

Association Between Alcohol Use Among College Students and Alcohol Outlet Proximity and Densities

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ABSTRACT

Background: Alcohol consumption is common on college campuses and is associated with negative consequences. Factors associated with availability of alcohol are not completely understood.

Objective: To describe how proximity and density of alcohol outlets are associated with any drinking and binge drinking in students at the University of Wisconsin-Madison.

Methods: Participants were full-time students enrolled in the Young Adults Eating and Active for Health, a multisite, randomized intervention that assessed a variety of health behaviors. Geographic information systems were used to calculate proximity and enumerate alcohol outlet densities. Participants were categorized as “drinkers” or “nondrinkers” based on self-reported alcohol consumption. Binge drinking was categorized as “non-binge drinker,” “frequent binge drinker,” and “excessive binge drinker.” Analysis included regression, *t* tests, and chi-square tests.

Results. Among the 166 participants, 126 (76%) were drinkers. Among drinkers, 80 (63%) were either frequent or excessive binge drinkers. Drinkers lived closer to an alcohol outlet than nondrinkers (0.18 ± 0.15 vs 0.61 ± 1.59 miles, respectively, $P = 0.005$). Within a 1-mile walking radius, there were 47% more establishments for drinkers (153 ± 47 compared to 104 ± 55 outlets for nondrinkers, $P < 0.0001$). At distances of 0.10-0.25 and 0.25-0.50 miles, twice as many outlets were available to drinkers (19 ± 19 and 43 ± 25 , respectively) compared to nondrinkers (7 ± 11 and 20 ± 22 , respectively), $P < 0.001$. Proximity and density were not associated with binge drinking frequency.

Conclusion: Drinkers lived closer to alcohol outlets and had significantly more outlets available at a distance of up to 1 mile. Municipal and college administrators could consider limiting alcohol license distributions in municipalities with high alcohol consumption.

INTRODUCTION

Excessive alcohol consumption is prevalent during college years and is associated with unprotected sex, drunk driving, physical

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violence, social abuse, and other unintended consequences on college campuses across the United States.¹⁻³ The choice to drink operates through complex interactions of individual psychology, familial expectations, and community environment, among other factors. The micro-community of college campuses provides unique opportunities to implement strategies aimed at preventing this detrimental behavior and its consequences.

Physical accessibility of alcohol, as characterized by alcohol outlet density (ie, number of bars and liquor stores within a certain distance), is a critical component in alcohol consumption behavior.⁴⁻⁶ Previous studies have shown a correlation between high alcohol outlet densities and issues related to excessive drinking.⁴⁻⁶ For example, Gruenewald et al showed a positive correlation between alcohol beverage sales and alcohol outlet densities.⁵ Further, Weitzman et al found significant correlations between outlet density and heavy drinking, frequent drinking, and drinking-

related problems.⁵ Wechsler et al's analysis suggested that binge drinking was less prevalent when there was an absence of alcohol outlets within a mile of a college campus.³ Furthermore, high alcohol outlet densities could be a determining factor in drinking behaviors, norms, and preferences.⁶

An important component of alcohol availability that has received scant attention is proximity (ie, distance to the closest alcohol outlet). This, alone or in combination with density, may be an important factor of drinking behavior. In a study by Young et al, the association between proximity and weekly alcohol use among Scottish adolescents was tested. They found that individuals who were within 200 m (0.12 miles) of an off-sales outlet were nearly twice as likely to drink weekly as those who lived more than 800 m (0.50 miles) away.⁷

The study presented here evaluates associations between drinking behavior and proximity to alcohol outlets in a student residence area characterized by high outlet densities. A geographic information system (GIS) was used to quantify alcohol outlet proximity, which eliminates potential bias associated with self-reports. The purpose of this study was to determine whether proximity and/or density of alcohol outlets is associated with drinking behaviors among college students at a large Midwestern college campus.

METHODS

Study Design

The alcohol study is an ancillary sub-study of Project Young Adults Eating and Active for Health (YEAH).^{8,9} Project YEAH was a randomized intervention designed to assess the benefits of an online educational program aimed at preventing excessive weight gain in college students. Students at 13 institutions throughout the United States were enrolled, including those attending the University of Wisconsin-Madison. Participants were randomized to receive or not receive the online educational program after baseline questionnaires were completed. Follow-up was conducted at 3 months and 12 months post-intervention. All questionnaires, including alcohol behavior, were completed online. Physical measurements were obtained in person at each time point. This report is based on findings from subjects enrolled at the University of Wisconsin-Madison ($n=174$). The University of Wisconsin-Madison Institutional Review Board reviewed and approved the research protocol. Prior to online enrollment, all subjects provided online informed consent. Additionally, at the start of the baseline in-person assessment, written informed consent was obtained.

Alcohol Behavior Questionnaire

The ancillary study on alcohol behaviors was conducted to evaluate and measure alcohol consumption behaviors of college students. The alcohol questionnaire was modified from portions of the American College Health Association-National College Health Assessment-II (ACHA-NCHA-II) survey, which is a nationally recognized research survey that collects data about students' health habits, behaviors, and perceptions.¹⁰ Student drinking behaviors that Project YEAH survey evaluated were the percentage of the population who reported any alcohol consumption ("drinkers") and the percentage of drinkers who reported consuming 5 or more drinks in a sitting ("binge drinkers"). Students were provided with standard definitions for alcohol servings at the beginning of the alcohol portion of the survey.

Defining Drinking Status

Nondrinkers were defined by the question "During the last 12 months, when you partied/socialized, how often did you choose not to drink alcohol?"¹¹ Individuals who answered "Do not

drink/not applicable" were considered nondrinkers. Five subjects who answered "never" were also considered nondrinkers because they did not report any other alcohol consumption behaviors and were believed to have misunderstood the question.

Defining Binge Drinking

Binge drinking was defined by a response of ≥ 1 to the following question: "In the last 2 weeks, how many times did you have 5 or more drinks in a sitting?" Although heavy episodic ("binge") drinking is defined as 5 or more drinks in a sitting for men and 4 or more drinks in a sitting for women,^{1,12,13} the same question was posed to all subjects; women were not differentiated from men. Binge drinking responses were categorized as follows: 0 occasions (non-binge drinkers), 3 to 4 occasions (frequent binge drinker), and ≥ 5 occasions (excessive binge drinker). Non-binge drinkers were individuals who were drinkers but experienced zero occasions of having 5 or more drinks in a sitting in the previous 2 weeks. No subjects reported 1 or 2 occasions in the previous 2 weeks.

Proximity and Alcohol Outlet Densities From Geographic Information Systems (GIS)

Alcohol outlets were defined as on-site (ie, bars) and off-site (ie, liquor stores) establishments that were licensed for the sale of alcohol. Enumeration of alcohol outlets was done using ArcGIS 9.3.1 software (ESRI 2010. ArcGIS Desktop: Release 9.3.1. Environmental Systems Research Institute, Redlands, California) by geocoding each outlet into the software. Each outlet had its location matched with a geographic location (geocode) in the software, with $>93\%$ being matched. Outlets that could not be matched were removed from the study.

Each participant's proximity (in miles) to the closest alcohol establishment was calculated by the GIS software; this distance was calculated with the Network Analyst feature of the ArcGIS software. This technique differs from previous methods of calculating proximity⁷ in that it measures the shortest possible walking route to the establishment; the same method was used by Young et al.⁸

The number of alcohol outlets within specified distance perimeters ("alcohol outlet density" or AOD) also were computed by the GIS software for the following radii around participants' residential addresses: 0 to 0.25 mile, 0 to 0.50 mile, 0 to 1.0 mile, and 0 to 2.0 miles. "Alcohol outlet interval densities" (AOID) were calculated from AOD data. Specifically, distance intervals of >0.10 to 0.25, >0.25 to 0.50, >0.50 to 1.00, and >1.00 to 2.00 miles were calculated by subtracting a smaller perimeter AOD from the next larger one. For example, AOID of >1.00 to 2.00 miles was calculated by subtracting the 0 to 1.0 mile AOD from the 0 to 2.0 mile AOD. These AOIDs were constructed to refine the all-inclusive AODs into smaller intervals. AODs could overestimate the number of outlets visited by a population within a particular perimeter. For example, >0.50 to 1.00 mile AOID

enumerates the number of bars that are between >0.50 mile and 1 mile from the participant's residence while AOD of 0 to 1.00 mile enumerates all of the bars within a mile radius of a subject. Thus, AOIDs represent exclusive subsets of the larger AOD perimeters.

Statistical Analysis

Statistical analyses compared alcohol environment variables (ie, proximity and density of alcohol outlets) between drinkers and nondrinkers, and among binge drinkers with different frequency of binge drinking. SAS version 9.13 (SAS Institute, Inc, Cary, North Carolina) was used for all analyses. The student's *t* test was used for 2-group comparisons of continuous variables. Fisher's Least Square Difference method was used for multiple-group comparisons of continuous variables. Chi-square or Fisher's exact test was used to compare categorical variables. Multiple regression models were used to examine the associations between proximity and density and alcohol consumption behaviors, adjusting for age, race, and gender. Separate regression models for proximity, and each of the AOD and AOID distances were evaluated. Eight subjects were removed due to missing data: 4 were missing answers to the alcohol survey questions and 4 were missing GIS data. Thus, 166 were included in the analysis.

RESULTS

Demographic Results

Table 1 shows population characteristics according to drinking status. Drinkers represented 76% (120/166) of the subjects and were, on average, 19.4 years of age. Age was not associated with drinking status (76% were <21 years old and 78% were ≥21 years, *P*=0.56), however freshman represented a lower percentage of drinkers (65%) compared to sophomores (82%) and juniors (84%), *P*=0.034. Females represented 64% (106/166) of the population; the proportion of women and men drinkers was similar (*P*=0.34). There was a greater prevalence of drinkers among whites (79%) compared to non-whites (57%, *P*=0.02). The percent of drinkers living in on-campus housing (57%) was similar to the percent of drinkers living in off-campus housing (43%, *P*=0.62).

Proximity and Alcohol Outlet Density in Nondrinkers, Drinkers, and Binge Drinkers

Table 2 shows proximity to, and density of, alcohol outlets in nondrinkers versus drinkers, and compares non-binge, frequent binge, and excessive binge drinkers. On average, nondrinkers lived 0.43 miles further from the nearest alcohol outlet compared to drinkers (mean proximity in nondrinkers: 0.61±1.59 miles compared to drinkers: 0.18±0.15 mile, *P*=0.003). On average, drinkers had more alcohol outlets around their residence than nondrinkers at distances up to 2 miles (all *P*≤0.014). When examining AOID, the mean density of alcohol outlets was sig-

Table 1. Demographic Characteristics for Participants (N=166)

	Nondrinker n=40 (24%)	Drinker n=126 (76%)	P-value ^a
Age (years)	19.1 ± 1.0	19.4 ± 1.0	0.07
Age category [n (%)]			
< 21 years of age	34 (24%)	105 (76%)	
≥ 21 years of age	6 (22%)	21 (78%)	0.56
School Year			
Freshman	22 (35%)	41 (65%)	
Sophomore	10 (18%)	47 (82%)	
Junior/Senior	7 (16%)	38 (84%)	0.034
Gender [n (%)]			
Male	11 (20%)	45 (80%)	
Female	29 (26%)	81 (74%)	0.34
Race [n (%)]			
White	26 (21%)	99 (79%)	
Non-white	12 (43%)	16 (57%)	0.02
Housing Type			
On-campus (dorm)	24 (26%)	70 (74%)	
Off-campus	16 (22%)	56 (78%)	0.72

^a P-value from *t* test or chi-square/Fisher's exact test.

nificantly higher in drinkers compared to nondrinkers at >0.10 to 0.25 mile (19 ± 19 vs 7 ± 11, respectively, *P*=0.003), >0.25 to 0.50 mile (43 ± 25 vs 20 ± 22, respectively, *P*<0.0001), and >0.50 to 1.00 mile (87 ± 25 vs 75 ± 30, respectively, *P*=0.002). The highest difference in density is at >0.10 to 0.25 miles, where drinkers had 171% more alcohol outlets available. At >1.00 to 2.00 miles, there were a greater number of alcohol outlets for nondrinkers (127 ± 54) compared to drinkers (97 ± 40, *P*=0.0004). Among drinkers, neither proximity nor density were associated with binge drinking status (ie, non-binge drinker, frequent binge drinker, or excessive binge drinker).

DISCUSSION

Results from this study show that distance to the nearest alcohol outlet is significantly related to drinking status. Specifically, the nearest alcohol outlet for nondrinkers was almost a half mile farther away compared to the closest one for drinkers (0.61±1.59 miles for nondrinkers compared to 0.18±0.15 for drinkers, *P*=0.003). Furthermore, within defined distance perimeters up to a half mile, more than double the number of alcohol outlets were available to drinkers compared to nondrinkers. Though no significant differences in density or proximity were observed between binge drinking categories, excessive binge drinkers had substantively more outlets in quarter-mile (58% more outlets) and half-mile (40% more outlets) walking distances compared to drinkers who refrained from bingeing. Cause and effect cannot be implied from these cross-sectional results. Nevertheless, the strong associations observed may have important considerations for those invested in preventing any drinking and binge drinking

Table 2. Proximity and Density of Alcohol Outlets Among Nondrinkers, Drinkers, and Binge Drinkers (N=166)

	Drinker Status			Binge-Drinking Status			
	Nondrinker	Drinker	P-value ^a	Non-Binge Drinker (0 Occasions)	Frequent Binge Drinker (3-4 Occasions)	Excessive Binge Drinker (5+ Occasions)	P-value ^a
N	40	126		46	50	30	
Proximity^b							
Mean±SD	0.61±1.59	0.18±0.15	0.005	0.17±0.13	0.21±0.18	0.14±0.11	0.08
Median	0.28	0.14	0.006 ^c	0.15	0.15	0.12	0.47 ^c
Range	0.01-9.33	0-0.67		0.001-0.57	0.0-0.67	0.002-0.54	
Alcohol Outlet Density^d (AOD)							
0-0.25 mile	9±13	23±23	0.004	19±19	21±25	30±23	0.57
0-0.50 mile	29±31	66±40	<0.0001	60±34	61±44	84±35	0.21
0-1.00 mile	104±55	153±47	<0.0001	155±39	140±56	171±33	0.09
0-2.00 miles	231±62	250±21	0.014	253±5	246±32	253±4	0.10
Alcohol Outlet Interval Density^d (AOID)							
>0.10-0.25 mile	7±11	19±19	0.003	15±13	18±21	26±19	0.31
>0.25-0.50 mile	20±22	43±25	<0.0001	40±22	39±27	54±23	0.16
>0.50-1.00 mile	75±30	87±25	0.002	95±21	80±27	87±24	0.06
>1.00-2.00 miles	127±54	97±40	0.0004	98±35	105±47	83±30	0.22

^aP-value from regression models included age, race and gender as covariates.

^bWalking distance (miles) to closest alcohol outlet.

^cP-value from non-parametric median test.

^dNumber of outlets.

on college campuses.

The average alcohol outlet density within a 2-mile radius measured in this study was 245 outlets. This is considerably higher than the highest 2-mile densities reported by Weitzman et al⁵ (185 outlets), which indicates a higher physical availability of alcohol in our subjects' residential environment (which includes both dormitories and apartments). The high number of outlets is relevant to the troubling observation in this study that 76% of those under age 21 years were drinkers. Our small sample (n = 166) may not be representative of the more than 40,000 students at the University of Wisconsin-Madison, but underage drinking prevalence in Wisconsin was higher than the national average from 2004-2010.¹⁴⁻¹⁷ Wisconsin also ranks high for excessive drinking; in 2010, Wisconsin had the highest intensity (number of drinks per episode) of binge drinking, as well as the highest age-adjusted binge drinking prevalence rate.¹⁸ Thus, an underlying culture of drinking exists that needs to be taken into account when addressing illegal and excessive college drinking.

About 30% of University of Wisconsin-Madison students live on campus, and 60% of dormitory residences are within a 1-mile radius to numerous alcohol outlets. Popular off-campus apartments also are located more closely to the same high-density areas of alcohol establishments. The results are consistent with this housing configuration in that no significant association between residence type (on-campus vs off-campus residence) and drinking status were observed. Thus the on-campus and off-campus housing distinction is not highly relevant in this setting.

In this study, the closest alcohol outlets were, on average, well within normal walking distance. Proximity is a distinctive char-

acteristic of alcohol availability. Consistent with these results are those reported by Young et al, who showed that proximal alcohol outlets within walking distance were linked to adolescent drinking behaviors.⁸ Proximity was not associated with binge drinking frequency, but excessive binge drinkers lived in areas with a higher density of alcohol outlets compared to those with non-binge drinkers. Similarly, Scribner's study showed that high-density neighborhoods, not proximity, had a stronger effect on alcohol consumption and norms.⁶ Proximity and density are both important in defining physical availability of alcohol. This study's unique calculation of proximity clarifies its role in alcohol availability. Young et al believed that there are 3 contextual effects of proximity and outlet density that could explain discrepancies in associations between drinking behavior and alcohol availability: (1) proximity (how easily one can access alcohol), (2) amenity (how outlets influence the quality and characteristics of the neighborhood), and (3) outlet clusters (locations with multiple outlets in very close proximity).⁷ Our study found an association between drinking and outlet proximity but did not account for amenity or outlet cluster effects. Young et al stated that reducing the number of outlets could lead to unintentional creation of new outlet clusters frequented by drinkers.⁷ Studying amenity and outlet cluster effects would help understand policy implications when limiting outlet density.

Several limitations are of note. First, the binge drinking question was not gender-specific. Therefore, females were defined as binge drinkers at a level of 5 drinks in a sitting, which is more than the NIAAA definition for women of 4 drinks in a sitting.¹⁹ This may have resulted in an under-estimate of female binge drinkers.

Second, twice the number of participants were female compared to male, which also may contribute to a potential underestimation of binge-drinking on this college campus. Unfortunately, the self-selection of college women into health-related studies is common, and a majority of women participating is similar to other studies or surveys.^{2,5,10} Third, because of the small sample size and self-selection into this health-related study, the results cannot be generalized to the entire student population of University of Wisconsin-Madison, which has a more equal gender distribution (52% women). Finally, associations between alcohol outlet data and drinking behaviors are from cross-sectional data. It cannot be determined whether physical access to alcohol leads to consumption or that alcohol consumers choose to live close to the points of sale. However, the results do identify characteristics of a population at high risk of excessive drinking (ie, those living close to alcohol outlets) and factors potentially amenable to prevention strategies at the policy level.

The decision to drink or binge drink in college has multiple deciding factors and influences. Generational alcohol use, family upbringing, peer alcohol use, race, and gender all have been linked to the consumption of alcohol.^{20,21} The results presented here equally suggest that close proximity to alcohol may promote consumption, or that alcohol consumers choose to live close to the points of sale. The former scenario identifies factors potentially amenable to prevention strategies at the policy level, and the latter scenario identifies a characteristic of a population at high risk of excessive drinking (ie, choosing to live close to alcohol outlets), which could lend itself to public health strategies to curb drinking. The economic loss due to binge drinking in Wisconsin was estimated to be greater than \$6.8 billion,¹³ while the cost of underage drinking was estimated at over \$1 billion.²² Therefore, there are significant financial benefits to reducing excessive alcohol use. Municipal and college administrators could consider the proximity and density of alcohol outlets in conjunction with other strategies to mitigate the negative economic, personal, and societal impacts of this behavior.

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