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Microecological relationships between area income, off-premise alcohol outlet density, drinking patterns and alcohol use disorders: The East Bay Neighborhoods Study

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Abstract

Background.—Distinguishing the impacts of neighborhood income and off-premise alcohol outlet density on alcohol use has proven difficult, particularly given the conflation of these measures across neighborhood areas. We explicitly test for differential effects related to individual and area income and outlet densities on alcohol use and alcohol use disorders by implementing a stratified microecological sample.

Methods.—The East Bay Neighborhoods Study included a survey of 984 residents of 72 microenvironments within a geographically contiguous six-city area in California and Systematic Social Observations of each site. The sites included 18 areas in each of four strata (high/low median household income and off-premise outlet density). We assessed four outcomes: 28-day drinking frequency, average quantity of alcohol consumed per drinking occasion, 28-day drinking volume, and AUDIT score. We used zero-inflated negative binomial regression with standard errors adjusted for site clusters to relate drinking measures to individual-level age, race/ethnicity, gender, marital status, education, and income, and neighborhood indicators of site strata, physical disorder, and physical decay. An interaction term was tested representing site-level by individual-level income.

Results.—Living in a high-income site, regardless of off-premise alcohol outlet density, was associated with more frequent drinking and higher alcohol dependence/problems. Both individual- and site-level income were related to greater frequencies of use, but lower income drinkers in high-income areas drank more than comparable drinkers in low-income areas. Study participants living in high-density off-premise alcohol outlet sites drank less frequently but did not differ in terms of either AUDIT scores or heavy drinking from participants living in low-density sites.

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Conclusions.—Using a stratified microecological sampling design, we were able to directly assess statistical associations of off-premise outlet density and neighborhood median household income with patterns of drinking and alcohol use disorders. Caution should be used interpreting prior study findings linking off-premise outlet densities to drinking.

Keywords

alcohol outlets; area income; alcohol; neighborhoods; alcohol use disorders

INTRODUCTION

Several different aspects of neighborhood community alcohol environments have been linked to alcohol use (Galea et al., 2004), heavy drinking (Campbell et al., 2009; Foster et al., 2016), and alcohol dependence (Molina et al., 2012; Winstanley et al., 2008). However, signs and strengths of these relationships vary across study populations and neighborhood measures. Without detailed knowledge of the spatial scales and specific social mechanisms that relate neighborhood effects to alcohol use, it is difficult to evaluate the empirical status of these neighborhood effects (Hedstrom, 2006; Mair et al., 2019). One contentious issue in the alcohol research literature is the observation of significant positive, significant negative, and non-significant associations between stores that sell alcohol for consumption elsewhere (off-premise outlets) and alcohol use (Ahern et al., 2013; Gmel et al., 2016; Kavanagh et al., 2011; Morrison et al., 2016; Theall et al., 2011). While social and economic theory argue that greater availability of alcohol should be related to more use (Single, 1988), different off-premise density effects may be observed for three important reasons. First, relevant individual-level covariates related to alcohol use and related problems may not be adequately assessed; this is particularly problematic when these covariates are related to both outlet densities and use. Second, relevant neighborhood-level covariates related to use and problems may be overlooked. Here the greatest concern is to identify and measure social gradients related to alcohol use and problems (e.g., neighborhood measures of wealth and poverty). Third, the assessment of effects using ecological (i.e., neighborhood) samples may not adequately address confounding of highly correlated neighborhood conditions. Thus, while neighborhood income has been linked to drinking and frequencies of use (e.g., Galea et al., 2007) and some (but not all) studies have found alcohol use disorders (AUDs) and other alcohol-related problems to be linked to lower neighborhood income (Karriker-Jaffe, 2011), distinguishing the impacts of neighborhood income from outlet density effects on measures of alcohol use or problems using ecological samples will prove difficult when these covariates are conflated across neighborhood areas.

In general, individual-level measures of off-premise alcohol outlet densities and income are understood to be related to more frequent alcohol use and problem drinking (Babor et al., 2010; Stockwell and Gruenewald, 2004). Greater outlet densities increase use by providing ready access to alcohol. Higher incomes encourage more use (through income effects) and buffer against problems related to drinking (through health benefits associated with greater wealth; (Hasin et al., 2007). While these impacts can be measured at the individual level, they are also expected and can be observed at aggregate ecological levels like cities and states in the US (Gruenewald et al., 2014, 1993). However, these otherwise straight-forward aggregate effects are undermined by strong negative ecological correlations observed between aggregate measures of income, availability, and use within community neighborhoods. Individual alcohol use is responsive to individual income via demand effects, and individuals living in neighborhoods among other high-income neighbors may well be influenced to use more via social modeling (Caudill and Marlatt, 1975; Oostveen et al., 1996). In either case greater individual/community incomes are also related to lower neighborhood alcohol availability, as observed in urban economic models of alcohol outlet locations (Morrison, 2015; Morrison et al., 2015). While demand increases with income, high land rents in high-income residential areas exclude outlets from locating in those areas, thus reducing availability in a process related to the “not in my backyard”, NIMBY, phenomenon. That the relative strengths of these effects vary across community neighborhoods and are spatially structured bodes poorly for any community study that attempts to look at relationships between outlet densities, income, and alcohol use without considering this problem.

In order to disentangle and understand the separate impacts of exposure to off-premise alcohol outlets, individual and neighborhood incomes, and other neighborhood socioeconomic conditions on patterns of alcohol use and prevalence of alcohol use disorders, we developed a stratified microecological sample of 72 neighborhood areas within the East Bay region of Northern California using point-based sampling methods. Stratified by neighborhood off-premise outlet density and income, individual survey samples within these areas enabled us to explicitly test for differential effects related to individual and neighborhood income and outlet densities. By purposefully sampling small ecologic areas (i.e., those with approximately 200 residents), we were able to examine a broad range of exposures and risks by area while still obtaining an adequate sample. With this design in mind, we hypothesized that drinkers living in high vs. low off-premise outlet density neighborhoods would drink more often and exhibit more symptoms related to alcohol use disorders, while those in high vs. low income communities would drink more often but exhibit fewer symptoms related to alcohol use disorders.

MATERIALS AND METHODS

Setting

The East Bay Neighborhoods Study took place in a geographically contiguous six-city area (Oakland, Alameda, Piedmont, Berkeley, Albany, and Emeryville) in the northernmost part of Alameda County, California. These cities ranged from small municipalities (Piedmont) to large cities (Oakland), and included 510 Census block groups. This six-city area encompassed a wide range of characteristics in terms of off-premise outlet densities and median household incomes as well as race/ethnicities of residents. Data collected for this study included a survey of 72 microenvironments within the study area and Systematic Social Observations (SSO) of the 72 sites.

The 72 sites consisted of 18 areas in each of four strata: High median household income and low alcohol outlet density, high median household income and high alcohol outlet density, low median household income and low alcohol outlet density, and low median household income and high alcohol outlet density. To select these 72 sites, we first identified every intersection that connected three or more street segments (12,123 intersections). We then excluded all intersections in contact with Census blocks representing less than 100 persons (using a 10m buffer around the intersection point) and dropped all “non-valid” streets (e.g., highway ramps, driveways), leaving 8,458 intersections. We stratified the remaining intersections by the median household income of the block group in which they were located (highest 50% of intersection values vs. lowest 50% of intersection values). The cutoff for income was $62,569 based on 2015 estimates (Geolytics, 2015). For off-premise outlet density, intersections with two or more off-premise alcohol outlets within 0.2 miles of the intersection were considered high density. This resulted in 3,672 high-income low-density, 2,320 low-income low-density, 1,910 low-income high-density, and 556 high-income high-density intersections. Finally, within each stratum, we randomly selected one intersection, dropped all others within 0.3 miles, randomly selected an intersection from the remaining set, dropped all intersections within 0.3 miles of that intersection, and continued until there were 18 intersections selected for each of the four strata. These intersections formed the centroids of our 72 neighborhood sites. As shown in Figure 1, the 72 sites are distributed throughout the study area and are geographically non-contiguous.

Participants and Procedures

East Bay Neighborhood Survey.—We obtained survey responses from 1,124 residents recruited from the 72 sites. “Neighborhoods” were defined by sequentially chosen street segments radiating from the centroid of the Census block containing the originating intersection of each site. We included enough street segments to identify an approximate minimum of 200 potential households in each site and obtained address lists and phone numbers for all street segments. Letters were sent to all households in each study area, written in both English and Spanish, informing residents of data collection approximately one week before potential enrollment. 12,430 records had an appended phone number and were dialed using a computer-assisted telephone interviewing (CATI) system. All households were called up to three times, with the goal of enrolling 15 residents per site. Scripted messages in both Spanish and English were left on the first and third attempt for each household, indicating the purpose of the study, survey length, payment amount, record number, and toll-free phone number. In order to reinforce responsiveness in 21 low-responding sites, interviewers went door-to-door and left customized postcards that contained instructions for respondents to log-in and complete the web survey or to call a toll-free number to conduct the survey over the phone.

A total of 754 respondents completed the telephone survey and 370 respondents completed the web survey. The range of respondents per neighborhood was seven to twenty-six (mean 15.6). In total, 1,124 respondents completed the survey, of whom 860 (76.5%) had at least one drink within the past year. Complete data were available for 984 of these survey respondents; the remaining 140 were missing information on a combination of the following variables: income (n=104), race/ethnicity (n=36), gender (n=5), marital status (n=17), education status (n=11), and drinking frequency (n=24).

Systematic Social Observation.—Systematic Social Observations provide a well-validated method to collect observational data on social and physical characteristics of urban areas where study participants live (Raudenbush and Sampson, 1999; Sampson and Raudenbush, 1999). We collected SSO data on the environmental characteristics from all street segments forming the central block at the centroid of each of the 72 sites. Data were collected for all block faces by each of two field staff members. Although the majority of these blocks were formed of four segments with eight block faces, many blocks were formed from fewer roads (a minimum of two, e.g., when a block backed onto parkland) and some roads had fewer faces (e.g., one in the case of one roadway faced by another). All block faces were assessed twice with data collected on a standard form loaded onto a digital tablet; assessors paid attention to the inside of the block face the first pass and the outside on the second pass. Field staff walked most blocks. They were unable to do so for safety reasons for 20 blocks in suburban/exurban areas. These blocks extended over great distances (a mile or more), had no sidewalks, and were assessed by car.

Measures

The primary measures of alcohol use and dependence included Alcohol Use Disorders Identification Test (AUDIT) score (Saunders et al., 1993), mean quantity of alcohol consumed per drinking occasion, drinking frequency, and total volume of alcohol consumed. The AUDIT is a ten-question evaluation tool developed by the World Health Organization that assigns a score from zero to four for each item, with a total score any number from zero to forty (Saunders et al., 1993). A score of eight or higher is typically associated with hazardous drinking, while 13+ (women) and 15+ (men) indicates alcohol dependence. We also used a modified AUDIT score, removing the quantity and frequency (AUDIT-C) questions, to represent alcohol dependence/problems specifically. Survey respondents were asked the number of occasions they had consumed 1 or more, 2 or more, 3 or more, 6 or more, and 9 or more drinks in the last 28 days (past-month drinkers) or year (past-year drinkers). Using a model-based graduated frequency approach (Gruenewald et al., 2003a, 2003b), we estimated drinking patterns including the average quantity consumed per drinking occasion and past 28-day volume of alcohol consumed. Drinking frequency was measured as the number of days a respondent drank within the past year (range: 0–365), rescaled to frequency per 28 days.

Key demographic measures included age, race/ethnicity, gender, marital status, education, and income. Respondents reported their ages in years. Race/ethnicity was assessed by asking which groups best describe one’s family of origin, with response options including Black or African American, Hispanic (Latino, Mexican, Mexican-American, Chicano, or other Spanish), White or Caucasian, Asian or Asian-American, other, don’t know, and refused. This variable was recoded to Black/African American, White/Caucasian, and Other. Gender was measured as current gender identity, with male, female, trans male/man, trans female/woman, gender queer/non-conforming, different identity, don’t know, and refused as options. We recoded this variable to male, female, and gender minority. Current marital status options included married, living with someone (in a marriage-like relationship), separated, divorced, widowed, single (never married), don’t know, and refused. The variable was recoded to married or living with someone in a marriage-like relationship vs. not. The highest level of education completed was reported as one of five categories (Did not complete high school, high school graduate (or GED), some college or technical schooling, college or technical school graduate, graduate school, medical school or other post graduate education, don't know, refused). Education was dichotomized to college or technical school graduate or higher vs. a lower level of education. Respondents reported annual income as one of eight categories (<$10,000, $10,001 to $20,000, $20,001 to $40,000, $40,001 to $60,000, $60,001 to $80,000, $80,001 to $100,000, $100,001 to $150,000, $150,000+). A continuous version of this variable, calculated as the midpoint of each category (and $200,000 for the highest-income category) and rescaled per $10,000 increase, was used in analyses.

Measures collected using SSO included physical disorder and physical decay. Physical disorder is a nine-item scale that captures graffiti, litter, empty beer bottles, abandoned cars, broken glass, and other types of neighborhood disarray (Sampson and Raudenbush, 1999). Physical decay is a five-item scale that describes the deterioration and abandonment of residential, commercial, and recreational buildings. The reliability of field staff reports of physical disorder and decay was good (r=0.86 and 0.80, respectively). Finally, dichotomous variables representing neighborhood stratification (high vs. low site income, high vs. low off-premise alcohol outlet density) were generated.

Data Analysis

We assessed five outcomes in separate sets of models: 28-day drinking frequency, average quantity of alcohol consumed per drinking occasion, 28-day drinking volume, AUDIT score, and modified AUDIT (alcohol dependence/problems). Each outcome is a count variable with a high proportion of zeros. Furthermore, distinct processes may be responsible for a zero count in each case. For example, a person who consumed no alcohol in the past year may be recovering from alcohol use disorder; conversely, someone may be a drinker who did not have occasion to consume any alcohol in the past year. As such, we used zero-inflated negative binomial regression to assess each outcome:

$$\begin{cases} Y_i = 0, \text{ with probability } \pi_i, \\ Y_i | \mu_i, \alpha \sim NB(\mu_i, \alpha), \text{ with probability } 1 - \pi_i . \end{cases}$$

where Y_i is the outcome (drinking frequency, quantity, volume, or AUDIT score), μ_i is the mean, and α is the overdispersion parameter. As respondents were recruited from 72 sites, standard errors were adjusted for 72 site clusters.

We estimated separate models for each of the five outcomes. Each of the five models related a drinking measure (frequency, quantity, volume, AUDIT score, modified AUDIT) to individual-level covariates for age, race/ethnicity, gender, marital status, education, and income, and neighborhood indicators of site strata, physical disorder, and physical decay. Reflecting our interest in potential interactions between individual and aggregate income effects, an additional interaction term was added in all models representing site-level by individual-level income effects and retained where p<0.05. Variables chosen as predictors of zero inflation were individual-level characteristics whose inclusion in the zero-inflation component resulted in effect estimates with p-values below 0.05 and lower model Akaike information criterion (AIC) values; these included respondent age, marital status, and income.

RESULTS

Patterns of alcohol consumption varied across the four study site types (Table 1). 767 (78%) of the 984 survey respondents were past-year drinkers. The average AUDIT score was 2.8; 6.8% of survey respondents reported AUDIT scores of 8 or greater (cutoff for harmful or hazardous drinking), and 1.5% had a score corresponding to alcohol dependence (13+ women, 15+ men). Survey respondents in the low-income low-density sites had lower average AUDIT scores but a higher percentage reporting hazardous drinking (8.0% vs. 5.2% in high-density high-income sites). Respondents typically consumed 1.4 drinks per drinking occasion, which did not vary significantly across site type. Individuals living in high-income sites drank approximately twice as frequently as those living in low-income sites, with individuals living in high-income low-density sites reporting the most frequent drinking (9.4 per 28 days) and those in low-income high-density sites reporting the least frequent drinking (4.8 per 28 days). Differences in drinking frequency were non-significant within income strata. Driven by the differences in drinking frequency, individuals in high-income low-density sites drank the greatest total volume of alcohol across 28 days (16.6 drinks vs. 13.8 (high-income high-density), 11.1 (low-income low-density), and 10.7 (low-income high-density)).

There were demographic differences between respondents living in the four site types, with the largest differences between high- and low-income sites (Table 1). High-income high-density locations had the greatest percentage of individuals married or living with someone in a marriage-like relationship (59.1%), with low-income high-density reporting the lowest percentage (35.0%). The entire sample skewed older (mean age 53.8 years) and had a high level of education (72.0% college graduates; this varied from 85.7% (high-income high-density) to 58.6% (low-income low-density)). The percentage of White and Black respondents varied by site income; 8.3% and 7.0% of respondents in the high-income high-density and high-income sites identified as Black/African American vs. 33.5% and 37.3% in the low-income high-density and low-income low-density sites. The mean of the eight self-reported income category medians across all site types was $86,100, with variation from $110,000 (high-income low-density) to $63,500 (low-income high-density). For each of these demographic characteristics, there were no significant differences within income strata (i.e., between low-income high-density and low-income low-density, as well as between high-income high-density and low-income low-density). Low-income high-density sites had the highest observed physical decay and physical disorder scores, followed by low-income low-density, high-income high-density, and high-income low-density sites.

As shown in Table 2, drinking frequencies were associated with a number of individual- and site-level covariates. Of particular interest, net of individual-level effects related to race/ethnicity, gender, marital status, education, and income, drinking frequencies were greater in high-income sites but inversely related to off-premise alcohol outlet densities. At the individual level, White respondents drank 65% more frequently than non-White non-Black respondents, males 21% more frequently than females, those married or living in a marriage-like relationship 23% more frequently than those who were not, while those with a college degree or greater drank 58% more frequently than those with less education. Individual income was related to greater frequencies of use with these frequencies increasing 4% for each $10,000 of additional income in low-income areas. And, importantly, a significant disordinal interaction appeared between individual and site income; both individual- and site-level income were related to greater frequencies of use, but lower income drinkers in high-income areas drank far more than comparable drinkers in low-income areas (Figure 2).

Average drinking quantity exhibited different patterns than frequency of drinking (Table 2). Older respondents drank a smaller average quantity, while males drank 30% more drinks per drinking occasion than females. Similarly, older age and female gender were both associated with a lower total volume of alcohol consumed. For each $10,000 of additional income, individuals drank 2% greater volume of alcohol in 28 days. White individuals drank 66% greater volume than non-White non-Black respondents. There were no significant associations between site type or characteristics and either quantity or volume of alcohol consumed, nor individual- by site-level interactions.

Males had AUDIT scores 37% higher than females, while White individuals had 28% higher AUDIT scores (Table 2). Each additional year of age was associated with a 1.3% lower AUDIT score. Using a modified AUDIT score that dropped the AUDIT-C items (questions 1–3), representing alcohol dependence and problems (rather than heavy or hazardous drinking), younger age and White race were no longer statistically significantly associated with a higher AUDIT score, while gender minority status, high site income, and higher neighborhood physical decay were associated with higher scores.

The zero inflation component of the models showed that individuals with higher incomes were less likely to have a certain zero AUDIT score, volume, and quantity of alcohol consumed, which means that those with higher incomes are more likely to have consumed alcohol in the past 12 months and/or injuring/been injured by alcohol or having had a friend, relative, or health worker been concerned about drinking in their lifetime (AUDIT), as well as consumed a non-zero volume of alcohol in the past 28 days. Conversely, individuals who were married/in a marriage-like relationship were more likely to have a predicted certain zero AUDIT score, volume, and quantity of alcohol consumed. Older individuals were more likely to have a certain zero past-28 day AUDIT score and alcohol frequency and volume.

Since it has been demonstrated that results from these kinds of nonlinear models of problems related to alcohol use are subject to biases due to heteroskedastic drinking effects (Gruenewald et al., 2016; Gruenewald and Mair, 2019), two additional specification tests using alternative analytic strategies (heteroskedastic ordered logistic and Tobit models) were used with the same basic results obtained. We conducted several other specification tests. An interaction term between site income and off-premise outlet density was tested in each of the models but was non-significant in all cases. Adding site income and site density to the zero inflation components of the final models did not improve model fit and neither was significant in any model.

DISCUSSION

The East Bay Neighborhoods Study design enables the disentangling of specific neighborhood area effects related to alcohol use and related problems. Using a stratified microecological point-based sampling design, we were able to investigate the separate impacts of off-premise outlet density and neighborhood median household income on patterns of drinking and alcohol use disorders. Distinctive patterns emerged for different measures of alcohol use and, in the case of drinking frequency, for higher- vs. lower-income individuals. High site income and low outlet densities were associated with drinking frequency.

Contrary to expectation, study participants living in high-density off-premise alcohol outlet sites did not drink more heavily or have higher AUDIT scores than those in low-density sites. This was true in both high- and low-income sites. In descriptive analyses, individuals living in high-density sites had similar demographic characteristics and drinking patterns as those in low-density sites within income strata. This may be explained by the expectation that exposure to off-premise alcohol outlets would affect the frequencies by which alcohol is consumed, rather than the amount consumed (which requires additional drivers, as may be seen in some on-premise drinking locations such as bars). The literature on associations between off-premise alcohol outlet densities and drinking patterns has been quite mixed. One reason for this may be that outlet densities are highly correlated with other community characteristics, such as median household income, and any examined patterns may be due to the impact of these other factors. There is more robust evidence that off-premise alcohol outlets are associated with several alcohol-related problems, such as violence (Mair et al., 2013) and intimate partner violence (Cunradi et al., 2011) than with alcohol consumption itself.

On the other hand, living in a high-income site, regardless of off-premise alcohol outlet density, was associated with more frequent drinking and greater alcohol dependence (as represented by the modified AUDIT score). The association between site income and 28-day drinking frequency decreased as individual-level income increased. In high-income sites, all those except the lowest-income individuals drink equally frequently; put another way, high-income individuals drink equally frequently regardless of the income of their neighborhood. Important to note here is that lower-income individuals in high-income neighborhoods drink more often than those with similar incomes in low-income neighborhoods. Low income individuals residing in high income areas might be explained by several circumstances, for example, live-in domestic laborers; dependent adult children; boarders or renters of “in-law” units; or “low income advantaged” people, i.e., relatively young individuals from affluent families who are not yet earning high salaries. This observation has important implications for preventive interventions: Individual income effects are to be expected for all persons living in all neighborhoods, but it would appear that social influences within high-income neighborhoods promote more frequent drinking among low-income individuals. These would appear to be based upon influence mechanisms, requiring still more elucidation.

Physical disorder and physical decay, both measured through systematic social observation, were not associated with any alcohol use measures with the exception of the association between physical decay and greater alcohol dependence. There were, however, significant differences in both physical disorder and decay by site type. Highest levels were observed in low-income high-density sites, followed by low-income low-density, high-income high-density, and high-income low-density. Prior research has observed associations between neighborhood physical disorder and heavy alcohol use, though many of these studies have focused on low income women (Hill and Angel, 2005; Mulia et al., 2008) or high density urban areas (Bernstein et al., 2007). Our study, on the other hand, purposefully sampled individuals in high and low poverty microenvironments in a study area that includes a range of socio-economic conditions. It may be that physical disorder and physical decay have specific impacts on alcohol use among subpopulations or in specific types of neighborhoods, or that alcohol-dependent individuals may come to reside in neighborhoods characterized by physical decay. One of the posited hypotheses for the associations between off-premise alcohol outlet densities and alcohol use is that these outlets tend to be located in areas of higher social and physical disorder; another is that the outlets themselves send the message that there are low levels of social control and thus increase levels of neighborhood disorder directly and alcohol use indirectly (Bennett et al., 1996; Gorman et al., 2001). It appears, in our sample, that physical decay and disorder are not associated with patterns of alcohol use above and beyond their unsurprising correlations with area income. Future studies may consider comparing the impact of physical disorder and decay in specific neighborhood types or comparing for whom these conditions matter, as well as considering the impacts of alcohol dependence on place of residence.

It is important to note that our sample skews older (mean age 53.8), more female (60%), and with a higher education level (72% college graduates) than the population living in the East Bay of California, though other key demographic characteristics of our study population, such as race/ethnicity and income, resemble the larger population. The observed associations in this study may not hold up in other regions; patterns of alcohol consumption vary by state (Haughwout and Slater, 2018) and rural vs. urban communities (Matthews et al., 2017), and the impact of off-premise outlet density on drinking patterns may vary by other community-level characteristics. The area income variable was stratified by median household income in our study. The East Bay demonstrates a relatively wide socioeconomic range, with more affluent households compared to the other parts of the country, evidenced by an average median household income of $68,440 from 2014–2018 (vs. $60,293 across the United States). This potentially limits the representativeness of our income findings for other regions of the United States. Our measures of alcohol use did not include a full assessment of alcohol use disorder (AUD), instead using the AUDIT assessment of hazardous drinking. While not a clinical assessment, the AUDIT has been found to perform extremely well in detecting alcohol dependence (Lundin et al., 2015).

By utilizing a stratified sampling strategy with sufficient respondents per site, we were able to investigate the impact of both area income and off-premise alcohol outlet density on alcohol use above and beyond individual characteristics. The 72 microecological sites are smaller than Census tracts or block groups, and allow for the investigation of small-scale impacts on patterns of alcohol use. Our findings indicate that caution should be used in interpreting prior study findings linking off-premise outlet densities to heavier or more frequent drinking. While considerable progress has been made in the development of comprehensive models of the impacts of on-premise outlets, especially bars, upon specific problems like violent assaults and motor vehicle crashes (Lipton et al., 2018; Mair et al., 2013), the determination of the features of neighborhood alcohol environments that affect drinking and problems related to off-premise outlets remains an open scientific problem in the field.

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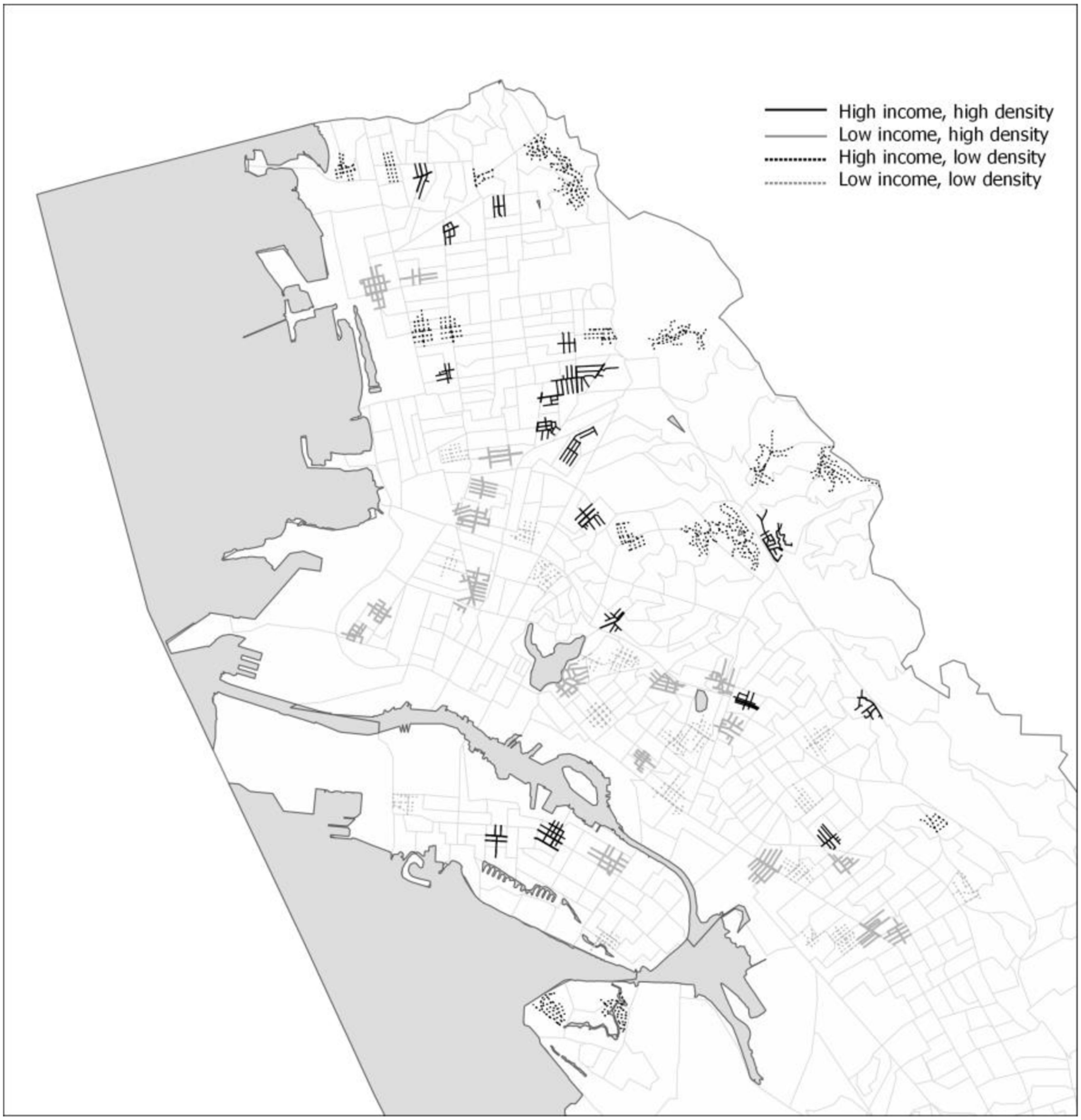

Figure 1.
Locations of 72 Sites in East Bay Neighborhoods Study, by Strata

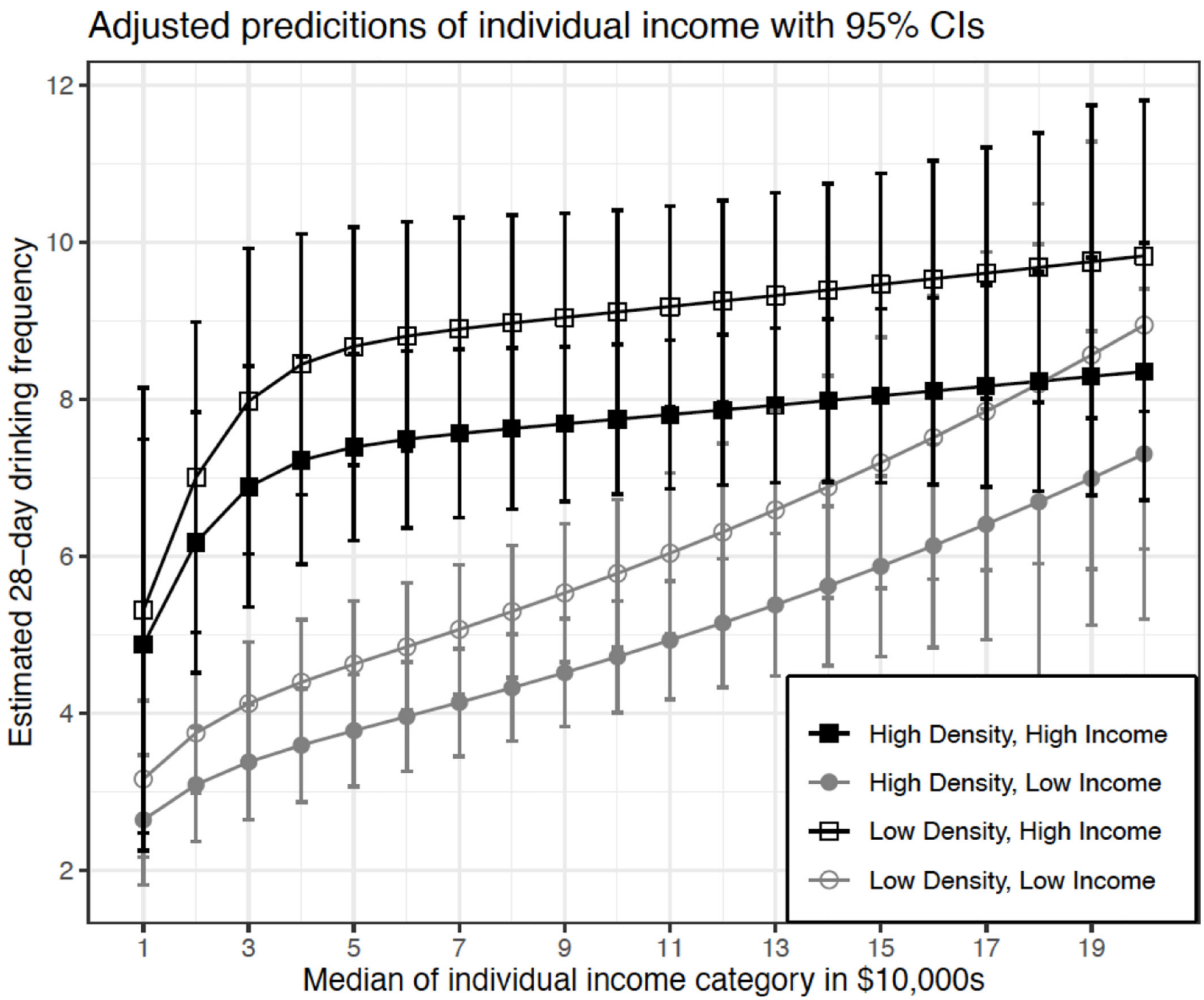

Figure 2.
Interaction between Site- and Individual-Level Income, Frequency Model

Table 1.

Descriptive statistics ($n = 984$ survey respondents; 72 sites)

	Site Type					
	High Income		Low income			
	High density	**Low density**	**High density**	**Low density**	**All sites**	***P*-value**
Number (%) of respondents	252 (25.58)	229 (23.27)	254 (25.79)	249 (25.28)	984 (100.00)	
Individual drinking measures						
Drinking frequency per 28 days, mean (SD)	8.02 (8.67)	9.38 (9.80)	4.80 (7.07)	5.81 (7.86)	6.95 (8.55)	<0.001**
Mean drinking quantity per 28 days, mean (SD)	1.45 (1.34)	1.38 (0.93)	1.46 (1.80)	1.35 (1.33)	1.41 (1.39)	0.435
Volume per 28 days, mean (SD)	13.76 (17.40)	16.61 (21.47)	10.75 (19.34)	11.10 (17.46)	12.980 (19.06)	<0.001**
AUDIT total score, mean (SD)	3.00 (2.77)	3.09 (3.11)	2.62 (3.72)	2.52 (3.34)	2.81 (3.26)	<0.001**
AUDIT items 4–10, mean (SD)	0.63 (1.59)	0.65 (1.95)	0.67 (2.26)	0.55 (1.88)	0.62 (1.93)	0.632
Age, mean (SD)	55.61 (16.26)	60.81 (16.25)	49.43 (16.53)	50.04 (15.23)	53.82 (16.68)	<0.001**
Marital status						<0.001**
Married or living with someone in a marriage-like relationship, number (%)	149 (59.13)	129 (56.09)	89 (35.04)	98 (39.36)	465 (47.21)	
Gender						0.056
Male, number (%)	102 (40.48)	102 (44.54)	98 (38.58)	79 (31.73)	381 (38.72)	
Gender minority, number (%)	2 (0.79)	1 (0.44)	3 (1.18)	7 (2.81)	13 (1.32)	
Employment						0.005*
Employed (part- or full-time), number (%)	146 (57.94)	112 (48.91)	161 (63.39)	156 (62.90)	575 (58.49)	
Education						<0.001**
College graduate, number (%)	216 (85.71)	190 (82.97)	156 (61.42)	146 (58.63)	708 (71.95)	
Race/ethnicity						<0.001**
Black/African American, number (%)	21 (8.33)	16 (6.96)	85 (33.46)	93 (37.35)	215 (21.83)	
White/Caucasian, number (%)	197 (78.17)	174 (75.98)	114 (44.88)	98 (39.36)	583 (59.25)	
Income						<0.001**
Less than $20,000, number (%)	18 (7.14)	21 (9.13)	55 (21.65)	45 (18.07)	139 (14.11)	
$20,000 to $60,000, number (%)	51 (20.24)	45 (19.57)	91 (35.83)	93 (37.35)	280 (28.43)	
$60,001 to $100,000, number (%)	65 (25.79)	54 (23.48)	57 (22.44)	55 (22.09)	231 (23.45)	
$100,001 or more, number (%)	118 (46.83)	109 (47.60)	41 (20.08)	56 (22.49)	334 (33.94)	

	Site Type					
	High Income		**Low income**			
	High density	**Low density**	**High density**	**Low density**	**All sites**	***P*-value**
Mean (SD) of eight income category medians (in $10,000s)	10.41 (6.15)	11.00 (6.78)	6.35 (5.17)	6.87 (5.48)	8.61 (6.25)	<0.001**
Site characteristics (n=72 sites)						
Number of respondents per site, mean (SD)	14.29 (2.27)	13.42 (2.36)	15.19 (3.67)	14.53 (3.52)	14.38 (3.10)	
Physical decay, mean (SD)	0.49 (0.69)	0.27 (0.64)	1.60 (1.01)	0.90 (0.99)	0.83 (0.99)	<0.001**
Physical disorder, mean (SD)	2.54 (1.23)	1.50 (1.42)	4.38 (1.23)	3.36 (1.56)	2.98 (1.72)	<0.001**

Table 2.

Coefficients [95% confidence intervals (CIs)], zero-inflated negative binomial regression, standard errors adjusted for 72 site clusters, AUDIT score, mean drinking quantity, frequency, and volume (n = 984 respondents)

	y = Frequency	y = Mean Quantity	y = Total Volume	y = AUDIT Score	y = AUDIT Items 4–10
	Coef. [95% CI][a]	**Coef. [95% CI][a]**	**Coef. [95% CI][a]**	**Coef. [95% CI][a]**	**Coef. [95% CI][a]**
Individual demographic characteristics					
Age	−0.002 [−0.007, 0.003]	−0.015 [−0.018, −0.011][b]	−0.008 [−0.014, −0.002][b]	−0.013 [−0.017, −0.008][b]	0.001 [−0.006, 0.009]
Race/ethnicity					
Black/African American	0.050 [−0.332, 0.432]	0.145 [−0.132, 0.422]	−0.064 [−0.523, 0.394]	−0.005 [−0.326, 0.316]	0.133 [−0.262, 0.528]
White/Caucasian	0.498 [0.258, 0.738][b]	0.141 [−0.047, 0.330]	0.509 [0.175, 0.843][b]	0.280 [0.063, 0.497][b]	0.218 [−0.166, 0.601]
Gender					
Male	0.189 [0.030, 0.349][b]	0.260 [0.135, 0.385][b]	0.395 [0.196, 0.595][b]	0.369 [0.227, 0.512][b]	0.373 [0.089, 0.657] [b]
Gender minority	0.500 [−0.191, 1.192]	−0.119 [−0.487, 0.249]	0.368 [−0.569, 1.305]	0.182 [−0.741, 1.106]	1.258 [0.835, 1.680] [b]
Married/living marriage-like relationship	0.209 [0.027, 0.392][b]	−0.040 [−0.175, 0.095]	0.039 [−0.139, 0.217]	−0.035 [−0.161, 0.091]	−0.522 [−0.858, −0.186] [b]
College education or higher	0.458 [0.226, 0.690][b]	−0.068 [−0.233, 0.096]	0.177 [−0.100, 0.455]	−0.001 [−0.198, 0.196]	−0.253 [−0.574, 0.068]
Income	0.044 [0.019, 0.068][b]	0.000 [−0.010, 0.011]	0.019 [0.000, 0.037][b]	0.003 [−0.009, 0.016]	−0.008 [−0.040, 0.024]
Site characteristics					
Income: high	0.431 [0.091, 0.772][b]	0.003 [−0.158, 0.164]	−0.012 [−0.232, 0.207]	0.088 [−0.057, 0.233]	0.349 [0.051, 0.647] [b]
Alcohol outlet density: high	−0.163 [−0.324, −0.003][b]	0.045 [−0.093, 0.183]	−0.112 [−0.301, 0.076]	−0.048 [−0.185, 0.088]	−0.211 [−0.457, 0.036]
Physical decay	−0.082 [−0.188, 0.023]	−0.028 [−0.112, 0.056]	−0.052 [−0.185, 0.080]	0.036 [−0.058, 0.131]	0.210 [0.062, 0.358] [b]
Physical disorder	−0.017 [−0.085, 0.051]	−0.017 [−0.066, 0.031]	−0.112 [−0.301, 0.076]	−0.020 [−0.075, 0.035]	−0.008 [−0.113, 0.097]
Interaction term					
Individual income x site income (high)	−0.036 [−0.065, −0.007][b]	-	-	-	-
Zero inflation: individual demographic characteristics					
Age	0.054 [0.009, 0.099][b]	0.014 [−0.016, 0.044]	0.039 [0.004, 0.074][b]	0.026 [0.003, 0.049] [b]	0.041 [0.029, 0.053] [b]

	y = Frequency	y = Mean Quantity	y = Total Volume	y = AUDIT Score	y = AUDIT Items 4–10
	Coef. [95% CI][a]	**Coef. [95% CI][a]**	**Coef. [95% CI][a]**	**Coef. [95% CI][a]**	**Coef. [95% CI][a]**
Married/living marriage-like relationship	2.184 [−0.251, 4.619]	2.113 [0.814, 3.413][b]	1.860 [0.513, 3.207][b]	1.600 [0.569, 2.632][b]	0.072 [−0.350, 0.494]
Income	−0.987 [−2.599, 0.626]	−1.012 [−1.484, −0.540][b]	−0.807 [−1.330, −0.284][b]	−0.652 [−0.954, −0.351][b]	−0.045 [−0.076, −0.013][b]
AIC	5556.13	2867.99	6488.30	4147.31	1522.16

[a]Standard errors are adjusted for 72 site clusters.

[b]Significant as indicated by a 95% confidence interval that excludes zero.