direct, negative bivariate relationship between AOD and overall life expectancy in years; and second, that this relationship will be mediated by community disadvantage and community violence. We also include measures of median household income and racial composition to control for known confounders. This study fills several gaps in the literature. First, this research looks at the path through which AOD may affect all-cause mortality (not just alcohol-related mortality) through mediating community characteristics, such as community disadvantage and violence. Second, we explore whether the relationship between AOD and all-cause mortality varies by alcohol outlet type (on-premise vs. off-premise). Finally, our research examines whether these relationships are affected by community race or income measures.

Baltimore City has 621,000 residents and spans 81 square miles. The population density is 7,671.5 people per square mile, making Baltimore the 13th most densely populated city in the United States (U.S. Census Bureau, 2010). Although the citywide median household income in 2010 was $41,819, more than one third of the city's households earn less than $25,0000 annually (U.S. Census Bureau, 2010). As of 2010, Baltimore City was approximately 64% African American and 28% non-Hispanic White.

Because alcohol control policies are decentralized in Maryland, each county or independent city writes and enforces alcohol laws independently. However, despite the hypothetical possibility of wide variation of policies determining the location of alcohol outlet and alcohol outlet clusters, nearby counties (such as Baltimore County) have similar zoning and alcohol regulatory laws; as such, there is no reason to believe there is spatial variation in outlet distribution. This is not the case with all counties and independent cities in Maryland, however, and should be considered in future work.

2.2 | METHOD

This cross-sectional analysis used publicly available data from a variety of sources. Our unit of analysis is the community statistical areas (CSA) in Baltimore City (N = 55). CSAs are clusters of neighborhoods delineated by Baltimore City's Planning Department based on recognizable city neighborhoods and are used to compare a variety of health indicators across neighborhoods (Baltimore Neighborhood Indicators Alliance, 2016). CSAs vary in size, economic composition, and racial composition. The smallest CSA has a population of 4,101 residents, while the largest CSA has a population of 23,557 (Baltimore Neighborhood Indicators Alliance, 2016). CSA median household incomes vary from a low of $14,105 to a high of $104,770 (Baltimore Neighborhood Indicators Alliance, 2016). Finally, the racial diversity index—the percent chance that two people picked at random within an area will be of a different race/ethnicity—ranged from 7.3 to 77.8 across CSAs (Baltimore Neighborhood Indicators Alliance, 2016).

We obtained both on-premise and off-premise alcohol outlet location data for 1,340 businesses for 2010 from the Board of Liquor License Commissioners for Baltimore City. Next, we obtained life expectancy data for 2011 from the Baltimore Neighborhood Indicators Alliance (BNIA), a nonprofit organization that organizes and compiles data from government agencies, local businesses, and universities. The BNIA also supplied data on median household income and total population of CSAs. Our measure of community disadvantage is an index modeled on Ross and Mirowsky's (2001) work; it was created using items from the 2007–2011 American Community Survey. Finally, we obtained violent crime data for 2010 from the Baltimore City Police Department.

2.3 | Outcome measure

2.3.1 | Life expectancy

We defined life expectancy as the average number of years a newborn born in 2011 can expect to live based on the 2011 death rates. We aggregated these individual level data to the CSA level. Because the life expectancy in one CSA was more than three standard deviations greater than the overall mean life expectancy, it was excluded from analysis. The resulting analytic sample included 54 distinct communities. The median life expectancy for the 54 CSAs was 72.8 years, ranging from a low of 64 years to a high of 88 years.

2.4 | Independent and mediating measures

2.4.1 | Alcohol outlet data

We obtained data on 1,340 outlets licensed to sell alcohol in 2010 from the Board of Liquor License Commissioners for Baltimore City. The data included location and license type of each facility. These data were geocoded in ArcGIS (version 9), with 97.5% of addresses successfully placed. The geocoded alcohol outlet data layer was joined with the CSA data layer using ArcGIS' spatial join tool (appends data from one map layer to another map layer using geographic location) to determine the number of alcohol outlets in each CSA.

There are 12 liquor license types administered by the board. Because Baltimore City prohibits the sale of alcohol in grocery stores and corner stores, nearly all alcohol purchases come from businesses with one of three alcohol sales licenses: LA, LA2, or LBD-7. There are no restrictions on proximity of alcohol outlets to schools or churches in Baltimore City. Restaurants, nonprofit private clubs, arenas, and hotels are licensed separately and were excluded from this analysis because we are primarily interested in the effects that alcohol-related businesses have on all-cause mortality.

Alcohol outlet density measures for both on- and off-premise were created using the number of alcohol outlets for each license class type divided by the population of the corresponding CSA in thousands. The outlets were classified into on-premise (bars and taverns that sell alcohol for on-site consumption only) and off-premise alcohol outlets (package goods stores that sell alcohol for off-site consumption only; Branas et al., 2009; Jennings et al., 2014) based on the liquor license type.

LA/LA2 (N = 242) licenses are package good stores that are open 6 days a week (no Sunday sales) from 6 a.m. to midnight and do not allow on-premise consumption. As such, outlets with LA/LA2 licenses were labeled off-premise alcohol outlets for this research. LBD-7 (n = 501) licenses are bars/taverns that are open 7 days a week (Sunday sales allowed) from 6 a.m. to 2 a.m. and do allow on-premise consumption. LBD-7s also have the capacity to sell packaged goods (such as bottled alcohol) for off-premise consumption, but may choose not to at the owner's discretion. LBD-7s are also the only license class allowed in certain restrictively zoned residential neighborhoods. This is because off-premise licenses, such as LA/LA2, were designated as inappropriate for residential zones in the Baltimore City zoning code of 1971 (Friedman, 2015). As such, LBD-7s have the most location options. Because LBD-7s are licensed as taverns, they are expected to devote at least half of their sales and floor space to on-site consumption (Baltimore City Department of Planning, 2009). As such, outlets with LBD-7 licenses were labeled on-premise alcohol outlets for this research.

2.4.2 | Violent crimes

We obtained violent crime data for 2010 from the Baltimore City Police Department. For these analyses, we used the four offenses identified as index violent crimes in the Federal Bureau of Investigation's Uniform Crime Report (UCR): rape, aggravated assault, homicide/manslaughter, and armed robbery (n = 9,746). Because the UCR is a national reporting system, by using the FBI's standard definition of "violent crime," our results are more comparable to other national and state-level statistics (for more information on the UCR, the FBI definition of violent crime, or how our analyses compare to other crime rates, please go to the Uniform Crime Report section of the FBI website.)

2.4.3 | Community disadvantage

A community disadvantage score was calculated using items from 2007–2011 American Community Survey at the census-tract level. The items used to create the index include the percentages of (a) adults ≥25 years with a college degree, (b) owner-occupied housing, (c) households with incomes below the federal poverty threshold, and (d) female-headed households with children. The formula, as outlined in Ross and Mirkowsky (2001), that we used to generate the index is {[(c/10 + d/10)−(a/10 + b/10)]/4}. Each one-unit increase in the community disadvantage score is equivalent to a 10% increase (households below poverty, female-headed households) or decrease (college degrees, owner-occupied) of each component of the index. The total score has a possible range from −5 to +5, where −5 is very low/little disadvantage, and +5 is very severe disadvantage.

2.4.4 | Median household income and race

Finally, because of the well-established association between area income and area racial composition and all-cause mortality, we also included measures of median household income and race as controls in our model. Median household income and race, operationalized as percent African American, were obtained from the 2007–2011 American Community Survey at the census-tract level.

2.5 | Statistical analysis

We conducted univariate, bivariate, and multivariate analytic procedures. Descriptive statistics provided the distribution of the measures used for this study. Spearman correlations quantified the independent associations between variables. Next, we conducted linear regression analysis (ordinary least squares) to assess the relationship between alcohol outlet density and life expectancy in different models and other mediating factors (see Baron & Kenny, 1986; Judd & Kenny, 1981). Although some scholars suggest that mediation analysis can only be used with either experimental or longitudinal data (Maxwell, Cole, & Mitchell, 2011), other seminal works have used mediation analysis with cross-sectional data (Rudy, Kerns, & Turk, 1988). Further, because of the paucity of research concerning the relationship between AOD, all-cause mortality, and other community factors, we consider this work to be exploratory in nature and encourage future research to test our model longitudinally.

Regression models were estimated separately for package goods-only alcohol outlets (LA/LA2 class alcohol outlets) and bars/taverns (LBD7 class alcohol outlets). Model 1 estimated bivariate linear regression coefficients for the predictors (e.g., package goods outlet density and bar/tavern outlet density) and mediators (e.g., community disadvantage and crime density). Model 2 was a semiadjusted model that regressed life expectancy on alcohol outlet density adjusting for community disadvantage, while Model 3 assessed this relationship adjusting for violent crime density. Model 4 examined the association between alcohol outlets and life expectancy while adjusting for community disadvantage and violent crime density. The stepwise models were estimated to assess community disadvantage and violent crime density as potential mediators in the relationship between alcohol outlet density and life expectancy.

Moran's *I* was used to assess spatial autocorrelation in the outcome of interest, life expectancy. Preliminary analysis indicates a positive but statistically insignificant spatial autocorrelation for life expectancy (Moran's $I = 0.85$, $p = 0.10$). Due to Tobler's Law, spatial autocorrelation exists within a variable if closer observations have related values. Moran's *I* tests for spatial autocorrelation and was used to assess the outcome of interest, life expectancy. Preliminary analysis indicates a positive but statistically insignificant spatial autocorrelation for life expectancy (Moran's $I = 0.85$, $p = 0.10$). In this case, we failed to reject the null hypothesis (life expectancy is randomly distributed among CSAs in the study area). A significant Moran's I indicates spatial autocorrelation, which violates assumptions for regression analyses. Moran's *I* was also computed for the residuals of the linear regression models to determine if there was remaining spatial autocorrelation (Waller & Gotway, 2004). There were no missing data. Significant findings were reported for p-values below 0.05. Stata (version 11.0), R version 3.2, and IMB SPSS (version 22) were used for statistical analyses. All geocoding and spatial analyses were conducted using ArcGIS.

TABLE 1 Descriptive characteristics of 54 community statistical areas in Baltimore City, 2011

	Mean	*SD*
Alcohol outlet density, *per 1,000 residents*	25.3	31.1
Bar/tavern density	10.1	13.6
Liquor store density	4.1	3.2
Community disadvantage	−0.0052	1.2
Violent crime density, *per 1,000 residents*	164.4	109.0
Life expectancy	72.8	4.7
Median household income, *in thousands*	42.0	17.2
Percent African American	62.3	33.7
Total population, *in thousands*	11.1	4.3

Note. SD = standard deviation.

TABLE 2 Spearman correlations among neighborhood characteristics of 54 community statistical areas and life expectancy in Baltimore City, 2011

	Alcohol outlet density	Bar/ tavern density	Liquor store density	Community disadvantage	Violent crime density	Median household income	Life expectancy
Alcohol outlet density	–						
Bar/tavern density	.925**						
Liquor store density	.666**	.569**					
Community disadvantage	−.069	−.014	.357**				
Violent crime density	.379**	0.404**	.519**	.729**			
Median household income	−0.010	−0.045	−.389**	−.914**	−.712**		
Life expectancy	−.118	−0.224	−.376**	−.788**	−.737**	.759**	
% of African Americans	−.505**	−.466**	.029	.690**	.388**	−.637**	−.594

*$p < .05$. **$p < 0.01$. ***$p < .001$.

3 | RESULTS

3.1 | Sample description

The mean population of the 54 CSAs was approximately 11,100 (standard deviation [*SD*] = 4,300), and the median household income was $42,000 (*SD* = $17,200) (Table 1). The average percent African American was 62.3 (*SD* = 32.7). The mean life expectancy was 72.8 (*SD* = 4.7). The mean alcohol outlet density was 2.53 outlets per community per 1,000 residents (*SD* = 31.1), ranging from 0.0 to 15.4. The mean violent crime rate was 16.4 incidents per 1,000 residents (*SD* = 10.9) and ranged from 1.76 to 71.8.

3.2 | Bivariate analysis examining associated factors of life expectancy

Table 2 shows a significant negative bivariate associations between life expectancy and (a) liquor store density ($r = -.376$, $p < .01$); (b) community disadvantage ($r = -.788$, $p < .01$); and (c) community violence ($r = -.737$, $p = -.01$). There was, however, a significant positive relationship between life expectancy and median household income ($r = .759$, $p < .01$). No significant relationship was found between life expectancy and overall alcohol outlet density or bar/tavern density.

In addition, there was a significant positive relationship between community disadvantage and liquor store density ($r = .357$, $p < .01$). Violent crime rate was also significantly, positively associated with overall alcohol outlet density

TABLE 3 Results from linear regression models assessing the relationship between alcohol outlet density and life expectancy across 54 community statistical areas, Baltimore City, 2011

	Model 1: Bivariate models β (*SE*)	Model 2: Semiadjusted[a] β (*SE*)	Model 3: Semiadjusted[a] β (*SE*)	Model 4: Fully adjusted[a] β (*SE*)
Liquor store density	−7.337 (1.774)***	−4.273 (1.399)**	.214 (2.067)	−1.032 (0.849)
Bar/tavern density	−.589 (0.475)			
Community disadvantage	−2.827 (0.378)***	−2.447 (0.373)***		−1.845 (0.418)***
Violent crime density	−.308 (0.423)***		−.312 (0.373)***	−0.165 (0.062)**
Moran's *I* (spatial correlation)				0.039

Note. SE = standard error.
[a]Adjusted for other covariates in the column.

($r = .379$, $p < .01$), bar/tavern density ($r = .404$, $p < .01$), liquor store density ($r = .519$, $p < .01$), and community disadvantage ($r = .729$, $p < .01$). Furthermore, median household income was significantly, negatively associated with liquor store density ($r = -.389$, $p < .01$), community disadvantage ($r = -.914$, $p < .01$), and violent crime density ($r = -.712$, $p < .01$).

3.3 | Multivariate analysis examining associated factors of life expectancy

Table 3 presents the estimated multivariate models examining the relationship between alcohol outlet subtypes and life expectancy for the 54 CSAs. Model 1 estimated bivariate linear regression coefficients for the predictors (liquor store outlet density and bar/tavern density) and hypothesized mediators (community disadvantage and violent crime density) on average life expectancy. For every 1-unit increase in liquor store outlet density, there was a 7.3-year decrease in life expectancy ($\beta = -7.34$, $p < 0.001$). Community disadvantage ($\beta = -2.83$, $p < 0.001$) and violent crime density ($\beta = -0.31$, $p < 0.001$) were also negatively associated with life expectancy. Although not significant, the relationship between bar/tavern outlet density (on-premise) and average life expectancy was in the hypothesized direction ($\beta = -0.59$, $p = 0.220$).

In Model 2 (semiadjusted model), we regressed life expectancy on liquor store density (off-premise AOD), adjusting for community disadvantage. Because there were nonsignificant findings in the bivariate analysis for bar/tavern outlet density (on-premise), we did not conduct semiadjusted or fully adjusted models for this outlet type. The results show that community disadvantage ($\beta = -2.45$, $p = 0.003$; Moran's $I = 0.19$, $p = 0.048$) attenuated the relationship between liquor store outlet density and life expectancy. For every unit increase in liquor store outlet density, there was corresponding 4.3-year decrease in life expectancy ($\beta = -4.273$, $p =$); for every 1-unit increase in community disadvantage, there was a corresponding 2.44 decrease in average life expectancy.

In Model 3, adjusting for crime rate, the relationship between liquor store density ($\beta = 0.21$, $p = 0.918$; Moran's $I = 0.11$, $p = 0.059$) and life expectancy was attenuated and became nonsignificant, suggesting that community violence fully mediates the relationship between life expectancy and liquor store density. For every 1-unit increase in community violence, there was a corresponding .31-year life expectancy decrease; this suggests that for every violent crime in an area, average life expectancy decreases by one third of a year. The relationship between community violence and liquor store density, however, remains significant; for every 1-unit increase in violent crime density, there was a .32 decrease in number of years for life expectancy ($\beta = -.31$, $p < .001$).

Finally, in Model 4, we examined the association between liquor store outlet density and life expectancy while adjusting for community disadvantage and violent crime density. The coefficient for liquor store density was nonsignificant ($\beta = -1.03$, $p = 0.568$; Moran's $I = 0.39$, $p = 0.220$). Both violent crime ($\beta = -0.165$, $p = 0.01$) and community disadvantage expectancy ($\beta = -1.845$, $p = < .001$) remained significant. For every 1-unit increase in violent crime density, there was a .165 decrease in the number of years of life expectancy; for everyone 1-unit increase in community disadvantage, there was a 1.845 decrease in years of life expectancy. To test whether this attenuated effect met

criteria for mediation (Baron & Kenny, 1986), we regressed violent crime density and community disadvantage on liquor store outlet density. Both were significant. For every unit increase in liquor store density, there was also an increase in violent crime density ($\beta = 24.18$, $p < 0.001$) and community disadvantage ($\beta = 1.25$, $p = 0.014$).

Because our sample size is small, and therefore potentially reducing the power, we decided to compute a post hoc power analysis. Using Stata (version 15.1) calculated the power we achieved for the relationship between off-premise outlets and life expectancy. Using a post hoc R-squared test of coefficients (the relationship between liquor store density and life expectancy), we found that we achieved sufficient power to detect a difference. With an alpha of .05, a sample size of 54, an R-Squared of .187, and 1 covariate, the model has 93% power.

4 | DISCUSSION

By damaging the social infrastructure of a community and making it less attractive to less problematic businesses, ecological theories suggest that predatory businesses can damage community health. Although we recognize that other businesses may also contribute to community ecology that is health harming, we chose to consider AOD because of the unique relationship between alcohol outlet density and violence in Baltimore City (Jennings et al., 2014; Furr-Holden et al., 2015). This investigation sought to begin the investigation into whether this exceptionally strong relationship held with other health outcomes in Baltimore City, including all cause mortality. Although other studies have found a direct, negative relationship between alcohol outlets and all-cause mortality, even after controlling for poverty (Matheson et al., 2014), we found a significant, negative bivariate relationship between liquor store density and life expectancy that was mediated by community disadvantage and community violence.

Our final model suggests that the harms of liquor store density on life expectancy do not operate directly; rather, they are mediated through community violence and community disadvantage. It is possible that there is a direct effect between AOD and all cause mortality after controlling for community disadvantage and violence, and that the model is underpowered because of the small sample size. However, we do not suspect this is the case. First, when we calculated a post hoc power analysis, we found that our model had 93% power. Next, as our models evolved, liquor store density not only decreased in significance, but also in effect size. In our first bivariate model, every 1-unit increase in alcohol outlet density decreased life expectancy by approximately 7 years; however, in our fully adjusted model, a 1-unit increase in liquor store density decreased life expectancy only by 1 year. While another important aim of the study was to understand the association between bars/taverns (on-premise) and life expectancy, we did not find a significant relationship between the two, even though the results were in the hypothesized direction.

Although there was no direct relationship between AOD and life expectancy in our fully adjusted model, policies limiting liquor store concentration may still be able to increase life expectancy by decreasing the violence associated with liquor stores. Liquor stores have long been found to have a robust and enduring relationship to violence in Baltimore City (Jennings et al., 2014; Furr-Holden et al., 2015). By decreasing the saturation of liquor stores in these communities, Baltimore City officials may be able to mitigate the public health consequences caused by their associated violence. There is little research on how community health is affected after a decrease in alcohol outlet saturation in a community.

Yu and colleagues (2008) found that after the 1992 Civil Unrest in Los Angeles, communities that had alcohol outlets destroyed had a significantly greater decrease in crime than communities without destroyed outlets for the following 5 years. There is also a fairly robust literature suggesting that limiting AOD in communities, as well as restricting hours and days of sales for alcohol, can decrease a variety of public health concerns, such as (over)consumption, problematic drinking patterns, and violence (Popova et al., 2009). This suggests that purposeful intervention to limit alcohol accessibility by decreasing AOD, particularly in Baltimore City, may be a fruitful avenue to decrease violence, increase community health, and reshape the social infrastructure of these communities.

4.1 | Limitations

This study has several limitations. First, our analyses relied on cross-sectional data, which does not allow us to make claims of causality. Although our conceptual model posits that AOD causes community violence and community disadvantage, which ultimately results in decreased life expectancy, it is equally plausible that community disadvantage causes AOD and community violence, for example. In the absence of experimental or longitudinal data, temporal ordering cannot be established. To our knowledge, there are no U.S.-based studies that prospectively examined the health effects of introducing liquor stores into a community over time. Similarly, with the exception of the Yu et al. (2008) study noted above, there is very little research examining the reduction of AOD over time (Campbell et al., 2009).

Next, there are several well-known limitations to using the summary statistics of the UCR. First, because these data rely on formal arrest data, any crimes not brought to the attention of police are, by definition, uncounted. Next, the UCR relies on the "hierarchy rule," which means that if multiple crimes occur during the commission of one incident (for example, in the course of a robbery, two people are assaulted and one is killed), only the most severe crime is counted (in our example: only the murder is recorded).

Further, by using the UCR violence definition, there may also be a modest bivariate relationship between violent crime and life expectancy. Homicide/manslaughter results in death, which (by definition) is premature mortality; however, homicide and manslaughter make up an extremely small percentage of the violent crimes counted, and other violent crimes (e.g., robbery, aggravated assault), by definition, do not involve a death. These crimes accounted for the vast majority of violent crime in Baltimore City. Future scholars may want to consider using victimization data, such as the National Crime Victimization Survey, to determine whether AOD is related to violence victimization in addition to violence arrest. Ultimately, all three of these considerations may result in an underestimation of criminal activity.

Finally, we did not control for social (e.g., gender), structural factors (e.g., segregation, discrimination), or other predatory businesses, which previous research suggests may also exert an influence on community health (Matheson et al., 2014). We were also unable to model the effects of potential protective factors, such as churches or other social support organizations. Ultimately, this limitation highlights the difficultly in disentangling the presence (or absence) of healthful structural and social supports from the presence of alcohol outlets in these communities.

4.2 | Conclusion

Despite these limitations, we believe this work is imperative and timely, given recent changes in Baltimore City alcohol zoning regulation. In December of 2016, Baltimore City approved the first major zoning rewrite in over 30 years, *TransForm Baltimore*. There are three components of the law, which, if appropriately enforced, have the ability to vitally change the alcohol landscape in the city. First, TransForm Baltimore requires all LA/LA2 that were made nonconforming in 1968 to either move to another location in the city or to change their business model to one that conforms to their residential zone. Second, the rewrite requires LBD-7s to operate with a business model that is appropriate for a tavern/bar by instituting a minimum requirement for on-premise and food sales; this limits LBD-7′s from functioning as de-facto, illegitimate LA/LA2. Finally, TransForm Baltimore requires all new liquor stores be at least 300 feet from any other alcohol outlet.

This natural experiment and it's purposeful, public health framework, combined with our unique relationships with the Baltimore City officials, allow us to address some of these prime limitations from this study in subsequent investigations. As TransForm Baltimore is enforced in upcoming years, the number of LA/LA2 will be reduced in the city, and the distribution of the remaining outlets will be significantly different. Because there is currently very little research on the effects of alcohol outlets on all-cause mortality (Matheson et al., 2014; Spoerri et al., 2014) and because there are no studies on the planned and purposeful reduction in AOD to increase community health, this study serves.

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