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Effects of College Climate on Students' Binge Drinking: Hierarchical Generalized Linear Model

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Abstract

Background Few studies have investigated the effect of college-level contextual factors on students' binge drinking. Most previous studies focused on the effect of individuals' characteristics on their binge drinking.

Purpose This study tested the effect of college-level contextual factors on students' binge drinking.

Methods The 2006 National College Health Assessment data collected from 76,542 students in 113 U.S. 4-year colleges were analyzed using the Hox five-step hierarchical random effects logistic regression models.

Results College-level variables, such as percentages of male students, marijuana users, Black students, and students with Greek affiliation, significantly predicted students' binge drinking above and beyond student-level predictors. An intraclass correlation was 0.10 in the null model, indicating that 10% of students' binge drinking could be explained by differences among colleges. Significant cross-level interactions were found between college-level variables and student-level variables.

Conclusions In order to reduce binge drinking in college, the findings underscore the need for active intervention within the college climate that addresses drinking.

Keywords Binge drinking · College climate · Multilevel model

Introduction

The term “binge drinking” defined as “consumption of five or more drinks in a row for men and four or more for women, at least once in the two weeks preceding the survey” [1] has been used in a number of studies to describe heavy episodic drinking behavior among young adults. In the early 2000s, the National Institute on Alcohol Abuse and Alcoholism (NIAAA) National Advisory Council redefined “binge drinking” as “a pattern of drinking alcohol that brings blood alcohol concentration (BAC) to 0.08 gram-percent or above” [2]. To reach this level, a typical adult male would consume five or more drinks in about 2 h, while a typical adult female would consume four or more drinks in that same time span [2]. Binge drinking is a widespread problem in U.S. college campuses [1]. Previous studies have presented associations between binge drinking and many negative health and academic consequences, such as alcohol-related unintentional injuries or deaths [3], assaults to innocent students committed by drunken students [3], sexual abuse and unsafe sex [3], academic problems [1], vandalism and property damage [4], and suicide attempts [1, 3].

Most previous studies among college students [1, 2, 4] have focused on the effect of individuals' characteristics on binge drinking. Males, Whites, those using other substances such as tobacco or marijuana, younger students, residents in a fraternity/sorority, and never-married students are more likely to report a higher frequency of binge drinking compared to their respective counterparts. Such attempts to identify correlates of binge drinking have been primarily made to better understand college students who are at risk in this regard and to intervene in their heavy-drinking behavior. An underlying assumption of these efforts is that binge drinking is the problem of the

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individual college student and that understanding related characteristics on the individual student level will help health educators and professionals tailor their programs to prevent binge drinking.

Although individual factors are important, environmental factors or social contexts, such as school-based norms or climates, may have a critical influence on the binge drinking of college students [5–7]. Schneider argued that people are bound to develop collective perceptions or climate because individuals attempt to capture order in their environment to be used as a framework for adaptive behavior [8]. Thus, once students enter college, they are likely to develop collective perceptions on drinking at their campus. Literature affirms that college students' perceptions of drinking norms influence their engagement in binge drinking [5, 7]. Despite numerous studies on binge drinking, relatively little attention has been paid to differences in the practice from college to college and the extent to which college climates contribute to the problem. Many previous studies tended to ignore the hierarchical or clustered nature of their data, conducted analysis by disaggregating all the data to the lowest level, and used conventional statistical methods because of the “statistically intractable” difficulty [9, 10]. But, because students in the same college tend to share certain characteristics, observations based on those students are usually not fully independent [1]. Hierarchical linear modeling (HLM) can adequately examine the effect of multilevel variables on an outcome variable as well as on cross-level interactions, taking into account the clustered nature of the data [11].

In recent years, the social ecological model has been widely used as a theoretical framework to reduce college binge drinking [12]. The field has shifted its efforts from approaches directed at individuals to more comprehensive and integrated prevention programs addressing contextual factors, such as the institution-wide climate and community environment. The NIAAA's 3-in-1 Framework is consistent with this social ecological model [7]. To effectively reduce excessive drinking, the NIAAA recommends that colleges use the 3-in-1 Framework in which individual students, the student body as a whole, and the college and surrounding community are simultaneously targeted for intervention efforts [7]. Both the social ecological model and the 3-in-1 Framework emphasize the importance of environmental influence on heavy drinking among college students. Although many professionals and researchers appear to agree on this social ecological framework, no research to date has demonstrated the magnitude of the campus-level predictors for explaining the variance of college students' binge drinking. Given that campus-level rather than individual-level interventions can reach more students at risk with limited resources, it is important to understand the magnitude of the campus-level predictors for binge drink-

ing, as it would suggest more cost-effective intervention efforts to curb it.

In this study, the effect of college-level contextual factors on students' binge drinking was investigated using HLM. The hypothesis was that college-level climate variables, such as percentages of male students, marijuana users, Black students, ages 21 or older, and students with Greek affiliation, would predict students' binge drinking behavior above and beyond student-level predictors.

Methods

Data

The data used for this study was provided by the American College Health Association (ACHA) [13]. In 1998, the ACHA initiated a work group to develop the National College Health Assessment (NCHA) Survey. The ACHA-NCHA survey collects information on a broad range of students' health behaviors, health indicators, and perceptions every semester. The data used in this study was collected in the spring semester of 2006 and originally consisted of 94,806 students on 117 campuses. Of the 117 campuses, 72 were public and 45 were private colleges or universities. Data was collected via both paper-and-pencil surveys administered in randomly selected campus classrooms and web-based surveys among randomly selected students. The response rate was 85.8% for the on-campus paper-and-pencil survey ($n=16,833$) and 23.2% for the web-based survey ($n=75,648$), leading to an overall response rate of 35.0% [14]. Considering that 90.7% of the students in this sample were aged from 18 to 28 years, the students who were older than 28 years were excluded to avoid any possible excessive influence on the model by age-related outliers. The students from four 2-year colleges were also excluded from the sample, reducing the sample size to 82,360 students in 113 4-year colleges. Finally, missing data were deleted as they showed no systematic pattern by Little's MCAR test [15], further reducing the sample size to 76,542 students in 113 colleges. The study protocol was approved by the authors' university institutional review board.

Measures

Data analysis involved student-level and college-level variables. Student-level variables consisted of binge drinking, gender, age, race, Greek membership, cigarette or marijuana use, and perceived percentage of students using cigarettes. All student-level variables except the perceived percentage of students using cigarettes were dichotomized. The outcome variable was binge drinking and measured by

the question “How many times, if any, have you had five or more alcoholic drinks at a sitting in the last two weeks?” The binge drinking variable was coded as 1 for any binge drinking and 0 for no binge drinking. Age was coded as 1 for 21 years or older and 0 for under 21 years. Race was coded as 1 for Blacks and 0 for Whites. Greek membership was coded as 1 for Greek members and 0 for nonmembers. Cigarette or marijuana use was coded as 1 for use within the last 30 days and 0 for nonuse. Perceived percentage of students using cigarettes was measured by asking students their perceived percentage of students using cigarettes on their campuses within the last 30 days. To help a model converge, the scale of perceived cigarette use was reduced in size from 0–98 (in percent) to 0–9.8 by dividing original scores by 10. College-level variables were created by aggregating corresponding student-level variables, including percentages of male students, cigarette smokers, marijuana users, Black students, ages 21 or older, students with Greek affiliation, and aggregated perceived percentage of cigarette smokers.

Data Analysis and Model Specification

For multilevel analysis, HLM 6.06 was used. It properly accounts for various dependencies of observations in a dataset with a hierarchical structure. Given the hierarchical structure of the sample and the binary outcome (Y_{ij}), a logistic multilevel modeling approach was employed. Taking the two-level HLM framework, the lower-level model (i.e., student-level model) captures the primary relation between student-level predictors and the outcome variable within each school. The higher-level model (i.e., college-level model) explains the effect of college-level explanatory variables on students' binge drinking behavior. In statistical terms, the two-level hierarchical generalized linear models (simplified forms) are represented by a level 1 (student level) and a level 2 (college level) regression model as follows [11, 16]:

Level 1 model :

$$\text{Logit}(\pi_{ij}) = \log[\pi_{ij}/(1 - \pi_{ij})] = \beta_{0j} + \beta_{1j}X_{ij}$$

where $Y_{ij}|\pi_{ij} \sim \text{Bernoulli}(1, \pi_{ij})$ and:

Level 2 model :

$$\beta_{0j} = \gamma_{00} + \gamma_{01}W_j + u_{0j},$$

$$\beta_{1j} = \gamma_{10} + \gamma_{11}W_j + u_{1j}$$

In the level 1 model, a logit of binge drinking for student i from college j is expressed as $\log[\pi_{ij}/(1 - \pi_{ij})]$ and is associated with a set of specific individual predictors X_{ij} by the coefficients β_{0j} and β_{1j} . In the binomial distribution, the lowest-level variance is not a free parameter but is

determined by the mean of a dichotomous variable [16, 17]. Therefore, the variance of the random effect for the level 1 model is fixed at 1.0 to define the scale of the underlying normal variate [16]. In the level 2 model, between-college variation is modeled as a function of college-level predictors W_j and random effects u_{0j} and u_{1j} . These random effects are assumed to be normally distributed with means 0 and variances τ_{00} and τ_{11} .

All the variables were initially examined via descriptive statistics and bivariate analyses. Then, separate models were estimated for men and women using the Hox five-step exploratory procedure [16]. First, the between-college variation in binge drinking in the absence of predictor variables (i.e., the null model) was assessed. Second, a model with only student-level predictors was analyzed, while the corresponding variance components of the slopes were fixed at 0. This step allowed us to assess the contribution of each student-level predictor. Third, college-level predictors were added to the step 2 model to examine whether the college-level predictors explained between-college variation in students' binge drinking above and beyond the variation accounted for by student-level variables. Fourth, whether slopes of student-level predictors had a significant variance component between colleges (i.e., a random coefficient model) were evaluated. Finally, whether there were significant cross-level interactions between college-level variables and selected student-level predictor variables (i.e., a full model) were examined. In all analyses, the full maximum likelihood method of estimation was used. All the student-level predictors were group mean centered [18] to disentangle effects of student-level and aggregated college-level predictors. The assumption of normality was examined using the $Q-Q$ plot. The distribution of random effects did not depart from normality. Few differences were found between male and female models in terms of both directionality and statistical significance of each effect. Thus, the model was estimated for the entire sample.

Results

Of the 76,542 students, 36% were male, 48% were 21 years of age or older, 77% were White, 4% were Black, and 9% were affiliated with Greek organizations. Their mean age was 20.9 years ($SD=2.4$). Of the entire sample, 17% and 15% smoked cigarettes and used marijuana in the last 30 days, respectively. The mean perceived percentage of cigarette smokers on their campuses was 38%. A total of 39% of the sample reported engaging in binge drinking at least once within the last 2 weeks.

As shown in Table 1, the average log odds of the null model was -0.496 , which corresponds to 0.378 population average probability of binge drinking, that is, $\pi_0 =$

Table 1 Multilevel logistic regression of students' binge drinking as a function of student and college characteristics

	Null model (step 1)	Level 1 predictors model (step 2)	Level 2 predictors model (step 3)	Random coefficient model (step 4)	Cross-level model (step 5)
Fixed effect (regression coefficient estimates)	Coefficients (SE)				
Student-level fixed effect					
Intercept	−0.496*** (0.059)	−0.524*** (0.070)	−2.312*** (0.499)	−2.084*** (0.447)	−2.190*** (0.452)
Male (vs. female)		0.656*** (0.018)	0.656*** (0.018)	0.660*** (0.018)	0.660*** (0.018)
21+years old (vs. <21 years old)		0.173*** (0.032)	0.173*** (0.032)	0.201*** (0.029)	0.495* (0.218)
Greek membership (vs. nonmembership)		0.991*** (0.053)	0.991*** (0.053)	0.928*** (0.047)	0.919*** (0.046)
Cigarette use in the last 30 days (vs. nonuse)		1.233*** (0.033)	1.233*** (0.033)	1.271*** (0.030)	1.215*** (0.143)
Marijuana use in the last 30 days (vs. nonuse)		1.397*** (0.037)	1.397*** (0.037)	1.425*** (0.031)	0.978*** (0.158)
Perceived percentage of cigarette smokers/10 ^a		0.065*** (0.006)	0.065*** (0.006)	0.065*** (0.006)	0.065*** (0.006)
Black (vs. White)		−0.964*** (0.074)	−0.964*** (0.074)	−0.966*** (0.072)	−0.966*** (0.071)
College-level fixed effect					
Percentage of male students			1.638** (0.534)	1.447** (0.486)	1.346** (0.487)
Percentage of students aged 21 years or older			−0.183 (0.365)	−0.078 (0.311)	−0.182 (0.316)
Percentage of students with Greek membership			1.903** (0.607)	1.961*** (0.480)	1.964*** (0.472)
Percentage of students using cigarettes in the last 30 days			0.588 (1.237)	−0.134 (1.083)	0.032 (1.051)
Percentage of students using marijuana in the last 30 days			4.114*** (0.884)	3.532*** (0.743)	4.141*** (0.821)
Aggregated perceived percentage of cigarette smokers/10 ^a			0.170 (0.099)	0.179 (0.087)	0.187 (0.087)
Percentage of Black students			−2.046*** (0.399)	−2.073*** (0.355)	−1.914*** (0.351)
Cross-level interaction					
21+years old (vs. <21 years old)× percentage of students using marijuana					−1.281** (0.423)
Marijuana use (vs. nonuse)× percentage of White students					0.589*** (0.147)
Random effect (variance estimates)					
College-level residuals	0.376*** (0.052)	0.503*** (0.074)	0.208*** (0.030)	0.218*** (0.031)	0.215*** (0.031)
Slopes for 21+years old (vs. <21 years old)				0.046*** (0.014)	0.023*** (0.012)
Slopes for Greek membership (vs. nonmembership)				0.083*** (0.012)	0.084*** (0.008)
Slopes for cigarette use in the last 30 days (vs. nonuse)				0.037** (0.022)	0.022 (0.022)
Slopes for marijuana use in the last 30 days (vs. nonuse)				0.025* (0.013)	0.016 (0.011)
Slopes for Black (vs. White)				0.145*** (0.027)	0.146*** (0.027)
Deviance	225,779	213,270	213,177	212,938	212,864
Estimated parameters (<i>n</i>)	2	10	18	45	58

Table 1 (continued)

	Null model (step 1)	Level 1 predictors model (step 2)	Level 2 predictors model (step 3)	Random coefficient model (step 4)	Cross-level model (step 5)
Fixed effect (regression coefficient estimates)	Coefficients (SE)				
Hierarchical model testing ^b					
χ^2 value		12,509.4	92.6	239.4	73.9
<i>df</i>		8	8	27	13
<i>p</i> value		<0.001	<0.001	<0.001	<0.001

Student predictors were group mean centered

^a The scores of perceived cigarette use were divided by 10

^b Each model was compared to the immediate previous model

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

$e^{-0.496}/(1 + e^{-0.496}) = 37.8\%$ (95% confidence interval, 35.1–40.6%). The variance of a logistic distribution with a scale factor of 1 is $\pi^2/3 = 3.29$ [16]. Because the college-level residual variance was 0.376 (see Table 1), the intraclass correlation (ICC) ($\rho = \tau_{00}/(\tau_{00} + \sigma^2)$), the percentage of the residual variance attributed to between-college variation, was $0.376/(0.376 + 3.29) = 0.10$, which means that 10% of variance in students' binge drinking was between colleges. The fixed effects of seven student-level predictors of binge drinking (i.e., gender, age, race, Greek membership, cigarette use, marijuana use, and perceived percentage of cigarette smokers) were then entered. All the student-level predictors contributed to the regression. Being a male ($\gamma = 0.660$), being a sorority/fraternity member ($\gamma = 0.919$), cigarette use ($\gamma = 1.215$), marijuana use ($\gamma = 0.978$), and perceived percentage of cigarette smokers ($\gamma = 0.065$) were positively associated ($p < 0.001$) with students' binge drinking. Being a Black student ($\gamma = -0.966$) was negatively associated ($p < 0.001$) with students' binge drinking. That indicates, on average, males, those with Greek membership, cigarette or marijuana users, and those with higher perceived level of cigarette use are more likely to binge drink than females, those without Greek membership, nonusers of cigarettes or marijuana, and those with lower perceived level of cigarette use, respectively. On the contrary, students who were Black were less likely to binge drink than Whites.

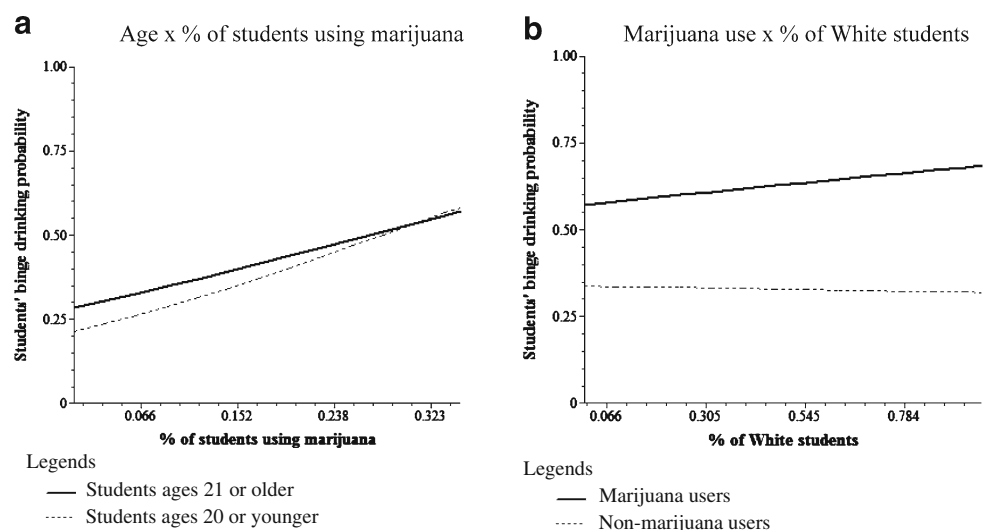
Next, the corresponding seven college-level predictors were entered, allowing a test of the main hypothesis, namely, that college-level climate variables would predict the probability of students' binge drinking behavior above and beyond student-level predictors. Of the seven college-level predictors, four were significant ($p < 0.01$)—percentage of male students, percentage of students with Greek membership, percentage of Black students, and percentage of students using marijuana in the last 30 days. The model was gradually improved not only by adding student-level and college-level predictors but also by allowing random slopes and cross-level interactions.

As shown in Table 1, 42.8% $((0.376 - 0.215)/0.376)$ of between-college variation in students' binge drinking was accounted for by the final model. The added college-level variables to the random coefficient model (step 4) reduced the variance in the slope for students aged 21 years or older by 50%, for cigarette use by 41%, and for marijuana use by 36% in the final model (step 5).

The interactions were plotted in Fig. 1. Figure 1a presents a plot of the regression lines of students' binge drinking probability predicted by aggregated marijuana use by students' dichotomized age. It shows that students aged 21 years or older had a higher level of binge drinking at a college with a lower level of marijuana use compared to those younger than 21 years. With an increase in college-level marijuana use, students' binge drinking probability increased more quickly for those <21 years of age. Figure 1b shows the effect of percentage of White students on a campus on the relation between marijuana use and binge drinking. The probability of students' binge drinking was higher among marijuana users than nonusers, and it increased among marijuana users as the proportion of White students on a campus increased, whereas it stayed relatively unchanged among nonmarijuana users regardless of the proportion of White students on a campus.

Discussion

This was one of the first studies to investigate the effect of college-level contextual factors on students' binge drinking and the cross-level interactive effects between those factors, while using an appropriate multilevel analytic technique on a large representative sample of U.S. college students: 76,542 students in 113 colleges. The study grew from the finding that students exposed to a heavy-drinking college environment were more likely to engage in frequent binge drinking [6]. Results of this study supported the previous

Fig. 1 Cross-level interaction

finding, affirming the existence of group factors that make college students susceptible to binge drinking. Percentage of male students, percentage of students with Greek membership, percentage of Black students, and percentage of students using marijuana significantly predicted students' binge drinking above and beyond their corresponding student-level predictors. This finding affirms the need for college-level interventions aimed to prevent high-risk drinking to be more focused on Greek-affiliated students, students using marijuana, and White male students than on general student populations. The target population of the majority of grants awarded by the U.S. Department of Education to prevent high-risk drinking among college campuses is either the general student population in an awarded institution or a small group of high-risk drinkers who are under the judiciary system [14]. More resources may need to be devoted to a drinking-prevention program that targets high-risk students, such as White male students with Greek affiliations and those who use marijuana. Also, future studies that would develop a valid and reliable scale that can measure college-level, not student-level, drinking climate would be desirable. They would allow college administrators and health professionals to compare drinking climate between colleges and across different times.

An ICC in this study indicated that 10% of students' binge drinking could be explained by differences among colleges. A typical ICC value ranges from 0.05 to 0.20 in educational research [17]. Due to the paucity of data on ICC in college binge drinking, further studies are needed to generate a reliable range of ICC on this topic. Although 10% might appear to be small, it should be noted that slopes of three student-level predictors had a significant variance component between colleges. The way such variables as age, race, and Greek membership affected binge drinking was different between colleges. This finding is important because it implies that different approaches are

needed for different colleges and universities to effectively curb high-risk drinking. For example, some campuses show high binge drinking rates among younger students than other campuses. Thus, given the typical campus situation where many different programs compete for limited resources, efforts to prevent high-risk drinking can be better targeted based upon the population segmentation by these variables. A universal approach might result in only limited success compared to an approach tailored to the needs and specifics of each college and university, even if the universal approach accounts for evidence-based research. In terms of model building, this justifies the use of a random effects model for college students' binge drinking.

Perhaps one of the unique contributions of this study to the literature would be an investigation of cross-level interactions between college-level predictors and student-level predictors of binge drinking. It is noteworthy that students younger than 21 years had a lower level of binge drinking than those aged 21 years or older at a college with a lower level of marijuana use. However, the binge drinking probability increased more quickly among students younger than 21 years than their counterparts as the proportion of marijuana users on a campus increased. This indicates that underage drinking is more prevalent on a campus where marijuana use is widespread, providing an insight into the contradictory findings in the literature. Some researchers found that students aged 21 or older binged more frequently than underage students [19] but others reported a reverse pattern [20]. This inconsistency probably resulted from lack of consideration of college-level contextual factors. According to the finding of this study, the former is more likely to happen on a campus with a low level of marijuana use, but the latter is more likely to happen on a campus with a high level of marijuana use. This further indicates that the well-established tendency of co-occurrence of addictive behaviors at individual levels [1, 2, 20] might be reinforced by drug-friendly group

culture. This finding further demonstrates the need for addressing multiple addictive or risk behaviors in a single study rather than focusing on one risk behavior. Although transdisciplinary and interdisciplinary approaches are emphasized by many researchers and granting agencies, there is lack of studies that actually address multiple health conditions or behaviors in a single project due, in part, to the compartmentalized nature of many granting agencies.

The findings of this study should be interpreted in light of the following limitations. This study analyzed a dataset collected through a cross-sectional survey design. Causality should not be inferred from the present findings. Unlike the conventional differential operational definitions of binge drinking between females and males (i.e., five or more drinks in a row for men and four or more in a row for women) [1], the ACHA-NCHA survey adopted a single operational definition (i.e., five or more drinks in a row regardless of gender). Thus, according to the conventional definition of binge drinking, the prevalence of binge drinking among female students might be underestimated in this study. However, in order to reduce the underestimation of binge drinking among female students, the originally continuous binge drinking variable was collapsed into a binary variable (yes/no). Finally, our model was limited to the data collected by the ACHA-NCHA survey which was not solely designed for collecting data regarding binge drinking and related college characteristics. Thus, there may be other potential predictors of binge drinking which were not accounted for by the model. It would be desirable to refine the model and monitor cross-level interactions between student-level and college-level predictors of binge drinking longitudinally in future studies. Despite these limitations, this study contributes to the literature by showing the significant effect of selected college-level contextual variables on students' binge drinking behavior above and beyond student-level predictors and by examining cross-level interactions between college-level predictors and student-level predictors of binge drinking. College administrators and health educators should actively intervene in the college drinking climate to reduce binge drinking among college students.

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