Prevention Science (2019) 20:342–352
https://doi.org/10.1007/s11121-018-0877-6

Is Alcohol and Other Substance Use Reduced When College Students Attend Alcohol-Free Programs? Evidence from a Measurement Burst Design Before and After Legal Drinking Age

Eric K. Layland[1] · Brian H. Calhoun[1] · Michael A. Russell[1] · Jennifer L. Maggs[1]

Published online: 8 March 2018

Abstract
College drinking and its negative consequences remain a major public health concern. Yet, many prevention efforts targeting college drinkers are expensive, are difficult to implement, use indicated approaches targeting only high-risk drinkers, and/or are only marginally effective. An alternative strategy taken explicitly or implicitly by many colleges is campus-led alcohol-free programming which provides students with attractive leisure alternatives to drinking on weekend nights. This study aimed to extend work by Patrick et al. (*Prevention Science, 11*, 155–162, 2010), who found that students drank less on weekend nights they attended LateNight Penn State (LNPS) activities during their first semester of college. Here, daily diary and longitudinal data on college students' daily lives and risk behaviors were collected from 730 students on 19,506 person-days across seven semesters at a large university in the Northeastern United States. Generalized linear mixed models were used to estimate alcohol and illegal substance use on weekend days as a function of LNPS attendance, gender, legal drinking status (≥ 21 years), and day of the weekend. Across college, students who attended LNPS used alcohol and illegal substances less in general and less on days they participated compared to themselves on days they did not participate. Legal drinking status moderated the association between LNPS attendance and alcohol and illegal substance use such that levels of use were lowest for students under 21 years old on weekend days they attended LNPS. Our findings provide support for campus-led alcohol-free programming as a potential harm reduction strategy on college campuses.

Keywords College drinking · Alcohol use · Substance use · Prevention · Multi-level modeling

Introduction

Heavy drinking among traditional-aged college students is a major public health concern due to its high prevalence and myriad negative consequences (Hingson et al. 2009; Lipari et al. 2014). For example, heavy drinking has a deleterious impact on college students' physical health, academic performance, social relationships, and sexual behaviors (Hingson et al. 2009; Perkins 2002; Wechsler and Nelson 2008). Illegal substance abuse is also harmful to college students as it has been linked with lower academic performance, failure to fulfill role responsibilities, and loss of interest in activities (Palmer et al. 2012). Yet, prevention efforts targeting college students' abuse of alcohol and other substances are often expensive, are difficult to implement, use indicated approaches targeting only high-risk drinkers, and/or are marginally effective (Cronce and Larimer 2011). In light of these challenges, alcohol-free programming on college campuses may be a promising alternative approach to reducing levels of alcohol and substance use among college students.

Alcohol and Substance Use During College

The college experience provides a context where experimentation with alcohol and other substances is facilitated by new freedoms, ample free time, reduced supervision, transitions to new social contexts, and a culture of partying (Miech et al. 2017; Stone et al. 2012). US college students consume an average of 9.5 drinks on binge drinking occasions (4+/5+ drinks for females/males; Slutske et al. 2004), and the odds of alcohol-related harm increase with amounts consumed per occasion (Wechsler and Nelson 2001). High-intensity

✉ Eric K. Layland
elayland@psu.edu

[1] Pennsylvania State University, State College, PA, USA

drinking, defined as drinking two times the binge drinking threshold (i.e., 8+/10+ drinks for females/males; Patrick and Terry-McElrath 2017), is also common among college students and contributes to many adverse outcomes (e.g., academic failure, sexual assault, death; HHS 2007; White and Hingson 2014; White et al. 2006). Use of marijuana and other substances by college students also remains high, with concomitant risks for academic achievement, injury, dependence, and cancer (Johnston et al. 2016; Volkow et al. 2014).

In the USA, the legal drinking age of 21 years old falls during the college years for most students who attend college immediately following high school. Although considerable alcohol use occurs earlier (e.g., Johnston et al. 2016), prior to age 21, there are legal and practical challenges to obtaining and consuming alcohol. After age 21, drinkers can purchase alcohol openly and drink in bars; thus, the age of majority represents a key developmental and legal transition (Weybright et al. 2016).

Alcohol-Free Programming on College Campuses

Alcohol-free programming on university campuses is designed to provide appealing social alternatives during peak social times, thereby diverting students who would otherwise be engaging in risky behaviors toward safer yet fulfilling activities (DeJong and Langford 2002). Prior studies suggest that students who spend more time in naturally occurring alcohol-free activities including academics, volunteering, and campus activities (excluding fraternity and sorority activities) report less alcohol use (Fenzel 2005; Weitzman and Kawachi 2000).

This paper is guided by three theoretical approaches supporting the use of alcohol-free programs on college campuses. First, behavioral economic approaches suggest that alcohol use is impacted by the perceived availability and cost of alcohol and alcohol-free activities as well as the consequences of consuming or abstaining from alcohol (Correia et al. 2005; Murphy et al. 2007). Therefore, the availability of attractive alternatives to substance use may effectively reduce substance use (Murphy and Dennhardt 2016). Second, the routine activity perspective proposes that when an individual socializes in unstructured, unsupervised contexts, the likelihood of and rewards for participating in deviant behaviors increases (Osgood and Anderson 2004). Opportunities for unstructured leisure in commercial premises specifically designed for consuming alcohol while socializing (i.e., bars) increase greatly after the 21st birthday, as well as the ability to purchase alcohol for home and party use. Third, experimental research based on a psychosocial developmental approach has demonstrated that the likelihood of taking risks in lab settings is particularly influenced by the presence of peers among individuals transitioning to adulthood (Gardner and Steinberg 2005). Compared to performing risk-taking tasks alone, the presence of peers increases the number of risks taken, focus on benefits over costs, and risky decision making. Consistent with ideas from these three perspectives, one strategy for preventing substance abuse among college students, then, is to facilitate peer socialization in more structured and low-risk contexts. Indeed, an environmental strategy noted by the National Institute on Alcohol Abuse and Alcoholism (NIAAA 2015) is to provide attractive alcohol-free events and activities on campus as a social alternative to alcohol-related parties and bars. Alcohol-free programming was evaluated as promising but lacking robust studies to evaluate effectiveness by NIAAA's College AIM Alcohol Intervention Matrix (2015). The present study investigates the relationship between alcohol-free programming and student drinking and substance use.

LateNight Penn State

One program using this strategy is LateNight Penn State (LNPS) at the Pennsylvania State University. This campus-led recreation-based program provides alcohol-free programming and entertainment for undergraduate students during prime times of the social weekend (e.g., Del Boca et al. 2004; Finlay et al. 2012): Thursday (9:00 pm to 12:00 am), Friday (9:00 pm to 2:00 am), and Saturday (9:00 pm to 2:00 am). The program was designed with three primary goals: (1) provide an alternative to alcohol-related activities, (2) satisfy diverse student interests by providing a variety of quality programs, and (3) encourage student involvement in program development. LNPS offers an array of activities including live music, movies, dance lessons, crafts, video games, sports, and many other activities varying from week to week. During the first semester of this study, LNPS reported attendance of 22,930 non-unique students (i.e., a student would be counted every time she attended, resulting in inflated attendance reporting) across 14 weeks or 42 weekend days. Average attendance was highest on Fridays ($M = 868.4$ students), followed by Saturdays ($M = 623.8$), and Thursdays ($M = 145.6$). At the time of data collection, programs were financially supported by Student Affairs.

In prior work focusing on the first semester of college, Patrick et al. (2010) found that students consumed fewer drinks and had lower odds of any drinking and binge drinking on weekend nights they attended LNPS, compared to weekend nights they went out (e.g., attended parties, other campus events, or entertainment). They also found that students who attended LNPS more frequently consumed fewer drinks and had fewer days with any drinking and with binge drinking, on average. Although randomized controlled trials (RCTs) of alcohol-free programs using between-campus, between-person, or, ideally, within-person randomization would provide

the strongest evidence of effectiveness, such designs are at best expensive and at worst impractical. An alternative design option is an intensive repeated-measures study following participants across multiple days, weekends, and years. Such a daily diary design can leverage the repeated measures across days and semesters to use each person as his or her own "control" across time, allowing within-person comparisons that hold constant all stable person-level characteristics that may confound the association between attending alcohol-free programming and alcohol use (e.g., personality characteristics, drinking history, and gender). In the present naturalistic study, we use a measurement-burst design to draw conclusions one step closer to causal influence than those permitted by traditional between-person comparisons.

Here, we extend the work of Patrick et al. (2010) on variation in first-semester students' alcohol use as a function of LNPS attendance in three key ways. First, we model within-person fluctuations in the total number of drinks, any drinking, and binge drinking across 42 weekend days assessed across 4 years of college. Second, we address two key additional outcomes in the same data: high-intensity drinking and illegal substance use. We hypothesize that on days participants attend LNPS, they will drink less and be less likely to engage in any drinking, binge drinking, high-intensity drinking, and illegal substance use compared to themselves on days they go out, across all seven semesters. Third, we tested whether the day-level association between LNPS attendance and drinking/illegal substance use differs by legal drinking status (i.e., under 21 versus 21+ years).

Methods

Data came from the University Life Study (ULS), a longitudinal study assessing the daily lives and risk behaviors of college students at a large, land-grant university in the Northeastern United States (Howard et al. 2015). The ULS used a longitudinal measurement-burst design in which participants completed a longer, Web-based survey followed by 14 consecutive daily Web-based surveys in each of seven semesters. Participants were recruited using a stratified, random sampling procedure aimed at recruiting similar numbers of females and males in each of the four largest US racial/ethnic groups. Eligible participants were first-time, full-time, first-year students who were under 21 years of age; were US citizens or permanent residents; and lived within 25 miles of the main campus.

Of the randomly selected students, 65.6% ($N = 744$) provided informed consent and participated in semester 1. By semester 7, 81.5% ($N = 608$) of the semester 1 sample remained. In semester 1, students' mean age was 18.45 years ($SD = .43$); 50.8% were female. The sample was racially and ethnically diverse: 25.1% were Hispanic/Latinx American, 27.4% European American non-Hispanic/Latinx (NHL), 23.3% Asian American/Pacific Islander NHL, 15.7% African American NHL, and 8.5% multi-racial NHL. Participants completed daily surveys on up to 98 days (14 days × 7 semesters). To focus on drinking during the social weekend (Del Boca et al. 2004; Maggs et al. 2011) and the days when LNPS was offered, only daily surveys for Thursday, Friday, and Saturday were used. Therefore, each participant could provide up to 42 days of observations (6 days per semester × 7 semesters). The analytic data set included 19,506 person-days within 4025 person-semesters within 730 students. The average student provided 26.74 days of observations ($SD = 11.27$, range = 1–42 weekend days) to the analyses.

Measures

Daily Activities

Each day, participants were asked "From the time you woke up until you went to sleep, how much time did you spend doing the following activities?" Possible responses included "did not do" (0) and "did do" with time ranges from "up to 30 min" (1) to "10+ hours" (9). Daily activities were coded into one of three mutually exclusive categories: attending LNPS, going out, and staying in. On days when participants reported any time spent "Attending LateNight Penn State," they were coded as *attending LNPS*. When participants did not attend LNPS but reported any time spent "Going to bars, parties, etc.," "Attending sports, concert, movie, other entertainment," or "Attending another campus event or club," they were coded as *going out*. Finally, on days when participants did not report attending LNPS or going out, they were coded as *staying in*. Two dummy coded daily-level (level 1) variables, *LNPS* and *staying in*, were included in analyses, with *going out* as the reference group.

Substance Use

Total number of drinks (range = 0–25+ drinks) was assessed with the question, "How many drinks of alcohol did you drink?," in reference to the previous day from the time students woke up until the time they went to sleep. Students used a pull-down menu containing response options ranging from 0 to 25+ drinks. A single drink was defined as, "half an ounce of absolute alcohol, for example 12 ounce can of beer or cooler, 5 ounce glass of wine, or a drink containing 1 shot of liquor or spirits" (NIAAA 2003). This variable was used continuously and was recoded into three binary drinking outcome variables for each day. Total number of drinks was collapsed to a single, binary *any drinking* variable (0 = no drinks, 1 = any drinks). *Binge drinking* and *high-intensity drinking* were defined as consuming 4+/5+ and 8+/10+ drinks for females/males, respectively (Hingson et al. 2002; Wechsler et al. 1995). Participants were also asked, "What substances did you use?,"

selecting options from a list including marijuana, cocaine, steroids, methamphetamines, prescription drugs, and any other types of drugs. This variable was collapsed to a single binary variable (0 = no, 1 = yes) indicating days with *any illegal substance use*.

Two additional demographic variables were included in the model. First, gender was coded at the person level with females as the reference group (0 = female, 1 = male). Second, the minimum legal drinking age was used to code semesters in which participants were 21 years of age or older (0 = under 21 years, 1 = 21 or older; Howard et al. 2015).

Statistical Analyses

Five generalized linear mixed models (GLMMs) nesting days within semesters within persons were used to predict each of the five alcohol and substance use outcome variables as a function of gender, age, activity, and day of the week using SAS 9.4. Total drinks were assessed with a count variable and thus modeled using a Poisson GLMM (Coxe et al. 2009; Raudenbush and Bryk 2002). The other four outcomes were dichotomous and were modeled using logistic GLMMs with a Bernoulli distribution (Raudenbush and Bryk 2002). The presence of more or less variability in the data than would be expected under assumptions of Poisson or binomial statistical models was accounted for using daily-level (level 1) random effects capturing over- or underdispersion (Coxe et al. 2009; Raudenbush and Bryk 2002). The equation for the GLMM predicting any drinking was:

$$\begin{aligned}\text{logit}(Y)_{ijk} = {} & \gamma_{000} + \gamma_{001}(\text{Gender})_k + \gamma_{002}(\text{Person mean LNPS attendance})_k + \\ & \gamma_{003}(\text{Person mean staying in})_k + \gamma_{010}(\text{Age 21})_{jk} + \\ & \gamma_{020}(\text{Semester mean LNPS attendance})_{jk} + \gamma_{030}(\text{Semester mean staying in})_{jk} + \\ & \gamma_{100}(\text{Daily LNPS attendance})_{ijk} + \gamma_{101}(\text{Gender})_k(\text{Daily LNPS attendance})_{ijk} + \\ & \gamma_{110}(\text{Age 21})_{jk}(\text{Daily LNPS attendance})_{ijk} + \gamma_{200}(\text{Daily staying in})_{ijk} + \\ & \gamma_{201}(\text{Gender})_k(\text{Daily staying in})_{ijk} + \gamma_{210}(\text{Age 21})_{jk}(\text{Daily staying in})_{ijk} + \\ & \gamma_{300}(\text{Friday})_{ijk} + \gamma_{400}(\text{Saturday})_{ijk} + \mu_{01k} + r_{0jk}\end{aligned}$$

The equations for the binge drinking, high-intensity drinking, and any illegal substance use models were identical. The equation for the total number of drinks model was identical, aside from the outcome being in log units, as opposed to logit units.

The variables used in the GLMMs were coded so the intercept reflected the substance use of underage female students who had average levels of LNPS attendance and staying in at both person and semester levels. Person mean LNPS attendance was grand mean centered by subtracting the sample-wide mean LNPS attendance (0.0865) from each individual's mean LNPS attendance. Person mean staying in was similarly grand mean centered. Mean semester LNPS attendance was grand mean centered by subtracting the sample-wide mean LNPS attendance (0.0865) from each individual's mean LNPS attendance in each semester. Mean semester staying in was similarly grand mean centered. Indicators for Friday and Saturday were grand mean centered by subtracting each sample-wide mean (0.3407 and 0.3086, respectively) from the value of each variable on each day. Daily LNPS attendance and daily staying in were uncentered.

Results

Descriptive Statistics

Sixty-nine percent of students (n = 506; 78% of females, 60% of males) attended LNPS at least once across the 42 assessed weekend days, and the average student reported attending LNPS on 2.31 days (SD = 2.82). LNPS attendance was reported on 9% (n = 1689) of all weekend days, going out on 37% (n = 7129), and staying in on 55% (n = 10,705). Drinking was reported on 27% of all weekend days (n = 5260), binge drinking on 19% (n = 3669), high-intensity drinking on 7% (n = 1393), and illegal substance use on 4% (n = 772). The average number of drinks reported on weekend days was 1.69 (SD = 3.50, range = 0–25+). On weekend days that students reported consuming at least one drink, the average number of drinks reported was 6.28 (SD = 4.06). There were 15,950 days assessed within semesters that students were under 21 years of age and 3573 days when students were 21 years of age or older.

Generalized Linear Mixed Models

Research Question 1: Was LNPS Attendance Associated with Less Alcohol Use Across College?

Models 1–3 in Table 1 test whether the associations between LNPS attendance and alcohol use reported by Patrick et al. (2010) extended into the fourth year of college. Across college, students consumed fewer drinks and had lower odds of any drinking and binge drinking on weekend days they attended LNPS (γ_{100}) compared to weekend days they went out. Similarly, students who attended LNPS more frequently consumed fewer drinks and had fewer any drinking and binge drinking days across college (γ_{002}). Males consumed more drinks on the average weekend day, but there were no gender differences in the likelihood of any drinking or binge drinking (γ_{001}). Students aged 21 or older consumed

Table 1 Main effects in generalized linear mixed models examining the relation between LateNight Penn State attendance and alcohol and illegal substance use

	Model 1 Total drinks	Model 2 Drinking days	Model 3 Binge drinking days	Model 4 High-intensity drinking days	Model 5 Illegal substance use days
	IRR [CI]	OR [CI]	OR [CI]	OR [CI]	OR [CI]
Fixed effects					
Average drinking on weekend days, π_{0jk}					
Intercept, γ_{000}	.94 [.82, 1.07]	.58 [.48, .70]***	.20 [.16, .25]***	.008 [.006, .011]***	.001 [.000, .001]***
Male gender, γ_{001}	1.30 [1.07, 1.57]**	1.10 [.85, 1.42]	1.25 [.92, 1.71]	2.66 [1.77, 4.01]***	2.56 [1.46, 4.49]**
Person mean LNPS, γ_{002}	.01 [.00, .02]***	.001 [.000, .003]***	.0004 [.0001, .0024]***	.0003 [.0000, .0042]***	.0001 [.0000, .0048]***
Person mean SI, γ_{003}	.05 [.03, .08]***	.02 [.01, .03]***	.01 [.00, .02]***	.01 [.00, .02]***	.03 [.01, .14]***
Age 21, γ_{010}	1.32 [1.22, 1.44]***	1.84 [1.58, 2.14]***	1.41 [1.18, 1.68]***	1.67 [1.28, 2.17]***	1.42 [.94, 2.14]
Semester mean LNPS, γ_{020}	.85 [.65, 1.12]	1.47 [.90, 2.39]	1.05 [.59, 1.87]	.98 [.42, 2.29]	1.58 [.35, 7.06]
Semester mean SI, γ_{030}	1.07 [.92, 1.24]	1.88 [1.44, 2.45]***	1.89 [1.39, 2.59]***	1.76 [1.11, 2.81]*	.79 [.40, 1.56]
Daily LNPS, π_{1jk}					
Daily LNPS, γ_{100}	.76 [.71, .82]***	.36 [.31, .42]***	.38 [.33, .44]***	.67 [.57, .78]***	.47 [.39, .56]***
Daily SI, π_{2jk}					
Daily SI, γ_{200}	.24 [.23, .25]***	.06 [.06, .07]***	.05 [.04, .05]***	.08 [.07, .08]***	.49 [.45, .54]***
Friday, π_{3jk}					
Friday, γ_{300}	1.74 [1.66, 1.82]***	3.20 [2.92, 3.50]***	3.42 [3.10, 3.77]***	3.88 [3.49, 4.31]***	1.49 [1.37, 1.63]***
Saturday, π_{4jk}					
Saturday, γ_{400}	1.75 [1.67, 1.83]***	2.94 [2.67, 3.23]***	2.91 [2.63, 3.22]***	4.49 [4.03, 5.00]***	1.79 [1.64, 1.96]***
	Estimate [CI]	Estimate [CI]	Estimate [CI]	Estimate [CI]	Estimate [CI]
Random effects					
Level 3 intercept, μ_{01k}	1.28 [1.12, 1.49]***	2.19 [1.90, 2.56]***	3.03 [2.63, 3.55]***	4.10 [3.50, 4.87]***	6.13 [5.19, 7.33]***
Level 2 intercept, r_{0jk}	.42 [.38, .47]***	1.58 [1.44, 1.74]***	2.17 [1.99, 2.37]***	3.68 [3.37, 4.03]***	5.82 [5.28, 6.44]***
Level 1 dispersion	2.03 [1.98, 2.07]***	.57 [.55, .58]***	.43 [.42, .44]***	.20 [.20, .21]***	.087 [.086, .089]***
Variance explained					
Fixed effects (%)	19.79	26.69	21.67	8.57	2.30
Fixed and random effects (%)	64.01	62.66	64.13	58.84	61.75

N = 19,433–19,506 days nested within 730 persons

IRR incidence rate ratio, *OR* odds ratio, *CI* 95% confidence interval, *LNPS* LateNight Penn State attendance, *SI* staying in

*$p < .05$; **$p < .01$; ***$p < .001$

more drinks on the average weekend day and had more any drinking and binge drinking weekend days than underage students (γ_{010}). Students were more likely to consume any drinks and to binge drink in semesters they had more staying in days (γ_{030}). These associations were in the opposite direction of the associations between drinking and daily- and person-level staying in within each model. Levels of alcohol use were higher on Fridays (γ_{300}) and Saturdays (γ_{400}) than on Thursdays.

Research Question 2: Was LNPS Attendance Associated with High-Intensity Drinking and Illegal Substance Use?

Models 4 and 5 in Table 1 test whether the association between LNPS attendance and alcohol use extends to high-intensity drinking and illegal substance use. Across college, students were less likely to engage in high-intensity drinking or illegal substance use on weekend days they attended LNPS (γ_{100}) compared to weekend days they went out. Students who attended LNPS more frequently across college reported fewer high-intensity drinking and illegal substance use days (γ_{002}). Males engaged in high-intensity drinking and illegal substance use on more weekend days than females (γ_{001}). Students aged 21 or older had more high-intensity drinking days than underage students, but there was no association between legal drinking status and illegal substance use (γ_{010}). Students were more likely to have high-intensity drinking days in semesters they stayed in more frequently (γ_{030}). This association was in the opposite direction of the associations between high-intensity drinking and daily- and person-level staying in. Levels of high-intensity drinking and illegal substance use were higher on Fridays (γ_{300}) and Saturdays (γ_{400}) than on Thursdays. Taken together with the results of research question 1, we confirm our hypotheses that compared to themselves on days participants attended LNPS, they drank less and were less likely to engage in any drinking, binge drinking, high-intensity drinking, and illegal substance use across seven semesters of college.

Research Question 3: Did Legal Drinking Status Moderate the Relationship Between LNPS Attendance and Alcohol and Illegal Substance Use?

Table 2 shows models testing whether legal drinking status moderated the association between daily LNPS attendance and each of the five alcohol and substance use outcome variables in Table 1. Significant interactions between daily LNPS attendance and legal drinking status were observed in all models (γ_{110}) except for the high-intensity drinking model (model 4). Table 3 gives the simple slopes for each of the four statistically significant daily LNPS × age 21 interaction terms reported in Table 2. Daily LNPS attendance was associated with consuming fewer drinks for underage students, but there was no association between daily LNPS attendance and the number of drinks consumed that day for students 21 years of age or older (γ_{110}) (model 1, Table 3). This moderation effect is shown visually in Fig. 1, which provides the predicted number of drinks underage and of-age students consumed on weekend days they did and did not attend LNPS. Daily LNPS attendance was associated with lower odds of any drinking and binge drinking for all students, but the associations were stronger for students under 21 years old (models 2 and 3, Table 3). Students under 21 years were less likely to use illegal substances on weekend days they attended LNPS, but there was no daily association between LNPS attendance and illegal substance use for students aged 21 or older (model 5, Table 3). Figure 2 depicts these moderation effects, showing lower predicted probabilities of any drinking, binge drinking, and any illegal substance use for underage students than for of-age students on weekend days they did and did not attend LNPS. Thus, the association between daily LNPS attendance and reduced alcohol and substance use was stronger for underage students than for students who had turned 21, indicating a moderation effect of legal drinking status.

Gender also moderated the daily association between LNPS attendance and any drinking and any illegal substance use. Lower odds of drinking on days attending LNPS were observed among females and males, but the strength of the association was stronger for females (model 2, Table 3). Both genders had lower odds of any illegal substance use on weekend days they attended LNPS, but the association was stronger for males (model 5, Table 3).

Models were also tested to determine whether alcohol or illegal substance use on the previous day significantly predicted use on the current day. Across all models in Tables 1 and 2, use of alcohol or illegal substances on the previous day was associated with less use on the current day ($p < .001$). However, the odds ratios and incidence rate ratios for the main and interaction effects of LNPS attendance fluctuated minimally, if at all, in these models. Given that the association between previous and current day alcohol and illegal substance use may be more complex than that depicted by a single, linear fixed effect, and for the sake of parsimony, these lagged outcome predictor variables were not included in the final models.

Discussion

Results from this longitudinal, measurement-burst design study contribute to a growing body of knowledge on the effectiveness of campus-led alcohol-free programs by documenting that on nights students attended LNPS

Table 2 Interaction effects in generalized linear mixed models examining the relation between LateNight Penn State attendance and alcohol and illegal substance use

	Model 1 Total drinks IRR [CI]	Model 2 Drinking days OR [CI]	Model 3 Binge drinking days OR [CI]	Model 4 High-intensity drinking days OR [CI]	Model 5 Illegal substance use days OR [CI]
Fixed effects					
Average drinking on weekend days, π_{0jk}					
Intercept, γ_{000}	1.02 [.89, 1.17]	.64 [.53, .78]***	.21 [.17, .27]***	.009 [.007, .012]***	.0008 [.0005, .0012]***
Male gender, γ_{001}	1.11 [.91, 1.34]	.84 [.64, 1.10]	1.06 [.77, 1.45]	2.30 [1.52, 3.48]***	2.29 [1.30, 4.06]**
Person mean LNPS, γ_{002}	.01 [.00, .02]***	.001 [.000, .003]***	.0004 [.0001, .0024]***	.0003 [.0000, .0041]***	.0001 [.0000, .0053]***
Person mean SI, γ_{003}	.05 [.03, .08]***	.02 [.01, .03]***	.01 [.00, .02]***	.01 [.00, .02]***	.03 [.01, .13]***
Age 21, γ_{010}	1.33 [1.22, 1.46]***	1.92 [1.60, 2.30]***	1.53 [1.26, 1.86]***	1.71 [1.30, 2.24]***	1.33 [.87, 2.03]
Semester mean LNPS, γ_{020}	.90 [.69, 1.18]	1.50 [.92, 2.44]	1.10 [.62, 1.95]	.97 [.41, 2.29]	1.55 [.34, 7.06]
Semester mean SI, γ_{030}	1.09 [.95, 1.27]	1.85 [1.42, 2.41]***	1.86 [1.36, 2.54]***	1.74 [1.09, 2.78]*	.80 [.40, 1.59]
Daily LNPS, π_{1jk}					
Daily LNPS, γ_{100}	.65 [.59, .72]***	.25 [.21, .31]***	.31 [.26, .38]***	.58 [.46, .72]***	.49 [.38, .61]***
Daily LNPS × gender, γ_{101}	1.12 [.98, 1.28]	1.57 [1.18, 2.07]**	1.12 [.84, 1.50]	1.34 [.99, 1.80]	.49 [.34, .71]***
Daily LNPS × age 21, γ_{110}	1.35 [1.18, 1.55]***	2.26 [1.62, 3.15]***	1.84 [1.32, 2.56]***	1.05 [.76, 1.45]	2.87 [1.87, 4.39]***
Daily SI, π_{2jk}					
Daily SI, γ_{200}	.18 [.17, .20]***	.05 [.05, .06]***	.04 [.03, .05]***	.05 [.04, .06]***	.38 [.33, .45]***
Daily SI × gender, γ_{201}	1.74 [1.57, 1.92]***	1.83 [1.52, 2.20]***	1.82 [1.47, 2.25]***	1.93 [1.51, 2.47]***	1.52 [1.26, 1.84]***
Daily SI × age 21, γ_{210}	.82 [.72, .93]**	.70 [.55, .88]**	.52 [.39, .69]***	.86 [.64, 1.16]	.99 [.79, 1.26]
Friday, π_{3jk}					
Friday, γ_{300}	1.74 [1.67, 1.82]***	3.22 [2.94, 3.53]***	3.44 [3.12, 3.80]***	3.91 [3.53, 4.35]***	1.51 [1.38, 1.65]***
Saturday, π_{4jk}					
Saturday, γ_{400}	1.75 [1.67, 1.84]***	2.95 [2.69, 3.25]***	2.94 [2.66, 3.25]***	4.53 [4.07, 5.05]***	1.82 [1.66, 2.00]***
	Estimate [CI]	Estimate [CI]	Estimate [CI]	Estimate [CI]	Estimate [CI]
Random effects					
Level 3 intercept, μ_{01k}	1.28 [1.11, 1.48]***	2.19 [1.90, 2.56]***	3.01 [2.60, 3.52]***	4.08 [3.48, 4.84]***	6.11 [5.18, 7.32]***
Level 2 intercept, r_{0jk}	.42 [.38, .47]***	1.58 [1.44, 1.74]***	2.17 [1.99, 2.38]***	3.69 [3.38, 4.04]***	5.83 [5.29, 6.45]***
Level 1 dispersion	2.04 [1.99, 2.08]***	.56 [.55, .58]***	.43 [.42, .44]***	.20 [.20, .21]***	.088 [.086, .090]***
Variance explained					
Fixed effects (%)	19.73	27.03	21.84	8.68	2.39
Fixed and random effects (%)	64.69	62.82	64.27	58.92	61.92

N = 19,433–19,506 days nested within 730 persons

IRR incidence rate ratio, *OR* odds ratio, *CI* 95% confidence interval, *LNPS* LateNight Penn State attendance, *SI* staying in

*$p < .05$; **$p < .01$; ***$p < .001$

they engaged in less alcohol and other substance use compared to nights they went out. The results build on previous LNPS research in this sample (Patrick et al. 2010) in three key ways. First, associations between daily LNPS attendance and alcohol and illegal substance use were observed across seven semesters of college, as opposed to only the first semester. Second, negative associations between daily LNPS attendance

Table 3 Estimates of simple slopes for statistically significant interactions

	Model 1 Total drinks IRR [CI]	Model 2 Drinking days OR [CI]	Model 3 Binge drinking days OR [CI]	Model 4 High-intensity drinking days OR [CI]	Model 5 Illegal substance use days OR [CI]
Simple slopes					
Daily LNPS × gender, γ_{101}					
Daily LNPS, female	–	.29 [.24, .35]***	–	–	.59 [.47, .74]***
Daily LNPS, male	–	.46 [.37, .58]***	–	–	.29 [.22, .39]***
Daily LNPS × age 21, γ_{110}					
Daily LNPS, under 21	.69 [.63, .75]***	.31 [.26, .37]***	.33 [.28, .39]***	–	.35 [.29, .43]***
Daily LNPS, age 21+	.93 [.83, 1.05]	.70 [.52, .95]*	.60 [.45, .81]***	–	1.00 [.69, 1.46]
Daily SI × gender, γ_{201}					
Daily SI, female	.17 [.16, .19]***	.05 [.04, .06]***	.04 [.03, .04]***	.05 [.04, .06]***	.38 [.33, .44]***
Daily SI, male	.30 [.28, .32]***	.09 [.08, .10]***	.06 [.06, .08]***	.10 [.09, .12]***	.58 [.51, .66]***
Daily SI × age 21, γ_{210}					
Daily SI, under 21	.23 [.22, .25]***	.07 [.06, .08]***	.05 [.05, .06]***	–	–
Daily SI, age 21+	.19 [.17, .21]***	.05 [.04, .06]***	.03 [.02, .04]***	–	–

N = 19,433–19,506 days nested within 730 persons

IRR incidence rate ratio, *OR* odds ratio, *CI* 95% confidence interval, *LNPS* LateNight Penn State attendance, *SI* staying in

*$p < .05$; **$p < .01$; ***$p < .001$

and two new outcomes, high-intensity drinking and illegal substance use, were observed in addition to alcohol use outcomes assessed previously. Third, associations between daily LNPS attendance and alcohol and illegal substance use were shown to be strongest for those under the legal drinking age. The within-person design of this study extends support for the behavioral economic approach by providing support for program impact by comparing an individual's free time choice with her own choices on other days. Overall, these findings support the value of alcohol-free programming as a campus-wide initiative targeted at all undergraduate students, regardless of age.

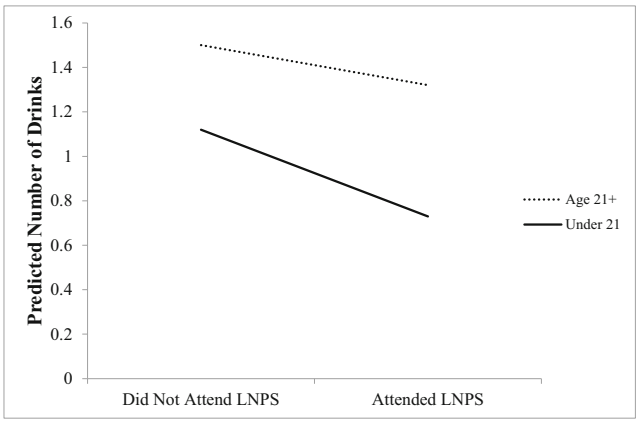

Fig. 1 Predicted number of drinks consumed on days students did and did not attend LateNight Penn State for students under 21 years of age and those aged 21 or older

By documenting that the odds of using illegal substances were also lower on LNPS nights, this study suggests a wider health-enhancing reach of alcohol-free campus programs. The impact of LNPS, a structured, university-sponsored program, on alcohol and substance use is consistent with predictions of routine activity theory (Osgood and Anderson 2004), which argues deviant behavior is more likely in unstructured, unsupervised contexts, and the psychosocial development perspective (Gardner and Steinberg 2005), which predicts more risk taking when individuals participate in unsupervised activities with peers. Based on these theories and the empirical findings of this study, attending substance-free programs such as LNPS is related to multiple risk behaviors simultaneously.

Tests of whether legal drinking status moderated apparent LNPS effects showed that although all substance use behaviors were lower or less likely on days attending LNPS, differences were larger when students were under the legal drinking age of 21 years. In addition, on days they attended LNPS, the odds of any drinking and any illegal substance use were lower for all participants with greater odds reduction of any drinking for females and substance use for males. Nonetheless, differences in high-intensity drinking on LNPS versus going out days did not differ by legal drinking status or gender. In summary, these findings suggest that a weekend, late-night set of varied and attractive social activities in substance-free venues may be an effective strategy to reduce alcohol and other substance use for all undergraduate students, especially for those under 21 years old.

The moderating effect of age 21 could be explained by the general increase in substance use across college and by the increased competition between options for free time use (e.g.,

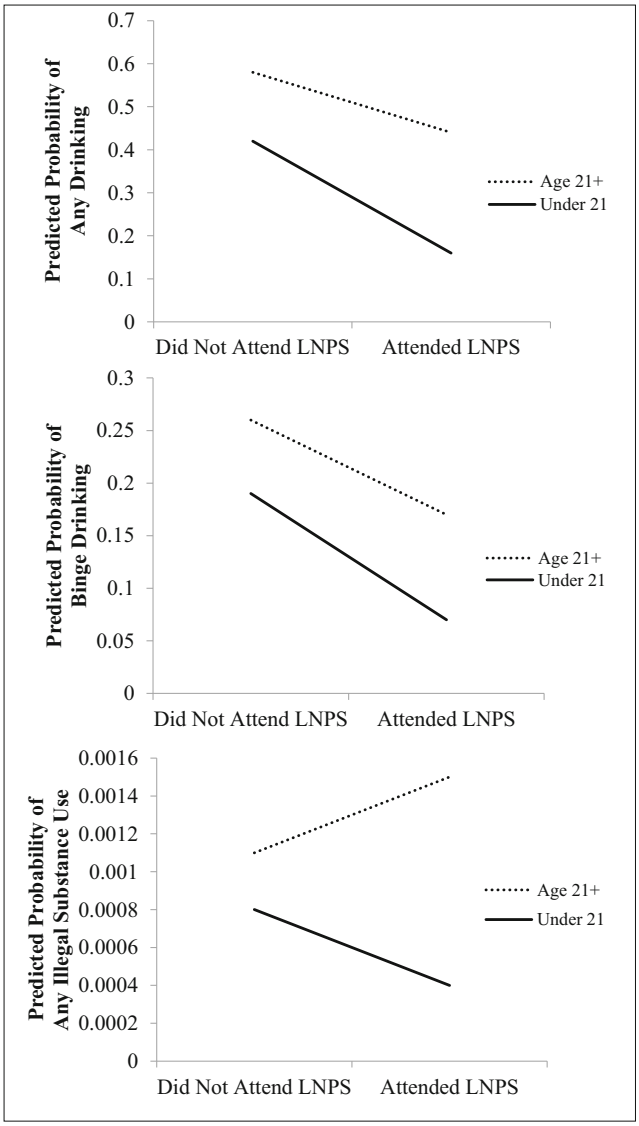

Fig. 2 Predicted probability any drinking (top), binge drinking (middle), and illegal substance use (bottom) on days students did and did not attend LateNight Penn State for students under 21 years of age and those aged 21 or older

LNPS versus legal access to alcohol). Increases in drinking across all seven semesters could be due to greater legal access to alcohol, for consumption either at bars or at home, as more friends and the individual turn 21. After age 21, individuals have more options for free time use on weekend nights, including bars, leading to increased competition for LNPS. In addition, students over age 21 could attend LNPS and still go out before or after. Results here support the age of majority as a transition point for alcohol use and differential effects of prevention programs.

At the semester level, odds of any drinking, binge drinking, and high-intensity drinking were higher with increased numbers of days spent staying in, particularly for students over age 21. An individual who spends a higher than average number of weekend days at home in a given semester may be exposed to more opportunities to drink in unstructured, at-home free time, and barriers to obtaining alcohol for at-home drinking may be reduced after age 21. The direction of results across person, semester, and day levels differs; however, we might not expect them to be in the same direction, because associations at each level are potentially driven by distinct causal processes unfolding at separate timescales. Future research into this question of timescale and differential effects is warranted. In addition, universities may need to consider multiple innovative strategies for attracting program participants and impacting substance use when considering drinking patterns of students over 21 and unique subsets of students such as those who stay in more.

Strengths, Limitations, and Future Directions

These novel findings are the first to demonstrate the impact of this prevention strategy using a longitudinal design that controls for between-person differences. Data across college showed daily within-person effects of attending LNPS, indicating potential for positive prevention impact beyond the first (Patrick et al. 2010) or a single (Wei et al. 2010) semester. By using a longitudinal, measurement-burst design to examine inter-individual differences in intra-individual change (i.e., within-person approach), this study was able to measure daily processes of substance-related risk behaviors and activity participation. This approach controls for all stable individual differences by comparing each individual to himself or herself across days and thus provides a more rigorous test than other observational designs that can primarily only make between-person comparisons. However, caution should be used in interpreting these results as they cannot be used to demonstrate causality. For example, although it is clear that students engage in less risky behavior on days they attend LNPS, it is possible that they choose to attend LNPS on nights they desire to be safer or healthier rather than the reverse. A more conclusive test of the impact of alcohol-free programming on substance use should use rigorous and innovative experimental designs—such as large-scale, matched between-campus comparisons; rigorous variation of substance-free programming across various nights or weekends; or careful control of program components through fractional or full factorial designs—to model intervention effects and test program components. Theoretical underpinnings guiding LNPS (e.g., behavioral economic theory and routine activity theory) and, more broadly, alcohol-free programming as a prevention strategy rely on providing attractive alternatives to alcohol-related activities that students may or may not choose. With individual choice at the core of this strategy, random assignment of control and treatment groups or even factorial designs become very difficult to implement. Therefore, an intensive repeated-measures design such as the one used here, which had up to 42 weekend nights to compare per participant, provides an alternative, methodologically rigorous way to reduce the impact of

between-person selection factors and explain within-person variation across occasions and across college.

Future research should further address selection factors impacting participation in alcohol-free activities by examining stable, developmentally changing, and situational influences, including interpersonal factors (e.g., relationship status, peer attendance), academic burden (e.g., major, homework load), geospatial constraints (e.g., residence location, access to transportation alternatives), satisfaction with activity choices including LNPS attendance, or intent to use substances. Studies with ambulatory assessments that examine individual intentions at the start of the day paired with behavioral reports and activity satisfaction the next day would allow researchers to investigate motivation-based selection factors. In particular, identifying factors leading to participation on high-risk occasions (e.g., football weekends, holidays) or by high-risk substance users would be especially important. Alternative quasi-experimental designs could include natural experiments such as changes in policies and programs within campuses combined with carefully matched controls.

LNPS represents a single program at a large, state-affiliated university in a college town surrounded by rural areas, limiting generalizability. Leisure opportunities are primarily those available on campus, in student apartments, and a small downtown with numerous bars. While this context is shared, to varying degrees, by many land-grant and liberal arts post-secondary institutions in the USA, it is not universal nor even typical. Across post-secondary institutions worldwide, the available leisure opportunities for students in diverse institutions and contexts (e.g., urban, rural, private, commuter, online, community college, part-time, non-residential) vary dramatically. Student activity budgets controlled by campuses (and students) also vary considerably, creating unique challenges in each environment regarding the cost-effective provision of exciting late-night options. It is notable, however, that free leisure options are likely to have appeal in all contexts, perhaps particularly in larger cities with high costs of living.

On-campus living and proximity to alcohol-free programming may also be influenced by student housing policies controlled by the university. For example, on-campus residence is only mandated for first-year students at the university in this study. In addition to institutional and contextual variation, the transition to adulthood is marked by diversity in pathways (Water et al. 2011), with many individuals never or not presently enrolled in higher education. Non-college-attending young adults experience many of the same freedoms and rapid changes as do college students—though clearly not all—and rates of heavy alcohol use and substance use are often similarly high (Johnston et al. 2016). The relative balance of competing alcohol and alcohol-free social options can also be shifted through environmental strategies such as reducing alcohol outlet density and opening hours, restricting bar promotions, and enacting or enforcing social host laws (Nelson et al. 2005).

Conclusion

Campus-led programming can create an alternative context free of alcohol and substances where students have choices to engage in social leisure and free time activities. Evidence from this study suggests that attending campus-led programs is linked with reductions in excessive drinking and substance use among college students, especially those under the legal drinking age, on days they attend. Future studies should further evaluate the effectiveness, challenges, and limits of alcohol-free programming as a prevention strategy.

Funding Information This research was supported by the National Institute on Alcohol Abuse and Alcoholism Grant R01 AA016016. The first author was supported by the National Institute on Drug Abuse of the National Institutes of Health under award number T32 DA017629. The third author is supported by grant numbers P50 DA010075 and P50 DA039838 from the National Institute on Drug Abuse. The views expressed in this article are ours and do not necessarily represent the official views of granting agencies.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Research Involving Human Participants and/or Animals The research was conducted in full compliance with the APA standards for ethical practice in research, under the review of the Pennsylvania State University Institutional Review Board. These findings have not been published in any form nor submitted for consideration elsewhere.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. This article does not contain any studies with animals performed by any of the authors.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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