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Alcohol outlets, drug paraphernalia sales, and neighborhood drug overdose

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Abstract

BACKGROUND: Alcohol outlets have been associated with various forms of injury and may contribute to neighborhood disparities in drug overdose. Few studies have examined the associations between alcohol outlets and drug overdose. This study investigated whether alcohol outlets were associated with the neighborhood drug overdose rate and whether the sale of drug paraphernalia contributes to this association.

METHODS: A cross-sectional ecological spatial analysis was conducted within census block groups in Baltimore City (n=653). Outcomes were counts of EMS calls for any drug overdose in 2015 (n=3,856). Exposures of interest were counts of alcohol outlets licensed for off-premise and on-premise consumption and the proportion of off-premise outlets selling drug paraphernalia (e.g., blunt wrappers, baggies, pipes). Negative binomial regression was used to assess the relationship between outlet count and overdose rate, and if paraphernalia sales altered this relationship,

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Ethical approval: This research was approved by the Institutional Review Board at the Columbia University Medical Center. All procedures performed were in accordance with the ethical standards of the Columbia University Medical Center's Institutional Review Board and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent: This study performed secondary data analysis on a de-identified dataset. At no time did authors have access to identifying information for EMS patients; consequently, informed consent was not necessary.

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controlling for other neighborhood factors. Spatial autocorrelation was assessed and regression inference adjusted accordingly.

RESULTS: Each additional off-premise alcohol outlet was associated with a 16.6% increase in the neighborhood overdose rate (IRR=1.17, 95%CI=(1.11, 1.23)), adjusted for other neighborhood variables. On-premise alcohol outlets were not significantly associated with overdose rate when adjusting for off-premise alcohol outlets (IRR=1.01, 95% CI=(0.97, 1.06)). The proportion of off-premise outlets that sold drug paraphernalia was negatively associated with overdose rate (IRR=0.55, 95% CI=(0.41, 0.74)) and did not alter the relationship between off-premise outlets and overdose.

CONCLUSION: This study provides preliminary public health evidence for informing policy decisions about alcohol outlet licensing and zoning. Alcohol outlets could be potential community partners for harm reduction strategies such as health communication in identifying overdose symptoms or Good Samaritan Laws.

Keywords

drug overdose; alcohol outlets; paraphernalia; neighborhoods

INTRODUCTION

From 1999 to 2017, the prevalence of illegal drug use and fatal drug overdose significantly increased in U.S. cities, with an average annual increase of 17% for fatal drug overdose from 2014 to 2017 (Hedegaard et al., 2019; Mack et al., 2017). The rate of drug overdose in urban counties currently surpasses that in rural counties, and urban areas report higher rates of overdoses involving heroin, cocaine, and synthetic opioids such a fentanyl (Hedegaard et al., 2019). At the same time, there are significant disparities in drug overdose rates across urban neighborhoods (Nesoff et al., 2020). Previous studies of drug overdose in urban areas point to neighborhood social and physical characteristics as important overdose risk factors (Cerdá et al., 2013; Hannon & Cuddy, 2006; Hembree et al., 2005; Nandi et al., 2006; Nesoff et al., 2020). Further inquiry into neighborhood context is critical to reduce disparities in drug overdose rates across urban neighborhoods.

Alcohol outlets may be one neighborhood feature that can potentially contribute to neighborhood disparities for drug overdose. Areas in close proximity to alcohol outlets may present as opportune locations for illegal drug sales as alcohol outlets are often located in communities with low social capital and collective efficacy (LaVeist & Wallace, 2000; Theall et al., 2009). People who use drugs (PWUDs) with co-occurring alcohol use disorder may frequent alcohol outlets, particularly those that sell drug paraphernalia, because communities with low social capital may be less able to resist the establishment of drug markets in their neighborhoods (McCord & Ratcliffe, 2007; Milam, Furr-Holden, Harrell, et al., 2014). More alcohol outlets are generally found in economically depressed, predominantly-minority neighborhoods, exacerbating health disparities in these communities (Berke et al., 2010; LaVeist & Wallace, 2000).

Furthermore, the type of alcohol outlet may impact neighborhood drug overdose differently. Alcohol outlets licensed to sell alcohol for off-premise consumption are more strongly associated with drinking problems, crime, and violence compared to outlets licensed for on-premise consumption only (Branas et al., 2011; Furr-Holden et al., 2016; Han et al., 2016; Schonlau et al., 2008). Off-premise settings include liquor and package stores and taverns that sell liquor, beer, and wine; on-premise settings include restaurants, bars, hotels, and entertainment venues (Campbell et al., 2009; Milam, Furr-Holden, Cooley-Strickland, et al., 2014). Unlike on-premise outlets, off-premise alcohol outlets can sell alcoholic beverages in large quantities that are distributed to patrons who are unmonitored by servers and often left to drink in nearby, uncontrolled environments such as motor vehicles, parking lots, or street corners (Branas et al., 2009; LaVeist & Wallace, 2000). Consequently, off-premise outlets are often surrounded by signs of alcohol consumption, such as empty or broken bottles, loiterers, and publicly intoxicated patrons (Cunradi, 2010; Scribner et al., 2007). Crime may occur more frequently around off-premise outlets because these features signal social disorganization and a lack of collective efficacy within the community (Theall et al., 2009).

Despite numerous studies examining neighborhood presence of alcohol outlets and a variety of injury-related outcomes including gun violence and suicides (Branas et al., 2009, 2011), intimate partner violence (Cunradi, 2010), motor vehicle crashes (Nesoff et al., 2018, 2019), and other unintentional injuries (Morrison et al., 2016), this research has not been extended to drug overdose. There is some evidence that alcohol outlet density is related to increased drug use. Proximity to alcohol outlets has been associated with past year marijuana use in youth (Milam, Furr-Holden, Harrell, et al., 2014). Greater neighborhood alcohol outlet density is also associated with greater prevalence of mental health problems such as depression, stress, and anxiety (Pereira et al., 2013); drug use and use disorders have been linked to mental health problems and major mental illness (L. Davis et al., 2008). Adults with mental health disorders, including anxiety and mood disorders, are significantly more likely to use nonprescription opioids (M. A. Davis et al., 2017) and significantly more likely to show opioid use disorder (Saha et al., 2017). To our knowledge, this is the first study to investigate neighborhood drug overdose rate in relation to alcohol outlet density.

The aim of this study was to investigate whether presence of alcohol outlets is associated with the neighborhood drug overdose rate and whether the sale of drug paraphernalia contributes to this association. Consistent with prior research, we hypothesize that off-premise alcohol outlets will be more strongly associated with the neighborhood drug overdose rate than on-premise outlets. We also hypothesize that drug paraphernalia sales are positively associated with neighborhood drug overdose rate.

METHODS

The Columbia University Medical Center institutional review board approved this study.

Data Sources

Drug overdose data—*Drug overdose data* were gathered through emergency medical services (EMS) records collected from January 1, 2015, to December 31, 2015 (n=3,856).

The Baltimore City Fire Department (BCFD) operates the City's EMS system; as Baltimore City is served by a single EMS system, these data are representative of all EMS calls for drug overdose. Paramedics on the scene confirmed drug overdose. When an emergency call was received, Dispatch administered a brief set of questions to the caller to determine the severity of the patient condition, then asked the patient's location; Dispatch then relayed the message to paramedics. Once on the scene, paramedics evaluated the patient and filled out the EMS patient report that included the code for drug overdose. An EMS run was considered a drug overdose if the primary or secondary impression was listed as "substance/drug abuse" or "withdrawal/overdose drugs."

Locations of alcohol outlets—*Locations of alcohol outlets* in 2015 were obtained through the Board of Liquor License Commissioners for Baltimore City. The 12 liquor license types administered by the Board (n=1,215) were classified into on-premise and off-premise alcohol outlets.(Jennings et al., 2014) Outlets licensed for on-premise consumption included restaurants, hotels/motels, entertainment venues, non-profit private clubs, and certain bar/tavern license classes (n=530). Off-premise alcohol outlets included all LA/LA2 (n=230) license class locations, liquor stores open six days a week from 9 a.m. to midnight (no Sunday sales) that do not allow on-premise consumption. Off-premise locations also included all LBD7 (n=422) license class locations, bars/taverns allowed to open every day from 6 a.m. to 2 a.m., providing on-premise consumption. LBD7s also sell packaged goods for off-premise consumption, depending on the owner's discretion. LBD7s are expected to devote at least half of their sales and floor space to on-site consumption; however, this stipulation was only recently incorporated into the zoning code, and there is little oversight to enforce this ruling.(Furr-Holden et al., 2020) LBD7s are also the only license class allowable in certain restrictively-zoned residential neighborhoods as LA/LA2 license types were considered inappropriate for residential zones when the City passed its last residential zoning code in 1971 (see Furr-Holden et. al (2020) for in-depth discussion of Baltimore liquor license classes). Stores licensed to sell only wine and beer (i.e., WA license type) exclusively for off-premise consumption (n=33), open six days a week from 6 a.m. to midnight, were also coded as off-premise outlets.

Observational off-premise alcohol outlet data: Observational data collection via field surveys took place in Baltimore City from June to August 2015 (full details of this study are described in (Furr-Holden et al., 2020)). In brief, the goal of this parent study was to identify characteristics of off-premise alcohol outlets related to compliance with local ordinances and identify possible targets for future policies to reduce the public health impact of alcohol outlets on communities. Research assistants went in groups of three in order to complete one full assessment of the alcohol outlet. In cases where the outlet was not accessible by minors (e.g., the outlet required an ID to enter the bar portion of the outlet), one of two project supervisors, both of whom were over age 21, completed the interior assessments. The interior assessment was a global assessment designed to take one minute that included a binary measure of whether the alcohol outlet sold drug paraphernalia. Items considered drug paraphernalia included: Items used to distribute or sell drugs (e.g., baggies, scales); items used for drug inhalation (e.g., pipes, hookahs, bongs, vaporizers, e-cigarettes); and unregulated synthetic drugs (e.g., synthetic cannabinoids)(National Institute on Drug

Abuse, 2018). A total of 685 off-premise alcohol outlets (license types LA/LA2, LBD7, and WA) were visited as part of this study. Observational assessments revealed that 22% of outlets (n=155) were chronically closed (e.g., never open, abandoned, or in reconstruction), in part because of a significant but undetermined number of stores that were burned down in April 2015 following the social unrest surrounding the death of Freddie Gray (Rector et al., 2015). Outlets were visited seven times by research assistants before they were deemed chronically closed at varying times of day and days of the week. Project supervisors made an additional three visits on Thursday, Friday, and Saturday evenings between 9 p.m. and 2 a.m. depending on the venue (e.g., clubs were visited later than bars or packaged goods stores) to ensure the establishment was not in operation during these peak times. Consequently, n=530 venues were successfully visited and assessed for drug paraphernalia availability. We then calculated the proportion of these off-premise alcohol outlets selling drug paraphernalia in each block group.

Neighborhood demographic variables—*Neighborhood demographic variables* for each census block group in Baltimore City (n=653), including population totals and median household income, were taken from five-year American Community Survey (ACS) estimates (U.S. Census Bureau, n.d.). Population density was calculated by taking the total population of each census block group and dividing by the area of the census block group in square miles.

Measures

Previous research has demonstrated the importance of neighborhood context in risk for drug use (Latkin et al., 2005) and drug overdose (Cerdá et al., 2013; Milam et al., 2012; Nesoff et al., 2020). To provide a window into the broader neighborhood context not fully explained by demographics, we calculated the neighborhood disadvantage score using census block group-level items from ACS. 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. We used Ross & Mirowsky's (2001) formula to generate the index: {[(c/10+d/10)−(a/10+b/10)]/4} (percentages are entered as whole numbers, not decimals). Each one unit increase in the neighborhood disadvantage score is equivalent to an increase of 10 percentage points for each component item of the index (Ross & Mirowsky, 2001). The total score has a possible range from −5 to +5, where −5 is very low/little disadvantage, and +5 is very severe disadvantage. This metric has been used in previous investigations examining the relationships between neighborhoods, mental health, and substance use (Furr-Holden et al., 2016; Nesoff et al., 2020).

We assessed the level of Black-White segregation in Baltimore census block groups using the Index of Concentration at the Extremes (ICE) (Krieger et al., 2016; Massey, 2001). We subtracted the number of non-Latino Blacks from the number of non-Latino Whites in a block group, and then divided by the entire population of the block group. The values range from −1 to 1, where −1 is 100% Black, 0 is 50% Black and 50% White, and 1 is 100% White. Whereas other measures of community-level racial segregation only give information about whether segregation exists, the ICE measure quantifies the polarization by group

and considers majority-White and majority-Black communities to be qualitatively different (Krieger et al., 2016).

Data Analysis

Statistical Analysis.—Locations of drug overdoses and alcohol outlets were geocoded and mapped using ArcGIS 10.4. BCFD provided the latitude and longitude points to which an ambulance was sent for a drug overdose; alcohol outlets were geographically coded to latitude and longitude points using street addresses. All overdose and outlet locations were successfully coded in this manner and then aggregated to the census block group level (Figure 1). We performed negative binomial regression in R 3.6.2, analyzing the counts of drug overdoses per block group (n = 693), while adding each control variable in a stepwise fashion. Negative binomial regression derives as an alternative to Poisson regression (the preferred distribution for analyzing count data) that accommodates over-dispersion. To test if alcohol outlet type differently impacted neighborhood drug overdose rate, we estimated a model with all alcohol outlets and then stratified by outlet type (on- versus off-premise alcohol outlets). As patrons of off-premise alcohol outlets may drink in nearby, uncontrolled environments, we expect the spatial scale for this mechanism to be very small, within 50–100m of the alcohol outlet; therefore, we expect most of the effect to be observable within the same block group as the alcohol outlet. However, areal units are arbitrary and people freely travel across adjoining block groups.(Coulton et al., 2001) As a sensitivity analysis, we assessed spatial autocorrelation across block groups with the spatial lag of alcohol outlets. This smooths the census block group overdose rate associated with alcohol outlets and suggests possible spillover effects that could arise due to people's movements across block groups.(Bivand et al., 2013) We then assessed if sale of drug paraphernalia was related to the neighborhood drug overdose rate. For each model, we calculated Residual Moran's I (RMI) to assess residual spatial variation not accounted for by the model's covariates using a queen's adjacency spatial weights matrix (Waller & Gotway, 2004) and Akaike's Information Criterion (AIC) to assess model fit and parsimony (see online supplemental Appendix A for sample R code).

Missing data.—Less than 5% (n=32) of block groups were industrial zones that had zero households, so values for neighborhood disadvantage score, ICE, and median household income could not be computed. Nevertheless, overdoses occurred in these block groups. We performed ordinary kriging to estimate a city-wide map of values for each of these measures (Waller & Gotway, 2004). We then assigned a kriged value for each measure to each block group with missing values. A similar issue arose when calculating aggregate measures of drug paraphernalia sales within alcohol outlets at the block group-level. Over half of Baltimore City's census block groups (n=377) did not contain at least one off-premise alcohol outlet, so the proportions of outlets that sold drug paraphernalia could not be computed. To address this problem, we assigned these block groups a uniform value—the mean proportion of outlets with paraphernalia among all block groups with outlets (mean=58.58%). This approach functions similarly to a missing indicator variable (Groenwold et al., 2012). The approach typically makes the restrictive assumption that values are missing at random, but it is justifiable in this instance because values are not missing, per se; rather, they are non-computable. While this procedure does not bias point

estimates, it can falsely shrink standard errors if a large number of observations are imputed. To assess whether this procedure possibly led to false positive findings, we conducted a sensitivity analysis where we included only census block groups that contained at least one off-premise alcohol outlet (n=276) and re-ran our analyses.

RESULTS

Table 1 shows the distribution of selected characteristics across block groups. There were an average of 5.91 (sd=16.0) drug overdose calls per block group. The count of drug overdose calls across block groups ranged from 0 to 268, with 13.3% of block groups (n=87) reporting no drug overdose calls. Over half (n=354) of block groups did not contain an off-premise alcohol outlet, while 75% (n=490) did not contain an on-premise outlet. On average, there were 1.05 (sd=2.05) off-premise alcohol outlets and 0.81 (sd=3.10) on-premise outlets per block group. Over half of open off-premise alcohol outlets sold drug paraphernalia (n=277). Among the block groups with off-premise alcohol outlets, the mean proportion of outlets that sold drug paraphernalia was 58.58% (sd=29.32).

Both types of alcohol outlets were significantly associated with neighborhood overdose call rate in univariable analysis ($p<0.001$) (Table 2). Each unit increase in the number of alcohol outlets was associated with a 6.7% increase in neighborhood overdose call rate (IRR=1.067, 95%CI=(1.043, 1.096), $p<0.001$), when controlling for neighborhood disadvantage score, segregation, and median household income. When we disaggregated by alcohol outlet type, on-premise outlets were no longer significantly associated with overdose (IRR=1.014, 95% CI=(0.973, 1.063), $p=0.514$). Each unit increase in the number of off-premise alcohol outlets was associated with a 16.6% increase in the neighborhood drug overdose rate (IRR=1.166, 95%CI=(1.112, 1.230), $p<0.001$) when controlling for neighborhood disadvantage score, segregation, and median household income. The off-premise outlet only model showed no residual spatial variation (RMI=0.015, $p=0.215$) and better fit compared to the all outlet type model (AIC=3493 v. 3501). In sensitivity analysis, the lagged variable was significantly associated with neighborhood overdose rate, but the model with the lagged variable showed significant unexplained spatial variation (see online supplemental Appendix B). We present the non-lagged variable here to ease interpretability of findings.

Drug paraphernalia sales were negatively associated with rate of drug overdose calls in univariable analysis (IRR=0.692, 95% CI=(0.515, 0.927), $p=0.033$) (Table 3; online supplemental Figure A). Each percentage increase in the proportion of off-premise alcohol outlets that sold drug paraphernalia was associated with a 45% decrease in rate of drug overdose calls (IRR=0.550, 95% CI=(0.410, 0.736), $p<0.001$) when controlling for off-premise alcohol outlets, neighborhood disadvantage and median household income. Additionally, drug paraphernalia sales did not alter the relationship between off-premise alcohol outlets and drug overdose rate. When restricting analyses only to the 530 off-premise alcohol outlets open during the study period, the relationship between alcohol outlets and drug overdose rate remained significant when controlling for drug paraphernalia sales in the multivariable model (IRR=(1.256, 95%CI=(1.181, 1.344), $p<0.001$). Segregation (ICE) showed multicollinearity (VIF>3) with neighborhood disadvantage score and was not significantly associated with drug overdose calls when neighborhood disadvantage score was

present in the model (IRR=1.135, 95% CI=(0.839, 0.946), p<0.001). In sensitivity analysis, when considering only block groups containing at least one off-premise alcohol outlet, the unadjusted (IRR=0.577, 95% CI=(0.418, 0.791), p<0.001) and adjusted (IRR=0.468, 95% CI=(0.344, 0.631), p<0.001) associations between drug paraphernalia sales and drug overdose rate were consistent with the interpolated model.

DISCUSSION

The objective of this study was to investigate whether presence of alcohol outlets is associated with the neighborhood drug overdose rate and whether the sale of drug paraphernalia contributes to this association. Off-premise alcohol outlets were significantly associated with neighborhood drug overdose rate when controlling for a variety of neighborhood factors, including neighborhood deprivation and segregation. Each increase in the number of off-premise alcohol outlets was associated with a 16.6% increase in the neighborhood drug overdose rate. We also compared drug overdose rate around alcohol outlets licensed for on- and off-premise consumption. Similar to studies of violent injury (Furr-Holden et al., 2016) and unintentional injury (Nesoff et al., 2018), off-premise alcohol outlets were more strongly associated with neighborhood drug overdose rate than on-premise outlets. When both types of alcohol outlets were present in the model, we found that on-premise outlets were not significantly associated with drug overdose rate. These findings add to previous studies of alcohol outlets and violent and unintentional injury, suggesting that off-premise alcohol outlets present a unique community risk factor for drug overdose. Further inquiry is needed to understand the mechanisms by which alcohol outlets impact drug use and drug overdose, particularly in low-resource and predominantly-minority neighborhoods, as well as the contribution of specific alcohol license classes to neighborhood drug overdose risk.

We also hypothesized that the sale of drug paraphernalia in off-premise alcohol outlets was associated with increased drug overdose rate, partially attenuating the relationship between off-premise alcohol outlets and drug overdose. Surprisingly, we found the opposite relationship, with drug paraphernalia sales negatively associated with the neighborhood drug overdose rate; drug paraphernalia had no effect on the relationship between off-premise alcohol outlets and drug overdose rate. It is important to note that the outcome measure for this study was EMS calls for drug overdoses, and not, for example, fatal drug overdoses measured by medical examiner case records. This distinction may have an impact on study findings. Because drug markets coalesce around alcohol outlets in low-resource neighborhoods, increased policing of these locations may negatively affect 911 calls for drug overdose. Studies show that drug arrests cluster around alcohol outlets (McCord & Ratcliffe, 2007), indicating increased policing around these establishments (Beckett et al., 2006; Johnson, 2009). In heavily-policed environments, PWUDs and other bystanders may be wary of calling 911 in the event of an overdose (Koester et al., 2017; Small et al., 2006). Even if a bystander has not been using drugs, mistrust of the police and fear of repercussions of police contact such as lost housing and child custody, social stigma, and repercussions from local drug dealers may deter 911 calls for drug overdose (Latimore & Bergstein, 2017). Good Samaritan Laws which provide bystanders immunity from prosecution appear to have not significantly reduced fears of criminal punishment among PWUDs (Koester et

al., 2017; Latimore & Bergstein, 2017). Further inquiry is needed to better understand the culture around alcohol outlets that sell drug paraphernalia to better understand whether this association is related to heavy policing or other unidentified community factors.

The limitations of this study merit discussion. This study is cross-sectional and, therefore, does not allow for discussion of changes in drug overdose over time. Almost one-quarter of off-premise alcohol outlets were closed at the time of observational inquiry in part because of social unrest surrounding the death of Freddie Gray (Rector et al., 2015), possibly affecting study findings. However, validating which outlets were operational is a study strength as discrepancies across administrative databases of alcohol outlets undermines research on community harms related to alcohol outlets (Milam et al., 2020; Ponicki et al., 2014). We used EMS records for drug overdose calls in 2015 as the outcome for this study. We do not have information on the specific substances involved in these overdoses, nor do we know the outcome of these overdoses (i.e., fatal versus non-fatal). It is possible that alcohol-involved drug overdoses account for the relationship between alcohol outlets and drug overdose rate; this relationship should be investigated in future studies. It is also possible that a different data source such as fatal drug overdoses from a medical examiner case archive might result in different results for the relationship between drug paraphernalia and drug overdose rate. These data were not available for this study, but future inquiry into this association should include both fatal and non-fatal overdoses.

Conclusion

Off-premise alcohol outlets are associated with neighborhood drug overdose rate when controlling for other neighborhood characteristics including neighborhood deprivation and segregation. This study provides preliminary public health evidence for informing policy decisions about alcohol outlet licensing and zoning. Alcohol outlets, particularly those that sell drug paraphernalia, could be potential community partners for harm reduction strategies such as naloxone distribution or health communication on drug purity or identifying overdose symptoms. Alcohol outlets may also be potential focal points for community outreach and education campaigns around Good Samaritan Laws to encourage bystander support for drug overdose.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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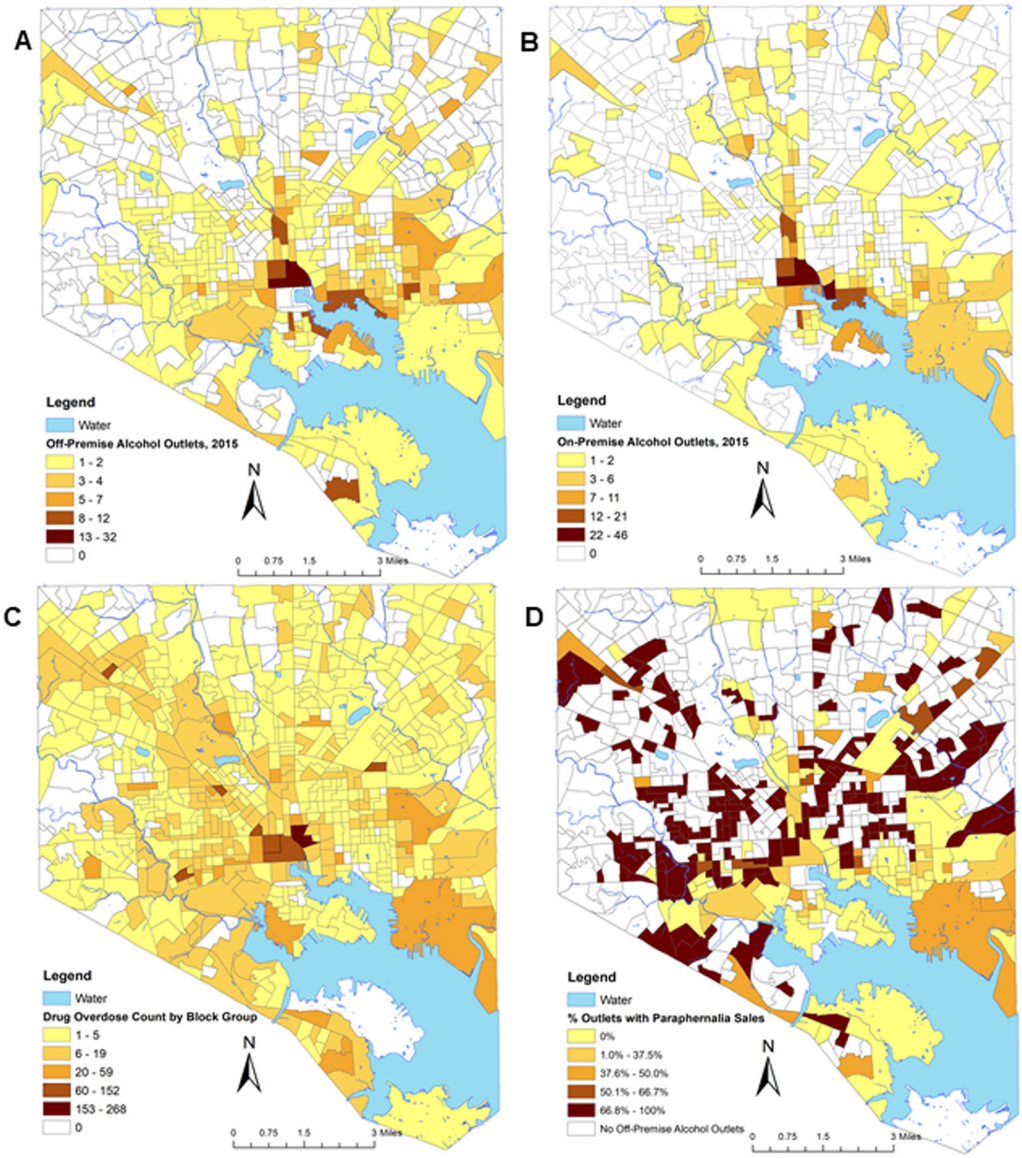

Figure 1.

Maps of (A) off-premise and (B) on-premise alcohol outlets; (C) drug overdoses; (D) proportion of off-premise alcohol outlets with drug paraphernalia sales by census block group, Baltimore City, 2015

Table 1.

Description of selected neighborhood characteristics by census block group, Baltimore City, 2015 (n=653)

	Total	By Census Block Group			
Variable	**N or %**	**Min.**	**Max.**	**Mean**	**SD**
Drug overdose count	3,856	0	268	5.91	16.0
Alcohol Outlet count	1,215	0	76	1.86	4.79
Outlets for off-premise consumption	685	0	30	1.05	2.05
Outlets for on-premise consumption	530	0	46	0.81	3.10
Off-premise outlets selling drug paraphernalia (count) *	277	0	6	0.42	0.76
Proportion of off-premise alcohol outlets selling drug paraphernalia (%) *	52.26	0	100.0	58.58	29.32
Neighborhood disadvantage score (range: −5 to +5)	--	−4.59	4.43	−0.04	1.90
Segregation (ICE) (range: −1 to +1)	--	−1.0	1.0	−0.36	0.67
Median Household income (in $10,000s)	--	0.82	20.88	4.70	2.62
Population density per square mile (in 10,000 residents)	--	0	8.39	1.37	0.97

* At the time of observational data collection, n=155 off-premise alcohol outlets were chronically closed

Table 2.

Univariable and multivariable associations between alcohol outlet types and rate of drug overdose by census block group, Baltimore City, 2015 (n=653)

Variable	Unadjusted IRR (95% CI)	p	All Outlets* IRR (95% CI)	p	By Outlet Type* IRR (95% CI)	p	Off-Premise* IRR (95% CI)	p
All alcohol outlets	1.05 (1.03, 1.09)	<0.001	1.07 (1.04, 1.10)	<0.001				
Off-premise alcohol outlets	1.16 (1.10, 1.23)	<0.001			1.15 (1.08, 1.23)	<0.001	1.17 (1.11, 1.23)	<0.001
On-prcmisc alcohol outlets	1.06 (1.04, 1.11)	<0.001			1.01 (0.97, 1.06)	0.514		
Neighborhood disadvantage score (−5 to +5)	1.32 (1.25, 1.40)	<0.001	1.30 (1.20, 1.41)	<0.001	1.28 (1.18, 1.39)	<0.001	1.28 (1.18, 1.39)	<0.001
Segregation (ICE) (−1 to +1)	0.84 (0.72, 0.98)	0.021	1.26 (1.04, 1.53)	0.016	1.24 (1.03, 1.51)	0.024	1.25 (1.03, 1.52)	0.002
Median household income (in $10, 000s)	0.84 (0.81, 0.87)	<0.001	0.91 (0.86, 0.96)	<0.001	0.90 (0.85, 0.96)	.001	0.90 (0.85, 0.96)	<0.001
Population density (in 10, 000s)	0.93 (0.85, 1.02)	0.158						
AIC			3499		3495		3493	
RMI			0.006	0.356	0.009	0.307	0.015	0.215
Intercept			1.951		1.922		1.925	
Dispersion parameter			0.9174		0.9227		0.9226	

Note: From negative binomial regression

*Adjusted for other covariates in the column

Table 3.

Drug paraphernalia sales in univariable and multivariable associations between alcohol outlets and rate of drug overdose by census block group, Baltimore City, 2015 (n=653)

Variable	Unadjusted IRR (95% CI)	p	Adjusted* IRR (95% CI)	p
Off-premise alcohol outlets**	1.22 (1.14, 1.32)	<0.001	1.26 (1.18, 1.34)	<0.001
Proportion of off-premise alcohol outlets selling drug paraphernalia (%)	0.69 (0.52, 0.93)	0.033	0.55 (0.41, 0.74)	<0.001
Neighborhood disadvantage score (−5 to +5)	1.32 (1.25, 1.40)	<0.001	1.23 (1.14, 1.33)	<0.001
Segregation (ICE) (−1 to +1)	0.84 (0.72, 0.98)	0.021		
Median household income (in $10,000s)	0.84 (0.81, 0.87)	<0.001	0.90 (0.85, 0.95)	<0.001
Population density (in 10,000s)	0.93 (0.85, 1.02)	0.158		

Note: From negative binomial regression. See Figure A in online supplemental material for plot of predicted overdose counts.

* Adjusted for other covariates in the column. AIC=3484, RMI=0.024 (p=0.112), Intercept=2.320, Dispersion parameter=0.9433

** Only outlets open at the time of data collection were included in these analyses (n=530)