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Associations between Neighborhood Alcohol Availability and Young Adolescent Alcohol Use

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Abstract

We investigated the association between alcohol outlet density and adolescent alcohol use, including whether this association differed by sociodemographic characteristics. We geocoded and mapped active license data from the California Department of Alcoholic Beverage Control from the year 2011 with ArcMap GIS to calculate the number of outlets within multiple circular buffers of varying sizes (density), centered at households of adolescents ages 10-16 (n = 2,724). We examined two indicators of alcohol use: any lifetime use, but not in past month; and any past month heavy use (defined as five or more drinks in one sitting). Cross-sectional hierarchal multivariate regression analyses were used to examine associations between alcohol outlet density and alcohol use, including the potential moderating effect of age, sex, race/ethnicity, and socioeconomic status. Analyses controlled for neighborhood level socioeconomic status and accounted for census tract-level clustering. A higher number of on- and off-premise outlets within 0.1, 0.25, and 0.5 miles around the respondents' homes was associated with higher odds of being a heavy drinker. In addition, the number of on-premise outlets within the 0.25 mile radius was associated with greater odds of lifetime drinking. For on-premise outlets where minors were not allowed (clubs/bars), we observed a positive and significant association between clubs/bars within the 0.25 mile buffer zone and higher odds of both lifetime and heavy drinking. Findings suggest that youth who are exposed to higher densities of on-premise alcohol outlets are at risk for both lifetime use and recent heavy use. It is critical to advocate for stricter laws limiting the number of alcohol outlets in neighborhoods, including clubs/bars where minors are restricted. More stringent enforcement of both age identification requirements and distribution of alcohol to minors are also needed at on-premise outlets, even minor-restricted clubs/bars.

Keywords

Alcohol; adolescents; alcohol outlet density; neighborhood; availability

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The middle school years represent a vulnerable period for the first onset of alcohol use (DeWit, Offord, & Wong, 1997; Gfroerer, Wu, & Penne, 2002; Wittchen et al., 2008). By the 8th grade (about 13 to 14 years old), 33% of U.S. adolescents report having initiated drinking (Johnston, O'Malley, Bachman, & Schulenberg, 2011). Early initiation of alcohol is a public health concern because it is associated with concurrent and future alcohol use problems and dependence (Brook, Brook, Zhang, Cohen, & Whiteman, 2002; D'Amico, Ellickson, Collins, Martino, & Klein, 2005; Merline, Jager, & Schulenberg, 2008), alcohol-related violence and delinquency (Swahn & Donovan, 2004), use of other substances (Komro, Tobler, Maldonado-Molina, & Perry, 2010), and risky sexual behavior (Stueve & O'Donnell, 2005). A growing compendium of literature suggests that the context of an adolescent's neighborhood plays a significant role in an adolescent's choice to use alcohol (Huckle, Huakau, Sweetsur, Huisman, & Casswell, 2008; Tobler, Komro, & Maldonado-Molina, 2009a; Truong & Sturm, 2009). These studies support Bronfenbrenner's ecological systems theory which purports that the entire ecological system, including neighborhood characteristics at the exosystem level (as well as other individual, peer, and family factors), influences personal choices such as alcohol use (Behrendt et al., 2008). Among those neighborhood characteristics most relevant to adolescent alcohol use is the availability of alcohol outlets that sell alcoholic beverages near an adolescent's home. Guided by this ecological systems theory, our analyses examine how alcohol outlet density is associated with alcohol use in a sample of young adolescents, independent of other multi-level characteristics.

Many adolescents access alcohol through both social and familial sources (Dent, Grube, & Biglan, 2005; Hearst, Fulkerson, Maldonado-Molina, Perry, & Komro, 2007; Paschall, Grube, Black, & Ringwalt, 2007; Tobler et al., 2009a; Wagenaar et al., 1993); however, the National Survey on Drug Use and Health also found that approximately 1 out of 13 drinkers aged 12-20 purchased alcohol directly from a bar, store, restaurant, or club (Center for Behavioral Health Statistics and Quality, 2012). Neighborhoods with large numbers of these types of alcohol outlets therefore provide more opportunities for youth to purchase alcohol (Hearst et al., 2007; Paschall, Grube, Black, Flewelling, et al., 2007; Wagenaar et al., 1993). Despite these trends, most studies that examine the association between alcohol outlet density and alcohol use focus on adult samples. To date, only eleven studies (Chen, Grube, & Gruenewald, 2010; Huckle et al., 2008; Kuntsche, Kuendig, & Gmel, 2008; Pasch, Hearst, Nelson, Forsyth, & Lytle, 2009; Paschall, Grube, Thomas, Cannon, & Treffers, 2012; Rootman & Oakey, 1973; Rowland et al., 2014; Stanley, Henry, & Swaim, 2011; Tobler, Komro, & Maldonado-Molina, 2009b; Truong & Sturm, 2009; Young, Macdonald, & Ellaway, 2013) have examined the association between alcohol outlet density and alcohol outcomes for adolescents age 18 or younger. These studies are summarized in Table 1. However, findings from these studies are mixed, perhaps because of variability in the country examined, racial/ethnic diversity of the sample, confounders included in the modeling strategy, and differences in the way outlet density was measured. Below we discuss why addressing these differences will help clarify the relationship between alcohol outlet density and adolescent alcohol use.

Measurement of Neighborhood Alcohol Availability

There are numerous methods to calculate neighborhood alcohol availability, such as alcohol outlet density, which refers to the number of alcohol outlets within a geographic area, or proximity to alcohol outlets, which refers to distance to the nearest alcohol outlet. Access can be measured within circular buffered zones, by roadway miles, or by administrative boundaries (e.g., census tracts or ZIP code areas). A recent systematic review of community-level alcohol availability found that density measures are far more frequently examined than proximity measures in studies on alcohol availability and alcohol consumption (Bryden, Roberts, McKee, & Petticrew, 2012). By and large, when studies compare the associations of alcohol use with density versus proximity to nearest outlet, density is a statistically significant predictor whereas proximity is not (Kavanagh et al., 2011; Pollack, Cubbin, Ahn, & Winkleby, 2005; Scribner et al., 2008). As such, we focus on alcohol outlet density as our measure of neighborhood availability in order to facilitate comparisons with previously published studies.

Alcohol outlets can be classified as on-premise or off-premise. On-premise alcohol outlets include establishments where alcohol is served on the premises, including restaurants, pubs, clubs, and hotels. Off-premise outlets include grocery stores and convenience stores that sell alcohol for off-premise consumption, although some outlets may do tastings on-site. Distinguishing between outlet types can influence the strength of the association with adolescent alcohol consumption. For example, one study examined off-premise outlet counts per 1,000 roadway miles at the ZIP code-level and found significantly greater levels of drinking among youth residing in ZIP codes with higher alcohol outlet densities (Chen et al., 2010). However, another study measured alcohol outlet density by dividing the total number of stores (either off- or on-premise sales) or bars selling alcohol by the land area around each adolescent's home and school, and they did not find an association with past month alcohol use or being drunk within the past month (Pasch et al., 2009). Whereas most studies on adolescents ages 18 and younger have measured the density of off-premise outlets, associations with alcohol use are mixed such that some studies report an association (Chen et al., 2010; Rootman & Oakey, 1973; Tobler et al., 2009b; Truong & Sturm, 2009), while others report no association (Pasch et al., 2009; Paschall et al., 2012; Stanley et al., 2011). Only three studies compare on- and off-premise outlet density, with two showing that only on-premise density was significantly associated with alcohol use (Kuntsche et al., 2008; Paschall et al., 2012) and one showing that both types mattered (Truong & Sturm, 2009). A possible reason why the two U.S. studies (Paschall et al., 2012; Truong & Sturm, 2009) had inconsistent findings is that Paschall and colleagues (2012) used a more racially homogenous sample (75% white) than did Truong & Sturm (2009). Thus, it may be that the distribution of alcohol outlet types differed substantially across these studies. Examining on- and off-premise outlet types separately is important because although off-premise outlets have been most frequently studied in relation to adolescent alcohol use, the likelihood of selling to underage youth from on-premise oulets may actually be just as high as for off-premise outlets (Britt, Toomey, Dunsmuir, & Wagenaar, 2006). Adults may also be more likely to provide alcohol (e.g., at restaurants) to younger adolescents ages 12-14 compared

to older adolescents 15-17 (Rowland et al., 2014). Thus, off-premise outlets are not the only way for younger adolescents to access alcohol.

Within the category of on-premise outlets, it is important to distinguish between those outlets in which minors are allowed and those in which they are not; adolescents may still gain access to alcohol through higher density of on-premise outlets where minors are not allowed (such as clubs and bars) through older friends, fake IDs, or increased exposure to alcohol use among adults of legal drinking age, which may influence beliefs about drinking norms for adolescents living nearby. As summarized in Table 1, two U.S. studies compared on- and off-premise outlet density in relation to adolescent alcohol use (Paschall et al., 2012; Truong & Sturm, 2009). However, Paschall and colleagues (2012) did not examine total on-premise outlets (only on-premise outlets that were clubs and bars). Thus, neither study was able to compare associations between different on-premise outlets. We therefore contribute to the body of literature published to date by further parsing out the sub-category of on-premise outlets to examine three different types of alcohol outlets (off-premise, on-premise, and on-premise outlets where minors are not allowed), which to date has not been done in any U.S. study.

Several years ago, the U.S. Task Force onCommunity Preventive Services (2009) suggested that there is sufficient evidence to recommend controlling the density and type of alcohol outlets to reduce excessive alcohol use. However, other studies summarized in a review by Bryden et al. (2012) suggest that although availability measured by density of alcohol outlets may provide the strongest evidence for an association between alcohol outlet availability and alcohol use, the quality of studies varies considerably and results across studies were not consistent. Therefore, examining several different buffer sizes within a U.S. sample is important because the geographic size of the most relevant area surrounding an adolescent's home can inform the debate about whether policy changes are needed to control the density and type of alcohol outlets, especially for younger adolescents who may not be able to access alcohol outlets at further distances because they cannot drive.

Differences in Neighborhood Alcohol Availability by Individual and Contextual Characteristics

Neighborhood alcohol availability varies by age, sex, race/ethnicity, and socioeconomic status. For example, one study found males were more likely than females to use commercial sources to purchase and/or obtain alcohol (Harrison, Fulkerson, & Park, 2000). Other studies have found that Hispanic, non-Hispanic black, and Asian/Pacific Islander adolescents and adolescents with lower household income had a significantly greater access to alcohol outlets around their home (Tobler et al., 2009a), even after controlling for population density (Truong & Sturm, 2009). Among the aforementioned eleven studies that examined the association between alcohol outlet density and adolescent alcohol use, only two studies examined whether individual-level characteristics (age and gender) moderated the association between alcohol availability and alcohol use among younger adolescents (Rowland et al., 2014; Young et al., 2013). Young and colleagues (2013) did not find any significant interactions by gender. Rowland et al. (2014) examined a representative sample

of Australian children in the State of Victoria and observed statistically significant interaction effects of alcohol outlet density and age. They found the strongest association between density of off-premise outlets and past month alcohol use among adolescents age 12-14, and the magnitude of the association declined as age increased, suggesting that younger adolescents may be most vulnerable to density of alcohol stores (Rowland et al., 2014). It is critical to determine whether age and other individual-level demographic characteristics modify the effects of alcohol outlet density in a U.S. sample of adolescents. Thus, the current study will address gaps in understanding about differential associations between alcohol availability and alcohol use by age, sex, race/ethnicity, and socioeconomic status within a U.S. sample that is more diverse than any other study conducted to date.

Prior studies have found that the density of alcohol outlets also varies by neighborhood socioeconomic status (NSES). Pollack et al. (2005) found that more deprived areas within California had the highest number of alcohol outlets, yet adults living in the least deprived areas had the highest levels of alcohol use. Thus, it is critical to adjust for NSES when examining the association between alcohol outlet density and alcohol use as NSES is associated with both increased risk of adolescent alcohol use (Truong & Sturm, 2009) and greater alcohol availability (Karriker-Jaffe, 2011). Of the eleven studies that examined alcohol outlet density in relation to adolescent alcohol use, only one study specified that it adjusted for NSES at the census tract-level (Truong & Sturm, 2009), which approximates neighborhoods (versus other studies that use ZIP code-level indicators of socioeconomic status, which are larger boundaries specified by the postal service). For instance, Rowland et al. (2014) found that ZIP code-level socioeconomic disadvantage was not significantly associated with alcohol consumption in Australian adolescents ages 12-17 suggesting that NSES at smaller geographic areas may be more relevant. Several studies on alcohol outlet density and adolescent alcohol use outside of the U.S. have adjusted for NSES (Huckle et al., 2008; Kavanagh et al., 2011; Rowland et al., 2014). However, the areas at which NSES was measured (e.g, census area unit, census collector district) may not be applicable in the U.S. Further, these studies were conducted in Australian and New Zealand samples with little variability in race/ethnicity and likely relatively low variability in their meaures of NSES.

Overall, our study is unique from previous studies in the U.S. and outside of the U.S. in several ways. First, we examine whether the density of on-premise and off-premise outlets within multiple buffered zones as small as 0.1 miles and as large as 2.0 miles around an adolescent's home may be associated with adolescent alcohol consumption. Second, we make a distinction between on-premise clubs and bars where minors are restricted from other on-premise outlets such as restaurants. Third, given the diversity of our sample we conduct the most comprehensive test to date of whether associations differ by age, race/ethnicity, sex, and socioeconomic status among this younger age group. Fourth, we examine how density is associated with both lifetime and heavy drinking because density of off- and on- premise outlets may have different associations with these two outcomes such that off-premise outlets may have stronger associations with heavy drinking which is less likely to occur at on-premise outlets. Lastly, we examine whether these associations are robust to potential confounding by neighborhood socioeconomic status which has only been examined in one other U.S. study to date (Truong & Sturm, 2009).

Based on the evidence presented in prior literature we hypothesize that (i) there will be positive associations between neighborhood alcohol outlet density and adolescent alcohol use, particularly for outlets within a smaller radii (0.1 miles, 0.25 miles) around an adolescent's home, and those that are on-premise outlets; and (ii) the associations between greater neighborhood alcohol outlet density and adolescent alcohol use will be significantly stronger for those who are male, are younger, belong to racial/ethnic groups who are at greater risk of drinking (Hispanics and non-Hispanic whites), and have lower socioeconomic status (based on father's educational attainment) compared to their counterparts.

Methods

Survey Data

Participants were part of a longitudinal study examining substance use among middle school adolescents from 16 middle schools within three school districts in southern California (D'Amico et al., 2012). Schools were selected to participate across the three districts based on the racial/ethnic composition of each school in order to obtain as diverse a sample as possible. Schools were also chosen so that alcohol and other drug use rates were similar at baseline. All students within each school were given a consent form to participate such that a total of 14,979 students across all 16 schools received parental consent forms to participate in the study; 92% of parents returned this form (n = 13,785). Approximately 71% of parents gave permission for their child to participate (n = 9,828) and 94% of consented students completed the first survey (n = 8,932). Students participated in five in-school surveys over a 2 ½ year period (Fall 2008, Spring 2009, Fall 2009, Spring 2010, and Spring 2011).

Analyses use Wave 5 data (Spring 2011) from seventh, eighth, and ninth grade students who were still residing in California at the time of the survey (n = 6,457). The initial number of California-based respondents in Wave 5 with valid, geocoded address data was 2,824. Cases were excluded from the analyses for the following reasons: (a) inability to contact or locate (n = 45), (b) duplicate record (n = 1), and (c) reported use of a fictitious drug (n = 54). The exclusions resulted in a final analytic sample of 2,724 respondents. Responses were protected by a Certificate of Confidentiality from the National Institutes of Health. All materials and procedures were approved by the institution's internal review board, school districts, and individual schools.

Alcohol Outlet Data

Data on alcohol outlets came from the California Department of Alcoholic Beverage Control database and included addresses, license status (active vs. pending), and license types on all alcohol retailers in the state in 2011. Among outlets with active license information with full address information, we classified alcohol outlets as either: (1) off-premise alcohol outlets, which include grocery and convenience stores that sell alcohol for off-premise consumption but may also do tastings on-site; (2) all on-premise alcohol outlets, including restaurants, pubs, clubs, hotels, clubs, and bars; and (3) on-premise alcohol outlets where minors are not allowed (heretofore referred to simply as clubs/bars).

Measures of Alcohol Availability

We measured alcohol availability by assessing the density of alcohol outlets. To calculate alcohol outlet densities for each respondent, we first geocoded participant addresses to their longitude and latitude using ArcGIS version 9.3 (ESRI, 2008). We then drew circles with radii of 0.1 miles, 0.25 miles, 0.5 miles, and 2.0 miles centered at respondents' residences to create four buffered zones. Radii sizes of less than 0.5 miles are ideal for adolescents because a distance of 0.5 miles is generally a 10 minute walk, which is accessible for most youth. Outlets up to 2 miles away from the adolescent's home may be desirable for older adolescents who can access these outlets by car (e.g., via friends who have cars and legal driver's licenses) if they want to avoid being seen by residents and merchants within their neighborhoods while illegally purchasing and/or consuming alcoholic beverages. Within each buffered circular zone, we mapped and counted the raw number of alcohol retailers using the Department of Alcoholic Beverage Control database. All four constructed buffers were considered as separate predictors.

Measures of Adolescent Alcohol Use

We measured lifetime and heavy alcohol use using well-established measures from Monitoring the Future (Johnston, O'Malley, Bachman, & Schulenberg, 2013) and Project ALERT (Ellickson, McCaffrey, Ghosh-Dastidar, & Longshore, 2003). A “drink” was defined as one whole drink of alcohol (not including a few sips of wine for religious purposes). A past month heavy drinker was assessed by asking about the number of days in the past 30 days that the respondent reported drinking 5 or more drinks in a row, within a couple of hours (“0 days” to “20-30 days”). Similar to other studies with younger adolescents, due to low rates of endorsement of the categorical measure, we constructed a dichotomous measure to indicate any heavy drinking during the past month, hereafter referred to as “heavy drinker” (D'Amico & McCarthy, 2006; Salas-Wright, Hernandez, Maynard, Saltzman, & Vaughn, 2014; Smith et al., 2014).

We constructed a dichotomous variable indicator for lifetime, but not current drinking which accounted for lifetime and past month alcohol use. We used this definition rather than lifetime use only so that the “lifetime, but not current drinking” outcome excludes any heavy drinkers. The lifetime survey question asked, “During your life, how many times have you used or tried one full drink of alcohol?” in which response options ranged from “none” to “7 or more times.” Another survey question asked, “During the past month (30 days), how many days did you have at least one full drink of alcohol?” in which response options included 0 days, 1 day, 2 days, etc…20-30 days. Youth who reported “no” to the lifetime use question were considered nondrinkers. Youth who reported “yes” to the lifetime use question and also reported no alcohol use in the past 30 days were considered to be lifetime, but not current drinkers (hereafter referred to as “lifetime drinkers”) since they reported use in their lifetime but did not report recent drinking. Baseline rates of alcohol use in our sample were comparable to national survey data on adolescent alcohol use (Center for Behavioral Health Statistics and Quality, 2012).

Covariates

Sociodemographic characteristics—Respondents reported their age, sex, ethnicity (Hispanic or not Hispanic) and race (U.S. Department of Health and Human Services, 2001) and were classified into one of four racial/ethnic groups: Hispanic, non-Hispanic White, Asian or Pacific Islander, and Other. Non-Hispanic Black respondents (2.4%) were grouped with “Other” along with Native Hawaiian, Native American, and multi-ethnic respondents. Respondents also reported the highest level of education for their father. This was divided into three categories: less than high school, high school graduate, and above high school.

Neighborhood socioeconomic status—We used the American Community Survey five-year average for 2007-2011 to create the percent of the population below the federal poverty level in each census tract. This variable was linked to respondents' census tracts and included as a covariate.

Statistical Analysis

For descriptive analyses, we compared the mean and median number of alcohol outlets for each license category by lifetime and heavy drinking status. To understand whether the density and type of outlets had different associations with lifetime and heavy drinking, we estimated separate models for each type of alcohol outlet (on-premise, clubs/bars, off-premise) within each of the four buffered zones (0.1, 0.25, 0.5, 2.0 miles). Due to the multiple regression models used we considered applying the Bonferroni correction to adjust p-values (Miles & Banyard, 2007; Perneger, 1998); however, there are many papers which suggest problems with p-value correction. For example, Perneger (1998) argues that the correction is based on the general null hypothesis that all null hypotheses are false – and that this is rarely of interest to researchers. He concludes that correction “creates more problems than it solves.” For these reasons, we have chosen not to use p-value correction for these analyses.

We estimated the odds of each outcome using generalized linear mixed regressions using proc glimmix with SAS software 9.2 (SAS Institute, 2008). For each model we included both outcomes (lifetime and heavy drinking) nested within individuals, and individuals were nested within census tracts. We first carried out a multivariate test of both outcomes simultaneously to reduce problems of multiple testing, and then examined individual odds ratio parameters. Model 1 adjusted for sex, age, race/ethnicity, father's educational attainment, and NSES. In Model 2, we added interaction terms between alcohol outlet density and sex, race/ethnicity, age, and father's educational attainment. These interaction terms were added to account for the non-additive associations with socio-demographic characteristics. For example, an interaction term between alcohol outlet density and sex would test whether the odds of being a lifetime drinker with a one unit increase in the number of alcohol outlets within a buffered circular zone would be even higher or lower for females compared to males. All analyses were clustered such that respondents were nested within census tract and standard errors were adjusted appropriately using a variance components covariance structure.

Results

Descriptive Statistics

Table 2 shows demographic information for the sample. Overall, we found that 22.62% of youth reported lifetime drinking, and 4.64% reported at least one heavy drinking episode in the past 30 days. Furthermore, lifetime drinkers were more likely to be Hispanic and tended to be slightly older than non-drinkers. Heavy drinkers were more likely to be Hispanic and female compared to those who were not heavy drinkers.

Table 3 provides the mean number of alcohol outlets within the different buffers by lifetime and heavy drinking statuses. The number of on-premise outlets is greater in each of four of radii buffers than both off- premise outlets and clubs/bars. The mean number of outlets is consistently larger than the median number, indicating that the distribution of alcohol outlets is skewed.

Comparing lifetime drinkers with nondrinkers, the average number of alcohol outlets of each type in the 0.25 mile buffer was significantly greater for lifetime drinkers (on-premise, $p = .037$; off-premise, $p < .001$; clubs/bars, $p = .002$). Within the 0.5 mile buffer zone, lifetime drinkers had access to significantly more off-premise ($p < .001$) and club/bar ($p = .002$) outlets than nondrinkers. In the 2.0 mile buffer zone, only the average number of off-premise ($p = .037$) outlets was significantly greater for lifetime drinkers than nondrinkers. No statistically significant differences in the number of off-premise, on-premise, or club/bar outlets for lifetime drinkers versus nondrinkers were observed at the 0.1 mile buffer range.

Comparing heavy drinkers to all other participants, heavy drinkers lived in areas with significantly more off-premise outlets in the 0.1 mile ($p = .005$) and 0.5 mile ($p = .018$) buffer zones. Heavy drinkers also lived in areas with a greater number of off-premise ($p = .001$) and club/bar ($p = .019$) outlets in the 2.0 mile buffer zone than all other participants. No statistically significant differences were found for the number of on-premise, clubs/bars, or off-premise outlets for heavy drinkers versus all other participants at the 0.25 mile buffer range.

Regression Results

Table 4 provides the p-values associated with the joint significance test of the two estimates, along with estimated Model 1 odds ratios (ORs) and associated 95% confidence intervals of the association between the number of alcohol outlets located in each buffer radius and each of the alcohol use outcomes. For on-premise outlets, a higher number of outlets within the 0.1, 0.25, and 0.5 mile buffered zones was associated with higher odds of being a heavy drinker. In addition, the number of on-premise outlets within the 0.25 mile radius was associated with greater odds of lifetime drinking.

For on-premise outlets where minors were not allowed (clubs/bars), we observed a significant association between a higher number of clubs/bars within the 0.25 mile buffer zone and higher odds of both lifetime and heavy drinking. Heavy drinking was associated with density of clubs/bars within a smaller geographic area (0.1 miles) and lifetime drinking was associated with density of clubs/bars within a larger geographic area (0.5 miles);

however, we interpret these parameter estimates with caution, as the joint tests narrowly failed to achieve significance ($p = 0.062$ and 0.061, respectively). A higher number of off-premise outlets within the 0.5 mile buffer zone was associated with higher odds of lifetime drinking although the joint test of significance was not below 0.05 ($p = 0.086$).

Examination of the covariates showed that younger age, Asian race, and higher father's education were all consistently associated lower odds of lifetime drinking ($p < 0.05$). For the heavy drinking outcome, adolescents who were male or Asian or of another race/ethnicity had statistically significant lower odds of heavy drinking whereas Hispanic adolescents had higher odds of heavy drinking ($p < 0.05$). Interaction terms for each of the demographic characteristics were not statistically significant ($p > 0.05$) and we therefore do not report Model 2 regression results.

Discussion

We examined the cross-sectional associations between alcohol availability and alcohol use among a large and diverse sample of youth. This study is unique because we assessed the association between a number of buffer sizes with different categories of alcohol outlet types for lifetime and past month heavy alcohol use among a group of younger adolescents. We found that after controlling for demographics and census tract-level socioeconomic status, both lifetime and heavy alcohol use among these younger adolescents were still strongly associated with greater alcohol outlet densities surrounding the adolescent's residence. The differences in associations for lifetime versus heavy drinking indicate that smaller buffer sizes (0.1, 0.25, and 0.5 miles) may matter more in terms of risk of heavy drinking, especially for on-premise outlets. Even on-premise outlets where minors are not allowed (clubs/bars) within 0.1 and 0.25 mile radii were associated with higher odds of heavy drinking. By contrast, off-premise outlet density was not related to heavy drinking, suggesting that restricting access to on-premise outlets very close to adolescents' homes may be key to preventing heavy drinking.

A slightly different set of associations were found for lifetime drinking; greater access to all three categories of alcohol outlets, but only at 0.25 and 0.5 mile buffers around an adolescent's home was significantly associated with lifetime use. Thus, efforts to prevent alcohol use among younger adolescents should target all three types of outlets, especially on-premise outlets, regardless of whether minors are allowed on the premises.

Our findings are consistent with the only two U.S. studies on alcohol outlet density that compared on- and off-premise outlet density which found more consistent significant associations with on-premise outlets (Paschall et al., 2012; Truong & Sturm, 2009). Our study further contributes to Paschall et al., (2012) by adjusting for NSES and to both studies by examining (1) smaller buffered zones, (2) interactions with demographic characteristics, and (3) minor-restricted on-premise outlets, showing that adolescent alcohol use is related to access to on-premise outlets within smaller zones than 0.5 miles around a student's home, and that this does not appear to vary by adolescent characteristics. Thus, collectively, these studies suggest that greater alcohol outlet densities, especially on-premise outlets, may be

associated with increased access to alcohol for U.S. adolescents, which may be subsequently associated with choices to try alcohol and potentially using alcohol more regularly.

It also important to note that there are other possible mechanisms that may be associated with adolescents' drinking behavior that were not included in this study, including alcohol advertisements (Hastings & Symes, 2002), peer influences (Chein, Albert, O'Brien, Uckert, & Steinberg, 2010), and parental factors, such as approval (Mrug & McCay, 2013) or monitoring (Stanley et al., 2011). Future studies could include these factors to better understand the overall effects of alcohol outlet density on adolescent alcohol use.

We expected that adjustment for NSES might attenuate associations; however, associations between alcohol outlet density and heavy drinking were strong and remained statistically significant, and NSES was a consistently and highly significant covariate. This suggests that the association of alcohol outlet density is independent of the poverty level of one's neighborhood and that it is critical to incorporate NSES when examining the associations between alcohol outlet density and young adolescent alcohol use.

The association between density of alcohol outlets and outcomes did not differ for males versus females, by age, race/ethnicity, or socioeconomic status as measured by father's education. Thus, it appears that for this younger population, prevention is generally important for all youth who live in communities with high alcohol outlet densities.

Understanding how the neighborhood environment affects underage drinking is important because numerous developmental changes (e.g., related to puberty, brain and cognitive-affective structures and functions, and family and peer relationships) occur during the ages of 10-15 that may affect the onset and more regular use of alcohol (Windle et al., 2008). Adolescence is an ideal time to introduce prevention programs within the home, schools, and neighborhoods to discuss the effects of substance use and potential consequences of other risk related activities, including driving while intoxicated (D'Amico, Osilla, & Stern, in press). Educating parents about the ways in which availability (number of stores, bars, clubs, and restaurants) and access (checking IDs to restrict access to minors) to alcohol outlets may increase risk for alcohol use may help parents become more vigilant about community level efforts that enforce regulations at both on-premise and off-premise outlets. Policymakers for districts, counties, and states could engage in efforts to minimize the density of alcohol outlets when awarding alcohol permits, not only at the county level, but at smaller geographic areas especially given that we found that density measured in very small buffer zones is relevant for early adolescent alcohol use. Parental involvement in decreasing alcohol availability may decrease the ease with which youth gain access to alcohol, which might in turn delay the onset of alcohol consumption and potentially decrease drinking among those who have initiated alcohol use (Barnes, Reifman, Farrell, & Dintcheff, 2000; Ryan, Jorm, & Lubman, 2010).

Youth may have access to alcohol at on-premise establishments, even in minor-restricted establishments, in a variety of ways, including direct purchases or assistance from adults or older friends and family members. One study found that funding for underage drinking enforcement activities was inversely related to past-year alcohol use, which emphasizes the

importance of community level enforcement activities (Paschall et al., 2012). More stringent enforcement of identification monitoring and distributing alcohol to minors is needed at on-premise outlets, especially at clubs and bars that youth may frequent or be exposed to simply by virtue of living nearby. California law has a minimum $1,000 fine and 24 hours of community service if a person buys alcohol and furnishes it to a minor who consumes it. Given that few individuals are caught, this likely reduces the fear of persecution and ultimately becomes less of a deterrent; thus, for prevention purposes, communities need to pay more attention to how youth are gaining access to alcohol and ways in which laws and regulations can be better enforced to decrease underage alcohol consumption. Additionally, youth who are underage and drink risk obtaining a misdemeanor offense and a fine of approximately $100. The penalty of $100 fine may not be enough; pilot testing and sensitivity analysis could be conducted in various urban and rural communities throughout California to ensure that the fine is sufficiently large to deter youth from attempting to illegally purchase alcoholic beverages. Future research is needed to understand the ways in which access occurs in these settings so that we can work towards preventing access to alcohol for these younger adolescents.

It is important to note that this cross-sectional study cannot address causality. Future work should begin to examine how alcohol availability may be associated adolescent drinking over the long-term. Second, African Americans were underrepresented in this sample, so the racial/ethnic comparisons focused on Hispanics, whites, and Asian youth. Future research is needed to understand how alcohol availability may be associated with drinking among African American youth. In addition, the data on alcohol use were self-report, the limitations of which are well known, although possibly exaggerated (Chan, 2008). We feel confident that these rates are accurate as rates of alcohol use in our sample match national norms (D'Amico et al., 2012). Further, our study procedures (e.g., discussing confidentiality, using Scantrons, ensuring teachers were removed from data collection by having specific staff on the project collect surveys) provided a safe space for youth to complete their questionnaires. Despite these limitations, our study provides important insights into how alcohol availability may be associated with alcohol use among younger adolescents.

In sum, youth who are exposed to higher densities of on-premise alcohol outlets are at risk of both lifetime and heavy alcohol use. It is well known that early onset of alcohol use increases the chances of alcohol and other drug use and dependence during adolescence and young adulthood and the impact is the strongest when onset occurs between 11 and 14 years old (Guttmannova et al., 2011). Thus, it is critical to continue to advocate for the enforcements of alcohol-related laws provided for the protection of younger adolescents in communities with higher availability of on- and off-premise alcohol outlet premises, including clubs/bars where minors are not allowed.

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Table 1

Review of studies that examined the association between alcohol outlet density and adolescent alcohol use

Author, year	Location	Sample characteristics	Alcohol outlet density measure	Interaction by any individual-level characteristics?	Control for contextual socioeconomic status?
U.S. studies					
Chen et al., 2010	50 ZIP codes in California, U.S.	N=1,091; 14-16 years; 33% Hispanic, 51% non-Hispanic white, 16% other	Off-premise outlets per 1,000 roadway mile at ZIP code-level	No	Yes; ZIP code median household income
Pasch et al., 2009	7 county metropolitan area of Minneapolis-St. Paul, U.S.	N=242; 9th-11th graders; 93% White	Off-premise outlets within 2 mile buffers	No	No
Paschall et al., 2012	50 cities in California, U.S.	N=1,213; 13-18 years; 75% White	Off-premise, bars, and restaurants outlets per roadway mile	No	No
Tobler et al., 2009	42 areas within Chicago, Illinois, U.S.	N=5,655; 11-14 years; 43% African American, 29% Hispanic	Off-premise alcohol outlets per 1,000 population per community area	No	Yes; area deprivation index (geographic level unclear)
Truong & Sturm, 2009	California., U.S.	N=3,660; 12-17 years; (race/ethnicity for adolescent sample not specified)	Off- and on-premise outlets within circular bands 0.1- mile-radius, between 0.1-mile and 0.5-mile radii, 0.5- and 1.0-mile radii and between 1.0- and 2.0-mile radii	No	Yes; census tract-level median household income
Stanley et al., 2011	219 rural communities across U.S.	N=151,703; 7-12th graders; 63% White, 13% African American, 14% Mexican American	Off-premise liquor/package stores and on-premise outlets per 1,000 residents within a ZIP code	No	No
Non-U.S. studies					
Huckle et al., 2008	Auckland, New Zealand	N=1,179; 12-17 year olds; 63% European, 12% Maori; 8% Pacific, 16% Asian, 1% other	All outlets within a meshblock	No	Deprivation score at the census area unit level
Kuntsche et al., 2008	254 communities in Switzerland	N=6,183; 12-17 year olds (race not specified)	On-premise, off-premise outlets per 1,000 residents	No	No
Rootman et al., 1973	45 schools and communities in Alberta Canada	N=4,724 junior high school students	Presence of any alcohol outlet within the community	No	No
Rowland et al., 2014	Victoria, Australia	N=10,143, 12-17 year olds, (race/ethnicity not specified)	Public bars, off-premise package outlets, on-premise outlets, and club outlets per 10,000 residents in a local government area	Yes; age	Yes; ZIP code-level socioeconomic advantage/disadvantage
Young et al., 2013	Glasgow, Scotland, U.K.	N=979; 15 year olds (race/ethnicity not specified)	On-premise, off-premise alcohol outlets within 1200m of postcode	Yes; gender	No

Note: Alcohol outlet density studies on adult samples are summarized in the review by Bryden et al., 2012.

Table 2

Descriptive statistics (n=2,724)

Descriptive Information	%/Mean	SD
Demographic information		
Age	14.10	0.82
Male	46.15	
Race		
Asian	18.47	
Hispanic	50.18	
Other	14.10	
White	17.25	
Father's Education		
Less than High School	18.87	
High School	60.80	
More than High School	60.80	
Neighborhood socioeconomic status		
% of adults with a bachelor degree*	16.73	8.17
% of population below federal poverty level*	7.25	7.16
Alcohol use		
Lifetime Drinking	22.62	
Heavy Drinking	4.64	

*Please note that the following statistics were measured at the census tract level

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Table 3

Density of Alcohol Outlets by Alcohol Use Status (n = 2,724)

	Lifetime Drinkers			Heavy Drinkers		
	Mean	**Median**	**SD**	**Mean**	**Median**	**SD**
All On-Premise Outlets						
0.1 Mile Radii	0.29	0	0.96	0.39	0	1.05
0.25 Mile Radii	2.17*	1	4.17	2.54	1	6.35
0.5 Mile Radii	8.99	6	11.98	10.44	6	16.29
2.0 Mile Radii	140.99	97	109.55	159.94	105.5	129.45
On-Premise Minor-Restricted Clubs/Bars						
0.1 Mile Radii	0.04	0	0.24	0.09	0	0.34
0.25 Mile Radii	0.36**	0	0.85	0.44	0	1.33
0.5 Mile Radii	1.28**	1	2.17	1.43	1	2.92
2.0 Mile Radii	15.49	11	14.97	18.79*	12	18.87
Off-Premise Outlets						
0.1 Mile Radii	0.24	0	0.55	0.4*	0	0.69
0.25 Mile Radii	1.64***	1	1.6	1.73	1	1.77
0.5 Mile Radii	5.88***	5	3.7	6.33*	5	4.48
2.0 Mile Radii	75.28*	70	30.79	85.11**	71	37.29

Note: On-premise alcohol outlets include establishments where alcohol is served on the premises, including restaurants, pubs, clubs, and hotels. The on-premise minor-restricted category is alcohol outlets where minors are not allowed, including night clubs and bars. Off-premise alcohol outlets include grocery and convenience stores that sell alcohol for off-premise consumption but may also do tastings on-site.

* $p < .05$;

** $p < .01$;

*** $p < .001$.

Table 4

Associations between alcohol use and alcohol outlet density (n = 2,724)

	On- Premise			*Clubs/Bars*			*Off- Premise*		
	Joint p-value	**Lifetime Drinkers**	**Heavy Drinkers**	**Joint p-value**	**Lifetime Drinkers**	**Heavy Drinkers**	**Joint p-value**	**Lifetime Drinkers**	**Heavy Drinkers**
		OR (CI)	**OR (CI)**		**OR (CI)**	**OR (CI)**		**OR (CI)**	**OR (CI)**
0.1 Mile Radii	0.027	1.08 (0.95, 1.23)	1.26 (1.04, 1.52)*	0.062	1.08 (0.69, 1.68)	1.92 (1.11, 3.34)*	0.325	1.00 (0.82, 1.22)	1.28 (0.93, 1.77)
0.25 Mile Radii	0.010	1.03 (1.00, 1.07)*	1.05 (1.01, 1.09)*	0.019	1.15 (1.01, 1.31)*	1.20 (1.00, 1.43)*	0.342	1.05 (0.98, 1.13)	0.99 (0.87, 1.12)
0.5 Mile Radii	0.046	1.01 (1.00, 1.02)	1.01 (1.00, 1.03)*	0.061	1.06 (1.00, 1.12)*	1.05 (0.96, 1.14)	0.086	1.03 (1.00, 1.07)*	1.00 (0.94, 1.05)
2.0 Mile Radii	0.580	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)	0.889	1.00 (0.99, 1.01)	1.00 (0.99, 1.01)	0.331	1.00 (1.00, 1.00)	1.00 (1.00, 1.01)

Note. Joint p-value = joint significance test of both estimates for lifetime and heavy drinking. OR = odds ratio; CI = confidence interval. Models adjust for age, sex, race/ethnicity, father's educational attainment, and census tract level percent of the population at or below the poverty level.

* p < .05;

** p < .01;

*** p < .001.