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Alcohol Outlet Clusters and Population Disparities

Pamela J. Trangenstein · **Claire Gray** ·
Matthew E. Rossheim · **Richard Sadler** ·
David H. Jernigan

Abstract Alcohol outlet clusters are an important social determinant of health in cities, but little is known about the populations exposed to them. If outlets cluster in neighborhoods comprised of specific racial/ethnic or economic groups, then they may function as a root cause of urban health disparities. This study used 2016 liquor license data ($n = 1204$) from Baltimore City, Maryland, and demographic data from the American Community Survey. We defined alcohol outlet clusters by combining SaTScan moving window methods and distances between outlets. We used multiple logistic regression to compare census block groups (CBGs) ($n = 537$) inside and outside of four types of outlet clusters: total, on-premise, off-premise, and LBD-7 (combined on-/off-premise). The most robust predictor of alcohol outlet cluster membership was a history of redlining, i.e., racially discriminatory lending policies. CBGs that were redlined had 7.32 times the odds of being in an off-premise cluster, 8.07 times the odds of being in an on-premise cluster, and 8.60 times the odds of being in a LBD-7 cluster. In addition, level of economic investment (marked by vacant properties) appears to be a key characteristic that separates CBGs in on- and off-premise outlet clusters. CBGs with racial/ethnic or socioeconomic advantage had higher odds of being in on-premise clusters and CBGs marked by disinvestment had higher odds of being in off-premise clusters. Off-premise clusters deserve closer examination from a policy perspective, to mitigate their potential role in creating and perpetuating social and health disparities. In addition to addressing redlining and disinvestment, the current negative effects of alcohol outlet clusters that have grown up in redlined and disinvested areas must be addressed if inequities in these neighborhoods are to be reversed.

P. J. Trangenstein (✉)
Alcohol Research Group, Public Health Institute, 6001 Shellmound St., Suite 450, Emeryville, CA 94608, USA
e-mail: ptrangenstein@arg.org

e-mail: ptrang@bu.edu

P. J. Trangenstein · D. H. Jernigan
Department of Health Law, Policy, and Management, Boston University School of Public Health, 715 Albany St, Boston, MA 02118, USA

D. H. Jernigan
e-mail: dhjern@bu.edu

C. Gray
Public Health Studies, Johns Hopkins University, 3505 N. Charles Street, Room 2, Baltimore, MD 21218, USA
e-mail: cgray27@jhu.edu

M. E. Rossheim
Department of Global and Community Health, George Mason University, 4400 University Drive, MS5B7, Fairfax, VA 22030, USA
e-mail: mrosshei@gmu.edu

R. Sadler
College of Human Medicine Department of Family Medicine/ Division of Public Health Flint, Michigan State University, Flint, MI 48502, USA

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Introduction

Economically disadvantaged neighborhoods have more alcohol outlets than do high-income neighborhoods [1–3], even though people with lower incomes are less likely to drink and drink less often than their higher-income counterparts. This environmental injustice likely creates a "double-jeopardy" scenario, where disadvantaged neighborhoods also contain alcohol riskscapes that endanger residents. Alcohol outlet density (i.e., the number of stores in an area that sell alcohol and the ease of traveling to them) is associated with higher levels of alcohol consumption, misuse, and related harms [4–6]. The association between alcohol outlets and violent crime is particularly well supported [7–12].

Alcohol outlet clustering is the more localized and extreme version of alcohol outlet density, which means that the neighborhood characteristics that lead to clustering and the resulting harms are likely different from those that lead to outlet density more generally. There are likely synergies such that neighborhoods with high alcohol outlet density and alcohol outlet clusters tend to have higher harms than areas with either of these risks alone. Inside clusters, the very high levels of alcohol availability may lead to more discounting of prices by retailers [13, 14]. This can attract patrons and ultimately result in the social aggregation of binge drinkers, which in turn can be a risk factor for violence [5, 15–17]. Despite evidence of the risk from alcohol outlet clusters [18–20], including the fact that lower-income populations are more negatively affected by such clusters [21], little is known about the populations who live inside them. Identifying the population subgroups with the highest exposure to alcohol outlet clusters could help explain the inequitable burden of health harms experienced by these populations and the communities in which they live.

Efforts to understand population disparities related to the local alcohol environment must consider the historical context. This study focuses on the city of Baltimore, which experienced dramatic changes over the last century. In the early twentieth century, Baltimore was a thriving port city and industrial giant with one of the largest populations of Blacks anywhere in the United States (USA). When suburbanization took hold toward the end of the twentieth century, it lured many high-income, white residents into the suburbs. This exodus has not stopped; Baltimore's population has fallen every year since it peaked at 949,708 in 1950 [22]. Decades of decline have decimated the low-skilled employment sectors, thus resulting in a majority Black population with few opportunities. They also shaped Baltimore's alcohol environment. In 1971, when Baltimore's population was still near its peak (the 1970 population was 905,759), the city established a moratorium on new liquor licenses so long as there is more than one license per every 1000 residents [23]. The continuous population declines [22, 24] have meant that closing large numbers of liquor licenses still did not reduce the outlet-to-person ratio below than 1:1000 standard.

Baltimore's legacy of discriminatory housing and investment practices are clear examples of ways that structural racism has contributed to an unjust distribution of risks and resources across the city. Structural racism includes the totality of ways in which policies, institutional practices, and cultural norms/beliefs create inequitable systems that perpetuate racial inequality [25]. Redlining (i.e., racially discriminatory lending policies) has been illegal since the 1960s [26], but racist housing practices persist today [27]. This creates "spatial stigmas" (i.e., negative representations of marginalized communities) that can lead to and perpetuate disinvestment [28], including deterring prosocial businesses (e.g., childcare) from moving into underdeveloped neighborhoods. Similar neighborhoods that escape such conditions often do so only via gentrification, the end result of which predominately benefits middle class and white residents who displace poorer and minority residents [29, 30]. While Baltimore has seen some of the highest rates of gentrification, it has been largely confined to white neighborhoods [31]. This focused reinvestment leaves majority Black and high-crime neighborhoods largely untouched, which only widens the inequality within Baltimore and across the state of Maryland (one of the wealthiest states in the USA) by creating "islands of decay in a sea of renewal." [32]

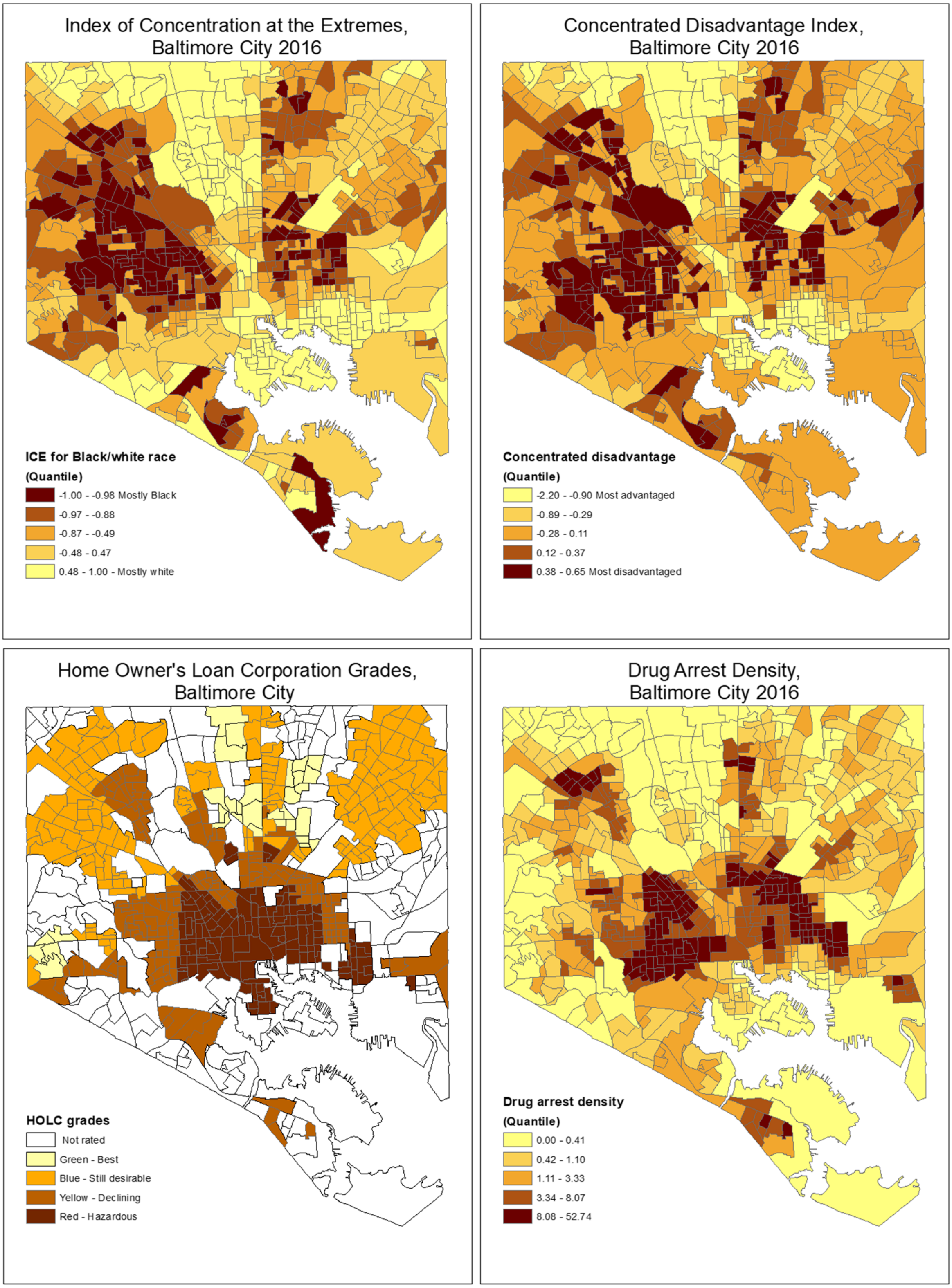

Fig. 1 Choropleth maps of Index of concentration at the extremes, concentrated disadvantage index, discriminatory lending practices, and drug arrest density, Baltimore City

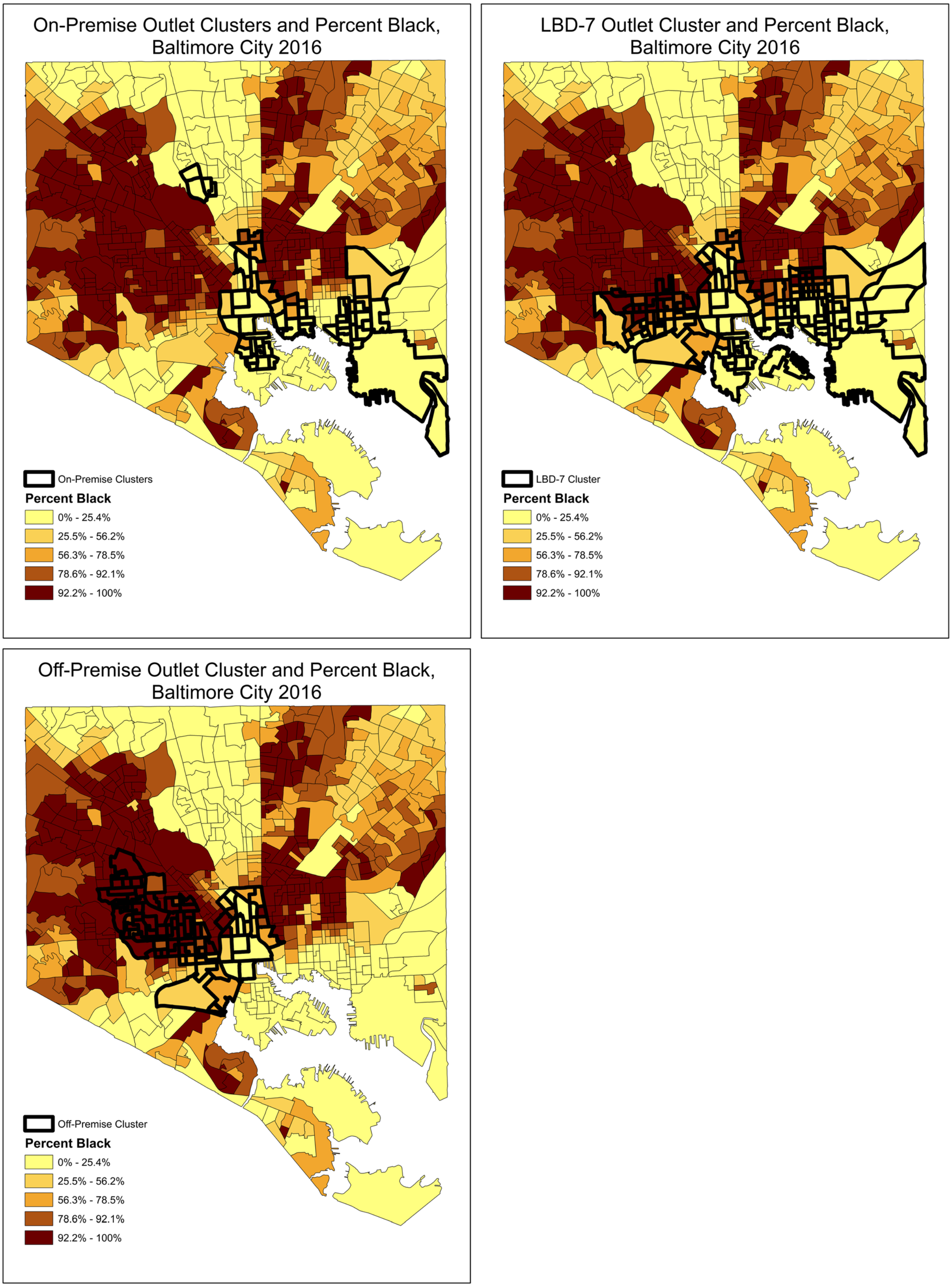

Fig. 2 Choropleth maps of alcohol outlet clusters by type of outlet and percent Black

Table 1 Demographics of Baltimore census block groups ($n = 537$).

	Mean	Standard deviation	Minimum	Maximum
Racial/ethnic composition				
Population	1003	488	166	3828
Percent Black	64.8%	35.8%	0.0%	100.0%
Percent white	30.6%	32.1%	0.0%	100.0%
Percent Hispanic/Latino	4.4%	8%	0.0%	45.4%
Index of concentration at the extremes[a]	− 0.34	0.72	− 1.0	1.0
Economic				
Concentrated disadvantage scale[b]	− 0.09	0.60	− 2.20	0.65
Median annual household income[c]	$50,094	$29,324	$9750	$250,000
Median home value	$163,643	$103,579	$10,000	$910,000
Percent living below the federal poverty line	17.9%	16.2%	0.0%	73.0%
Percent unemployed	36.8%	13.1%	6.5%	82.2%
Residential stability				
Percent single households	36.1%	14.0%	0.0%	87.7%
Percent renter-occupied housing	47.6%	22.8%	0.0%	95.9%
Percent of residents who changed residential addresses in the past year	15.5%	10.4%	0.0%	68.0%
Social control/disinvestment				
Drug arrest density	421 per mile^2	641 per mile^2	0 per mile^2	5274 per mile^2
Vacant housing density	922 per mile^2	1353 per mile^2	0 per mile^2	7643 per mile^2
Built environment				
Retail location quotient[d]	6.93	16.09	0.0%	222.54
Convenience stores	1.5	1.9	0.0	16
Schools	0.3	0.6	0.0	4

[a] Calculated as $ICE_i = (W_i - B_i)/T_i$ where W_i = number of white residents in CBG, B_i = number of Black residents in CBG, and T_i = total number of residents in CBG. Thus, CBGs with 100% white residents would have an ICE of 1.0, CBGs with 100% Black residents would have an ICE of − 1.0, and CBGs with 50% white and 50% Black residents would have an ICE of 0.0

[b] Calculated as $0.75{*}B_i - 0.80{*}(I_i/250000) - 0.93{*}C_i - 0.87{*}(H_i/910700)$ where B_i = percent of CBG_i that is Black, I_i = median annual household income for CBG_i, C_i = percent of CBG_i aged 25 years or older with a college degree, and H_i = median home value for CBG_i

[c] Censored at $250,000

[d] Calculated as R_i/T_i, where R_i = the proportion of the CBG that is zoned for retail land use and T_i is the proportion of Baltimore City that is zoned for retail land use

The residents of these spatial stigmas are often blamed for the resulting problems even though the root cause likely stems from discriminatory policies that shaped their neighborhoods. Given this history, it is important to identify the types of populations exposed to specific types of alcohol outlet clusters to better understand how the built environment may contribute to health disparities, and the harms [33–38] and potential zoning options depend on the type of outlets and neighborhood. This study compares the characteristics of populations and census block groups (CBGs) located inside versus outside of different types of alcohol outlet clusters in Baltimore City, Maryland. We hypothesize that alcohol outlet clusters will track along histories of redlining in the same way that clusters of poverty do.

Methods

Unit of Analysis

Census block groups (CBGs) were the unit of analysis for this study, because they are the smallest unit of analysis for which unrestricted American Community Survey (ACS) data are available. After excluding 116

CBGs with missing data, the analytic sample included 537 CBGs.

Data Sources

Alcohol Outlets We obtained a list of alcohol outlets licensed in Baltimore City from the Board of Liquor License Commissioners current as of June 4, 2016. We excluded 14 establishments (1%) due to limited days or hours of sale, including Pimlico Race Track ($n = 1$), Baltimore Zoo ($n = 1$), arenas ($n = 7$), and municipal licenses ($n = 5$). The analyses included 1204 establishments: 519 (43%) on-premise outlets, 264 (22%) off-premise outlets, and 421 (35%) LBD-7 outlets. LBD-7 license holders are permitted to serve alcohol on-premise as well as sell package goods for off-site consumption. We geocoded the addresses for outlets using ArcGIS and StreetMap 2013 with a 99% success rate.

Demographics We obtained demographic data from the American Community Survey (ACS), which is an annual survey of over 3.5 million households in the USA [39]. We used the 2016 5-year estimates. Variables we obtained from the ACS include percent white, percent Black, percent Hispanic/Latino, total population, percent renter-occupied housing, percent moved in the last year, median annual household income, median home value, and percent of adults aged 25 years or older with a college degree. All percentages were scaled so a one-unit increase is a 10% increase.

Environmental Data Baltimore City government publishes data to a free online data-sharing platform called Open Baltimore. We obtained 2016 data on number of drug arrests, Baltimore City Public Schools, and convenience stores from Open Baltimore. In addition, we obtained shapefiles of 2016 land use zoning (e.g., land zoned for retail services) and vacant houses from the Baltimore City Department of Planning.

US Home Owner's Loan Corporation Maps The US Home Owner's Loan Corporation (HOLC) mapped perceived lending risk at the city level. The National Community Reinvestment Coalition downloaded the maps and digitized them for 114 US cities, including Baltimore. This process has been described elsewhere [40].

Measures

This analysis aimed to characterize the people and neighborhoods located inside alcohol outlet clusters. Social Disorganization Theory argues that poverty/concentrated disadvantage, residential instability, and ethnic heterogeneity are key neighborhood factors that can undermine social ties and social control [41]. To this list, we added discriminatory lending policies as a potential cause and marker of weakened social control as well as disinvestment, to establish a fuller understanding of how historical practices shaped the alcohol environment in Baltimore.

Alcohol Outlet Clusters We created four cluster variables: (1) total, (2) on-premise, (3) LBD-7, and (4) off-premise outlets. To identify clusters, we combined SaTScan discrete Poisson purely spatial analysis software with nearest neighbor methods with definitions that varied by alcohol outlet type. There were substantially more outlets in the total outlet cluster variable (1204) than in the clusters specific to an outlet type (264–519). We defined clusters as 50 or more outlets located within 0.10 miles of the nearest outlet for the total variable and 25 or more outlets located within 0.15 miles of the nearest outlet for the on-premise, off-premise, and LBD-7 outlet cluster variables. We then operationalized clusters as CBGs that met both the SaTScan and nearest neighbor cluster definitions. We created a binary variable to indicate whether each CBG was located inside (1) or outside (0) of each cluster definition. This combined approach adjusts for underlying population and retains point-level information about outlets [15].

Racial/Ethnic Composition and Policies Most (63%) Baltimore residents are Black [22], and (like many urban areas) Baltimore has legacies of structural racism and restrictive land use policies that have created areas of concentrated disadvantage. To identify areas of racial segregation, we calculated the Index of Concentration at the Extremes (ICE) [42] for black and white residents (95% of Baltimore residents in 2016 belonged to one of these two racial groups) [22]. We calculated the ICE as follows: $ICE_i = (W_i - B_i)/T_i$ where W_i = number of white residents in CBG_i, B_i = number of Black residents in CBG_i, and T_i = total number of residents in CBG_i. Thus, CBGs with 100% white residents would have an

Table 2 Simple (bivariate) logistic regression results for the association between alcohol outlet cluster membership and census block group characteristics ($n = 537$) in Baltimore City 2016

	General clusters			On-premise cluster			LBD-7 cluster			Off-premise cluster		
	OR	Q-value[a]	95% CI	OR	Q-value	95% CI	OR	Q-value	95% CI	OR	Q-value	95% CI
Racial/ethnic composition												
Percent white	*1.02*	*< 0.001*	*1.01, 1.03*	*1.04*	*< 0.001*	*1.03, 1.05*	*1.02*	*< 0.001*	*1.02, 1.03*	*0.98*	*< 0.001*	*0.97, 0.99*
Percent Black	*0.98*	*< 0.001*	*0.98, 0.99*	*0.96*	*< 0.001*	*0.95, 0.97*	*0.98*	*< 0.001*	*0.98, 0.99*	*1.02*	*< 0.001*	*1.01, 1.03*
Percent Hispanic	*1.05*	*< 0.001*	*1.03, 1.07*	*1.04*	*< 0.001*	*1.01, 1.06*	*1.07*	*< 0.001*	*1.05, 1.10*	*0.91*	*< 0.01*	*0.85, 0.97*
Index of concentration for race[b]	*2.47*	*< 0.001*	*1.89, 3.22*	*7.97*	*< 0.001*	*4.87, 13.05*	*2.50*	*< 0.01*	*1.93, 3.25*	*0.45*	*< 0.001*	*0.29, 0.68*
Advantage												
Concentrated disadvantage index[c]												
Quartile 1—Most advantaged	(ref)			(ref)						(ref)		
Quartile 2—Slightly advantaged	*0.29*	*< 0.001*	*0.16, 0.52*	*0.14*	*< 0.001*	*0.06, 0.31*	*0.29*	*< 0.001*	*0.16, 0.50*	0.91	0.85	0.36, 2.31
Quartile 3—Slightly disadvantaged	*0.14*	*< 0.001*	*0.07, 0.28*	*0.03*	*< 0.001*	*0.01, 0.14*	*0.12*	*< 0.001*	*0.06, 0.25*	1.00	0.99	0.40, 2.49
Quartile 4—Most disadvantaged	*0.22*	*< 0.001*	*0.12, 0.42*	–[e]			*0.24*	*< 0.001*	*0.13, 0.43*	*4.25*	*< 0.001*	*2.00, 9.02*
Discriminatory policies												
HOLC grade												
None	(ref)				(ref)		(ref)			(ref)		
B	—[e]				—[e]		—[e]			0.68	0.55	0.21, 2.20
C—decline	1.74	0.08	0.96, 3.15	0.51	0.18	0.20, 1.31	*1.87*	*0.03*	*1.06, 3.30*	*5.54*	*< 0.001*	*2.37, 12.93*
D—full decline	*9.37*	*< 0.001*	*5.25, 16.72*	*5.08*	*< 0.001*	*2.57, 10.03*	*9.62*	*< 0.001*	*5.45, 16.97*	*10.18*	*< 0.001*	*4.37, 23.70*
Social control/disinvestment												
Drug arrest density	*1.08*	*< 0.001*	*1.06, 1.11*	0.97	0.24	0.93, 1.02	*1.08*	*< 0.001*	*1.06, 1.11*	*1.05*	*< 0.001*	*1.02, 1.08*
Vacant housing density	*1.01*	*0.02*	*1.00, 1.02*	*0.96*	*0.01*	*0.93, 0.99*	*1.01*	*0.04*	*1.00, 1.02*	*1.04*	*< 0.001*	*1.02, 1.05*
Population density	*1.06*	*< 0.001*	*1.04, 1.09*	*1.03*	*< 0.01*	*1.01, 1.05*	*1.06*	*< 0.001*	*1.04, 1.09*	1.02	0.14	0.99, 1.04
Residential stability												
Percent single households	1.01	0.11	0.99, 1.02	*1.02*	*< 0.001*	*1.01, 1.04*	*1.01*	*0.05*[f]	*1.00, 1.02*	*1.02*	*< 0.01*	*1.01, 1.03*
Percent residential mobility	*1.06*	*< 0.001*	*1.04, 1.08*	*1.05*	*< 0.001*	*1.02, 1.07*	*1.05*	*< 0.001*	*1.04, 1.07*	1.02	0.07	0.99, 1.04
Percent renter-occupied housing	*1.02*	*< 0.001*	*1.01, 1.03*	1.01	0.10	0.99, 1.02	*1.02*	*< 0.001*	*1.01, 1.03*	*1.03*	*< 0.001*	*1.02, 1.04*
Built environment												
Retail land use[d]	*1.03*	*< 0.001*	*1.02, 1.04*	*1.03*	*< 0.001*	*1.03, 1.05*	*1.03*	*< 0.001*	*1.02, 1.04*	*1.02*	*< 0.001*	*1.01, 1.03*

Table 2 (continued)

	General clusters			On-premise cluster			LBD-7 cluster			Off-premise cluster		
	OR	Q-value[a]	95% CI	OR	Q-value	95% CI	OR	Q-value	95% CI	OR	Q-value	95% CI
Convenience stores	*1.27*	*< 0.001*	*1.16, 1.40*	*1.22*	*< 0.001*	*1.10, 1.36*	*1.32*	*< 0.001*	*1.20, 1.45*	*1.23*	*< 0.001*	*1.11, 1.35*
Schools	0.89	0.53	0.64, 1.23	0.90	0.68	0.57, 1.42	0.96	0.82	0.71, 1.30	*1.59*	*< 0.01*	*1.17, 2.08*

Italics indicate that $q < 0.05$

OR odds ratio, *CI* confidence interval, *HOLC* Home Owner's Loan Corporation, *ref* reference group

[a] Adjusted probability score using a Benjamini-Hochberg-Simes false discovery rate correction

[b] Calculated as $ICE_i = (W_i - B_i)/T_i$ where W_i = number of white residents in CBG, B_i = number of Black residents in CBG, and T_i = total number of residents in CBG. Thus, CBGs with 100% white residents would have an ICE of 1.0, CBGs with 100% Black residents would have an ICE of − 1.0, and CBGs with 50% white and 50% Black residents would have an ICE of 0.0

[c] Calculated as $0.75*B_i - 0.80*(I_i/250000) - 0.93*C_i - 0.87*(H_i/910700)$ where B_i = percent of CBG_i that is Black, I_i = median annual household income for CBG_i, C_i = percent of CBG_i aged 25 years or older with a college degree, and H_i = median home value for CBG_i

[d] Calculated as R_i/T_i, where R_i = the proportion of the CBG that is zoned for retail land use and T_i is the proportion of Baltimore City that is zoned for retail land use

[e] No observations in this cell

[f] Q-value = 0.048

ICE of 1.0, CBGs with 100% Black residents would have an ICE of − 1.0, and CBGs with 50% white and 50% Black residents would have an ICE of 0.0. The scale closely mirrored the "Black Butterfly" and "White L" visible in Baltimore's racially and economically segregated landscape (see Fig. 1) [43].

Concentrated Disadvantage We calculated a concentrated disadvantage scale using exploratory factor analysis (EFA) [44, 45]. We used parallel analysis to determine the number of factors and iterative principal factor analysis to extract the factors. We used an iterative process where we dropped variables with factor loadings < 0.4 or uniqueness > 0.5. In the end, our scale comprised one factor with four variables: percent Black, median annual household income, median home value, and percent aged 25 years or older with a college degree. The income and home value variables used a different scale (dollars) than the other two variables (percentages), so we rescaled them by dividing by the range, which resulted in relative measures of income and home values. We then weighted each variable by its respective factor loading and subtracted the products. Thus, our concentrated disadvantage scale was calculated as $0.75*B_i - 0.80*(I_i/250000) - 0.93*C_i - 0.87*(H_i/910700)$ where B_i = percent of CBG_i that is Black, I_i = median annual household income for CBG_i, C_i = percent of CBG_i aged 25 years or older with a college degree, and H_i = median home value for CBG_i. In the regressions, we categorized the concentrated disadvantage scale by quartiles to aid interpretation and allow for non-linear associations. The distribution of the concentrated disadvantage scale is shown in Fig. 1.

HOLC Grades Redlining refers to the outlawed practice of categorizing city neighborhoods according to their perceived risk: green (best), blue (still desirable), yellow (declining), and red (hazardous). Mortgages and other lending was restricted in "hazardous" (red) neighborhoods. Areas that were not coded serve as the reference group; these neighborhoods were likely undeveloped when the maps were originally created. The HOLC grades are shown in Fig. 1.

Social Control and Disinvestment We included drug arrests as a proxy for weakened social control and vacant housing density as a proxy for disinvestment. We calculated kernel density estimation (KDE) [46] densities of vacant houses and drug arrests. Briefly, KDE measures spatial intensity by fitting a non-parametric probability density function over the point data. We summed the values of the KDE raster that fell inside each CBG.

Table 3 Multiple (multivariable) logistic regression results for the association between alcohol outlet cluster membership and census block group racial/ethnic composition, disadvantage, and built environment ($n = 537$) in Baltimore City 2016.

	General clusters			On-premise cluster			LBD-7 cluster			Off-premise cluster		
	aOR	Q-value[a]	95% CI	aOR	Q-value	95% CI	aOR	Q-value	95% CI	aOR	Q-value	95% CI
Index of concentration for race[b]	1.66	0.417	0.60, 4.54	3.71	0.303	1.06, 13.02	2.00	0.271	0.76, 5.25	0.18	0.050	0.05, 0.71
Concentrated disadvantage index[c]												
Quartile 1—Most advantaged	(ref)									0.51	0.542	0.09, 2.87
Quartile 2—Advantaged	0.34	0.189	0.10, 1.17	0.33	0.492	0.08, 1.31	0.33	0.210	0.10, 1.08	0.30	0.436	0.03, 2.75
Quartile 3—Disadvantaged	0.22	0.198	0.03, 1.38	0.24	0.767	0.02, 2.84	0.21	0.210	0.04, 1.27	0.57	0.670	0.06, 5.55
Quartile 4—Most disadvantaged	0.22	0.200	0.03, 1.44	–[e]			0.25	0.255	0.04, 1.55			
HOLC grade												
None	(ref)			(ref)			(ref)			(ref)		
A—Best	–[e]			–[e]			–[e]			–[e]		
B—Still desirable	–[e]			–[e]			–[e]			0.79	0.735	0.19, 3.17
C—Declining	0.95	0.907	0.37, 2.43	0.85	0.927	0.22, 3.24	1.19	0.714	0.48, 2.94	*4.80*	*0.031*	*1.56, 14.79*
D—Hazardous	*8.82*	*0.001*	*2.99, 25.98*	*8.07*	*0.019*	*2.26, 28.77*	*8.60*	*0.001*	*2.93, 25.20*	*7.32*	*0.018*	*2.00, 26.79*
Retail land use location quotient[d]	1.02	0.217	0.99, 1.04	1.02	0.303	1.00, 1.05	1.01	0.394	0.99, 1.03	1.02	0.089	1.00, 1.04
Convenience stores	1.19	0.189	0.99, 1.42	1.06	0.927	0.85, 1.32	*1.36*	*0.009*	*1.13, 1.62*	*1.23*	*0.050*	*1.05, 1.44*
Schools	0.81	0.506	0.47, 1.39	1.02	0.950	0.52, 2.01	0.74	0.386	0.44, 1.27	1.40	0.275	0.90, 2.17
Drug arrest density	*1.13*	*0.003*	*1.06, 1.21*	1.01	0.927	0.92, 1.11	*1.10*	*0.015*	*1.03, 1.17*	0.94	0.129	0.89, 1.00
Vacant housing density	0.96	0.076	0.93, 0.99	0.99	0.927	0.93, 1.05	0.97	0.165	0.94, 1.00	1.01	0.436	0.99, 1.04
Population density	1.04	0.189	0.99, 1.08	0.98	0.927	0.93, 1.04	1.04	0.210	0.99, 1.08	0.99	0.638	0.95, 1.03
Percent single households	0.98	0.267	0.96, 1.01	0.99	0.883	0.95, 1.02	0.99	0.407	0.96, 1.01	1.02	0.155	1.00, 1.04
Error spatial lag	0.99	0.482	0.97, 1.01	0.99	0.897	0.95, 1.02	0.99	0.551	0.97, 1.01	1.01	0.436	0.99, 1.03
Moran's I	*0.08*	*< 0.001*		< 0.01	0.55		*0.09*	*< 0.001*		*0.07*	*< 0.001*	

Italics indicate that $q < 0.05$

aOR adjusted odds ratio, *CI* confidence interval, *HOLC* Home Owner's Loan Corporation, *ref* reference group

[a] Adjusted probability score using a Benjamini-Hochberg-Simes false discovery rate correction

[b] Calculated as $ICE_i = (W_i - B_i)/T_i$ where W_i = number of white residents in CBG, B_i = number of Black residents in CBG, and T_i = total number of residents in CBG. Thus, CBGs with 100% white residents would have an ICE of 1.0, CBGs with 100% Black residents would have an ICE of − 1.0, and CBGs with 50% white and 50% Black residents would have an ICE of 0.0

[c] Calculated as $0.75{*}B_i - 0.80{*}(I_i/250000) - 0.93{*}C_i - 0.87{*}(H_i/910700)$ where B_i = percent of CBG_i that is Black, I_i = median annual household income for CBG_i, C_i = percent of CBG_i aged 25 years or older with a college degree, and H_i = median home value for CBG_i

[d] Calculated as R_i/T_i, where R_i = the proportion of the CBG that is zoned for retail land use and T_i is the proportion of Baltimore City that is zoned for retail land use

[e] No observations in this cell

Population Density and Residential Instability We calculated population density by dividing the total population of each CBG by the size of the CBG in square miles. We scaled this value so a one-unit increase equals an additional 1000 people per square mile. We also used variables for percent of the population who moved in the last year and percent of households in the CBG occupied by renters.

Retail Land Use Within the alcohol outlet density literature, retail land use emerges as a key consideration for understanding the association between outlets and related harms [47]. We calculated a location quotient summarizing the percentage of the CBG land zoned for retail services divided by the total percentage of Baltimore that is zoned for retail services.

Analysis

Statistical Analysis All statistical analyses were conducted using R [48]. We used multiple (multivariable) logistic regression to determine the association between CBG characteristics and alcohol outlet cluster membership by type of outlet. First, we ran a series of simple (bivariate) logistic regressions to identify variables that were associated with each type of cluster. Then, we entered all of the variables with a significant ($p < 0.05$) association in a second series of models, except when this would induce collinearity. These multiple regression models examined how adjusting for covariates changed odds of cluster membership. We refined the models until they were well-specified (as per link specification tests) and had good model fit (as determined by Hosmer-Lemeshow's Goodness of Fit). We applied a Benjamini-Hochberg-Simes multiple testing correction to minimize the odds of false positives [49]. Using this correction, we considered q-values (adjusted probability values) < 0.05 as statistically significant.

Spatial Analyses Our alcohol outlet cluster variables had positive spatial dependence (all Moran's Index values were > 0.80, and all ps < 0.001). This violates the independence assumption of logistic regression and would render our regression results susceptible to false positives, so we undertook spatial analyses. We used a row standardized adjacency matrix using inverse distances to identify neighboring CBGs. The initial regression covariates accounted for roughly half of the spatial dependence in the outcomes. We used spatial error models to account for the residual spatial variation. There was a small amount of positive spatial dependence left in all cluster, LBD-7, and off-premise models. To further protect against false positives, we used robust standard errors estimated using a Huber-White Sandwich Estimator.

Results

Sample Description

Table 1 summarizes the demographic characteristics of Baltimore City CBGs. The average CBG had 1003 people, and 64.8% of the residents were Black, 30.6% were white, and 4.4% were Hispanic/Latino. The average median household income was \$50,094 and varied widely (from \$9750 to over \$250,000+). One in six (17.9%) households had income levels that were below the federal poverty line. About one in six (15.5%) residents changed their address in the past year, and one-half of the population in a typical Baltimore CBG were renters (47.6%).

Cluster Descriptions

The on-premise and LBD-7 clusters were larger than the off-premise cluster (Fig. 2). Roughly 11.3% of the on-premise outlets, 32.2% of the off-premise outlets, and 33.3% of the LBD-7 outlets were located inside a cluster. All alcohol outlet clusters included some portion of the downtown area (the city center with a high retail concentration). The on-premise cluster extended north above downtown and along the inner harbor, where the retail concentration and percentage of residents who were white were also high. The LBD-7 cluster spanned a diverse segment of Baltimore City. The off-premise cluster was more localized and covered much of west Baltimore, which has a high concentration of Black residents.

Simple (Unadjusted) Logistic Regressions

In the simple logistic regressions, the general, on-premise, and LBD-7 outlet clusters tended to have similar patterns of racial/ethnic and economic advantage counterbalanced by residential instability and markers of weakened social control (see Table 2). There was a positive association between percent white and Hispanic/Latino and unadjusted odds of general, on-premise, and LBD-7 cluster membership, and the reverse was true for the percent Black. A one-unit increase in the ICE for racial segregation was associated with 2.5 times the odds of general and LBD-7 cluster membership and nearly 8 times the odds of on-premise cluster membership, suggesting CBGs that are mostly white had higher odds of being in these types of clusters.

The odds of belonging to a general, on-premise, or LBD-7 outlet cluster fell in a roughly linear fashion as concentrated disadvantage increased. Areas that were redlined had 9 ½ times the odds of being in a general or LBD-7 cluster and 5 times the odds of being in an on-premise cluster as compared to areas that were not categorized in the HOLC maps.

CBGs located in off-premise outlet clusters, on the other hand, were marked only by patterns of disadvantage, whether it was measured by racial/ethnic composition, economic disadvantage, residential instability, or markers of disinvestment. The association between off-premise outlet clusters and concentrated disadvantage was non-linear. The odds of off-premise cluster membership were the same among the three most advantaged quartiles, but CBGs in the most disadvantaged quartile had 4.3 times the odds of being in an off-premise outlet cluster (OR = 4.25, 95% CI: 2.00, 9.02, $p < 0.001$) as compared to CBGs in the most advantaged quartile. Areas that were redlined had 10 times higher odds of being in an off-premise outlet cluster (OR = 10.18, 95% CI 4.37, 23.70, $p < 0.001$) as compared to areas that were not categorized in the HOLC maps.

Adjusted Logistic Regression Results

Table 3 summarizes the results from the multiple logistic regressions. Redlining was the only variable that was associated with increased odds of cluster membership for every type of outlet. As compared to CBGs that were not categorized in the HOLC maps, CBGs that were redlined had 7.3 times the odds of being in an off-premise cluster (*aOR* = 7.32, *95% CI*: 2.00, 26.79, $q <$ 0.001), 8.1 times the odds of being in an on-premise cluster (*aOR* = 8.07, *95% CI*: 2.26, 28.77, $q = 0.02$), and 8.6 times the odds of being in an LBD-7 cluster (*aOR* = 8.60, *95% CI*: 2.93, 25.30, $q < 0.001$). No other variables predicted on-premise cluster membership.

A one-unit increase in the ICE racial segregation measure was associated with 82% lower odds of off-premise cluster membership (*aOR* = 0.18, *95% CI:* 0.05, 0.71, $q = 0.05$), suggesting that CBGs that are mostly white had very low odds of being in an off-premise cluster. In addition, every 100 additional drug arrests in a CBG was associated with 13% higher odds of being in a general outlet cluster (*aOR* = 1.13, *95% CI*: 1.06, 1.21, $q < 0.01$) and 10% higher odds of being in a LBD-7 outlet cluster (*aOR* = 1.10, *95% CI*: 1.03, 1.17, $q = 0.02$).

Discussion

There are clear racial and economic disparities among the populations located inside of alcohol outlet clusters. Approximately one in three (31.7%) Baltimore CBGs were located inside at least one type of alcohol outlet cluster. CBGs located inside off-premise alcohol outlet clusters were characterized by Black residents, economic disadvantage, and markers of disinvestment. The reverse was true for the on-premise alcohol outlet cluster, and the population demographics exposed to the LBD-7 outlet cluster fell in between. Overall, this analysis shows that it is important to consider alcohol outlet type, because overall associations may mask important variations.

These results support our hypothesis that on-premise alcohol outlet clusters were in advantaged areas, because the CBGs in the on-premise cluster tended to have more whites and fewer vacant properties in the unadjusted models. Redlining was the only predictor of CBG membership in an on-premise cluster in the multiple logistic regression. While this may seem like a marker of disadvantage, the on-premise clusters are the subset of CBGs that were initially redlined but later gentrified [31]. In 1958, a regional board of business leaders financed massive renovations to transform 22 acres of downtown Baltimore in an effort to counteract the city's dwindling populations and opportunities, and this coincides with the location of the on-premise outlet cluster today.

In contrast, the areas located inside the off-premise clusters are marked by disinvestment. This is evidenced by the strong association between vacant housing density and off-premise outlet cluster membership in the simple logistic regression. The most economically disadvantaged CBGs had the highest odds of being in an off-premise outlet cluster, which is concerning because the association between alcohol outlet availability and violent crime is stronger with off-premise outlets [7, 47, 50–52] and in disorganized areas [37, 53]. Thus, these data suggest that economically disadvantaged populations have the highest exposure to the types (off-premise outlets) and configuration of alcohol outlets (clusters) that are associated with the most harms.

The demographics of the populations who lived in LBD-7 outlet clusters were mixed. As entrepreneurs looked to open alcohol outlets, many were encouraged to open LBD-7 outlets because they had the most days and longest hours [54]. It is possible that the LBD-7 distinction combines two subtypes of outlets: LBD-7 bar/taverns that comply with the law and “sham” bar/taverns. Sham bars/taverns are LBD-7 outlets that devote less than 50% of the sales floor to on-premise consumption (which is required by state law). In essence, they function as extended hours liquor stores. Thus, it is possible that these two types of LBD-7 outlets are distributed differently and/or pose different risks to surrounding communities, but the administrative data used in this study did not contain the detail required to explore this hypothesis.

A recent zoning update called *TransForm Baltimore* contained provisions related to the distance between alcohol outlets in Baltimore City. Specifically, alcohol outlets may not open or relocate within 300 ft of an existing alcohol outlet (except downtown) (§14–336) [55]. While this is an important step toward a healthier alcohol environment, this 300-ft rule (0.06 miles) would not have prevented the clusters identified here. This suggests that infrequent incremental measures like a 300-ft rule likely will not achieve desired reductions in the levels of public health harms. *TransForm Baltimore* also mandated that all LBD-7 outlets must conform to the state statute for percentages of their sales floor and sales receipts to on-premise consumption [55]. This presents an opportunity to re-distribute 38% of Baltimore’s outlets in ways that will reduce and prevent health disparities. However, the available parcels to which these outlets may move are disproportionately located in areas of disinvestment, which means that this policy may simply re-shuffle alcohol outlets from one disadvantaged neighborhood to another [56]. Direct intervention and reinvestment are needed to ensure a more equitable alcohol environment.

This analysis has several limitations. First, we must consider the ecological fallacy, which states that associations at the aggregate level may not be true at the individual level. Second, this was a cross-sectional analysis, so we cannot make causal claims about the associations between population demographics and alcohol outlet cluster membership. To the best of our knowledge, no longitudinal studies have examined whether alcohol outlets move into specific types of neighborhoods or neighborhood dynamics change after alcohol outlets open. Future research should examine temporal ordering of this association. Third, we used spatial error models to account for residual spatial dependence. This undermines interpretation, because it assumes that the adjusted odds ratios hold constant the average residual for adjacent CBGs, which has limited meaning in policy discussions. Further, spatial dependence in regression residuals suggests that the regression may be missing covariates or using a unit of analysis that is unrelated to the phenomenon of inquiry. We considered a broad array of potential covariates that can be measured using administrative or survey data and included those that explained the most variability in cluster locations.

To our knowledge, this is the first analysis to examine the association between redlining and alcohol outlets and to characterize the populations who live inside alcohol outlet clusters. Our findings suggest that off-premise alcohol outlet clusters pose health equity issues, because (a) socioeconomically disadvantaged groups reside in these clusters and (b) the clusters themselves are associated with more harms [57]. There has been a tendency to blame neighborhoods and people who live in those neighborhoods for the high prevalence of harms that they face. This approach ignores alcohol outlet clusters and the forces that shaped them, which are the root causes of the harms. Crime clusters in specific environments more than among specific individuals [58]. In a seminal study, Sherman notes that future crime is “six times more predictable by the address of the occurrence than by the identity of the offender,” ultimately concluding that we should focus more on “wheredunit” rather than “whodunit” [58].

As jurisdictions consider approaches to spread risks and harms more equitably across socioeconomic and racial groups, it is important to consider how we reached the current status quo so as to not repeat past mistakes [57]. In this instance, the inequitable distribution of these outlet clusters arose over the last 40 years in the context of minimal oversight and standards for alcohol outlet locations and in a longer context of racial discrimination in housing that reproduced social inequities in the built environment. It is unlikely that cities like Baltimore will be able to re-distribute their alcohol outlets more evenly without direct and purposeful intervention that intentionally aims to protect racially and socioeconomically marginalized populations. It is also likely that other policies or social programs designed to assist the populations living in these clusters (e.g., job training) are likely to be undermined by the persistence of alcohol outlet clusters and the harms associated with them.

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