Drug and Alcohol Dependence 204 (2019) 107580

Contents lists available at ScienceDirect

Drug and Alcohol Dependence

journal homepage: www.elsevier.com/locate/drugalcdep

College attendance type and subsequent alcohol and marijuana use in the U.S

Joy Bohyun Jang[a,*], Megan S. Schuler[b], Rebecca J. Evans-Polce[c], Megan E. Patrick[d]

[a] Institute for Social Research, University of Michigan, 426 Thompson St., Ann Arbor, MI 48104, USA
[b] RAND Corporation, 20 Park Plaza, Boston, MA 02116, USA
[c] Center for the Study of Drugs, Alcohol, Smoking and Health, School of Nursing, University of Michigan, 400 N. Ingalls St., Ann Arbor, MI 48109, USA
[d] Institute for Translational Research in Children's Mental Health and Institute of Child Development, University of Minnesota, 1100 Washington Avenue S., Minneapolis, MN 55415, USA

ARTICLE INFO

Keywords:
College attendance
Alcohol use
Marijuana use
Alcohol use disorder
Marijuana use disorder

ABSTRACT

Background: College attendance is a risk factor for frequent and heavy drinking and marijuana initiation but less is known about the extent to which risk varies by type of college attendance and across age.
Methods: Using panel data of young adults who were high school seniors in 1990–1998 from the Monitoring the Future study (n = 13,123), we examined the associations between college attendance at age 19/20 (4-year college full-time, other college, and non-attendance) and subsequent alcohol and marijuana use at age 21/22, 25/26, 29/30 and 35. Inverse propensity score weighting was used to balance the three college groups on pre-existing differences when examining associations with substance use outcomes.
Results: Compared to non-attendance, attending a 4-year college full-time was associated with significantly greater odds of binge drinking at age 21/22 (aOR = 1.20) and 25/26 (aOR = 1.12) and lower odds of alcohol abstinence at age 35 (aOR = 0.51). Similarly, other college attendance was associated with greater odds of binge drinking at age 21/22 (aOR = 1.08) and 25/26 (aOR = 1.04) and lower odds of abstinence at age 35 (aOR = 0.70). Four-year college full-time attendance was associated with greater odds of marijuana use at age 21/22 (aOR = 1.07) and 25/26 (aOR = 1.02) but lower odds at age 29/30 (aOR = 0.99). Other college attendance was associated with lower odds of marijuana use at age 25/26 (aOR = 0.98) and 29/30 (aOR = 0.97). Marijuana use at age 35 did not differ by college attendance.
Conclusions: College attendance may confer elevated risk of substance use post-college. The magnitude and duration of risk vary by type of college attendance and substance.

1. Introduction

Broadly, there is an inverse relationship between years of education and the likelihood of being a heavy drinker and illicit drug user (e.g., Cutler and Lleras-Muney, 2010; Hasin et al., 2015; Lanza and Collins, 2006), suggesting a protective effect of college attendance on later substance use behaviors. Yet, young adults attending college are at particular risk for initiation and escalation of substance use during college, as college students report greater frequency and quantity of drinking (Blanco et al., 2008; Patrick et al., 2016c; Schulenberg et al., 2017; Slutske, 2005) and are at higher risk of marijuana initiation than non-college attending peers (Miech et al., 2017b). Some studies have shown that substance use during college is associated with later problematic use and thus college attendance may confer an enduring risk on substance use (Jennison, 2004; O'Neill et al., 2001). Given the increasing diversity of college attendance patterns (e.g., part-time attendance, 2-year college) in the U.S. (Snyder et al., 2019), it is critical to understand to what extent college attendance has long-term effects on substance use as well as how this risk may vary by college attendance type.

Prior studies examining the effects of college attendance on substance use have largely focused on differences between any college attendance and no college attendance (Blanco et al., 2008; Evans-Polce et al., 2017; Hingson et al., 2005; White et al., 2005). There is, however, notable heterogeneity across different college types with respect to both college environment and student population (Carter et al., 2010; Patrick et al., 2016b). Proportions of students living on campus and affiliated with a fraternity/sorority are higher at 4-year colleges than other colleges; both of these factors have been linked with heavy drinking and alcohol use disorder (Dawson et al., 2004; Evans-Polce

* Corresponding author.
E-mail address: joyjang@umich.edu (J.B. Jang).

https://doi.org/10.1016/j.drugalcdep.2019.107580
Received 20 November 2018; Received in revised form 8 August 2019; Accepted 13 August 2019
Available online 22 September 2019
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et al., 2017; McCabe et al., 2005, 2018). Student populations may also differ by college types; 4-year college students are more likely to be enrolled full-time and less likely to be employed or drop out compared to 2-year college students (Snyder et al., 2019). Only a few studies to date, however, have compared 2-year college attendance to 4-year college attendance with respect to substance use. These studies have found that the prevalence of heavy drinking is higher among those at 4-year colleges than those at 2-year colleges (Sheffield et al., 2005; Velazquez et al., 2011), and that 4-year college students show greater odds of high intensity drinking (5+, 10+ and 15+ drinks in a row) compared to both non-attendees and 2-year college students (Patrick and Terry-McElrath, 2017). Furthermore, 4-year college attendance, but not 2-year college attendance, has been found to be associated with increased marijuana use (Fleming et al., 2012).

Additionally, several studies have examined substance use trajectories across adolescence and young adulthood, finding that college attendance is associated with a time-limited increase in substance use that is most acute during the college years (Lanza and Collins, 2006; Muthén and Muthén, 2000; Patrick et al., 2016c). Yet, the effect of college attendance on substance use 10–15 years post-college has not been well-characterized, nor whether the effects are similar for 4-year college full-time attendees compared to other types of college attendees. It is plausible that college attendance may have an enduring association with substance use both because educational level has been shown to impact health behaviors across the lifespan (Belfield and Bailey, 2011; Muthén and Muthén, 2000) and substance use problems are often persistent and recurring (Jennison, 2004; O'Neill et al., 2001). Of central methodological importance is isolating college attendance effects from potential selection effects due to baseline differences between college attendees and non-attendees. Confounding may arise when factors related to young adult substance use are also related to college attendance. For example, adolescent substance use and lower family socioeconomic status have both been associated with lower rates of college attendance (King et al., 2006; Patrick et al., 2016b). Many prior studies have been limited by a lack of rigorous adjustment for pre-existing differences between individuals who attend college and those who do not, which may result in biased estimates of college attendance effects.

To address these gaps in the literature, the current study used data from the Monitoring the Future (MTF) study to examine the associations between college attendance and subsequent alcohol and marijuana use behaviors at multiple ages during young adulthood and adulthood, while rigorously controlling for baseline differences by college type. We extended previous research by classifying college attendance as 4-year college full-time attendance, other college attendance (i.e., 4-year college part-time, 2-year college part-time or full-time, and technical/vocational school part-time or full-time), and non-attendance. To address pre-existing differences across groups, we used propensity score methods to adjust for potential confounders measured at age 18 (prior to college attendance). Specific research aims were to examine the effects of different types of college attendance on binge drinking and marijuana use during young adulthood (i.e., at age 21/22, 25/26, and 29/30), and on symptoms of alcohol use disorder and marijuana use disorder at age 35.

2. Methods

2.1. Data

Data were from the Monitoring the Future (MTF) study, an ongoing, nationally representative school-based survey of 12th graders in the U.S. (Miech et al., 2017a). Each year, a subsample of respondents (n = 2450), over-sampled for substance users at age 18, were selected for participation in the longitudinal follow-up surveys (Schulenberg et al., 2017). Participants were randomly assigned to complete the first follow-up survey one year later (i.e., modal age 19) or two years later (i.e., modal age 20). The longitudinal surveys were administered by mail every two years until age 29/30 and then every five years thereafter beginning at age 35; participants were compensated for each follow-up survey completed. The MTF study was reviewed and approved on an annual basis by the University of Michigan's Institutional Review Board (IRB). More details are available elsewhere (Miech et al., 2017a; Schulenberg et al., 2017).

To minimize the effect of cohort, we restricted our sample to cohorts who were 12th graders in 1990–1998 and eligible to complete their age 35 follow-up surveys in 2007–2015 (n = 22,158). Individuals were excluded if they did not participate in the age 19/20 survey (n = 7068, 31.9% non-response rate at age 19/20) or if they did not participate in any follow-up surveys (n = 6837, 30.9% non-response rate). Our final sample was comprised of 13,123 individuals who participated in the age 19/20 survey and at least one follow-up wave (i.e., age 21/22, 25/26, 29/30, or 35). Weighting was used to account for MTF longitudinal cohort sampling as well as wave-specific attrition.

2.2. Measures

2.2.1. College attendance at age 19/20

Two survey questions were used to code *college attendance* at age 19/20. The first question asked participants, "During March of this year, were you taking courses at any school or college?" Response choices included no; part-time; full-time. The second question assessed the following educational activities: 1) attend technical or vocational school, 2) attend a 2-year college, 3) graduate from a 2-year college program, 4) attend a 4-year college, 5) graduate from a 4-year college program, and 6) attend graduate or professional school after college; for each option, respondents selected whether they were "doing [it] now", "have done [it]" or "plan to [do it]." College attendance at age 19/20 was coded into 3 categories: 1) non-attendance (not taking any courses at school) (2) 4-year college full-time attendance (attending/graduating 4-year college, taking courses full-time), and 3) other college attendance (attending/graduating 4-year college, taking courses part-time; attending/have attended 2-year college, taking courses part-time or full-time; graduating/have graduated 2-year college, taking courses part-time or full-time; attending/have attended vocational or technical school, taking courses part-time or full-time). Individuals who had already graduated from a 4-year college at age 19/20 (2.22%), were attending graduate or professional school at age 19/20 (0.06%), or were missing responses on both college questions (4.85%) were excluded from analyses.

2.2.2. Binge drinking at age 21/22, 25/26, and 29/30

Participants were asked at each follow-up, "During the last two weeks, how many times have you had five or more drinks in a row?" (none to 10+ times). A binary variable was created for binge drinking (1 = had 5+ drinks in a row in the last two weeks, 0 = none).

2.2.3. Marijuana use at age 21/22, 25/26, and 29/30

Participants were asked about their frequency of marijuana use during the last 30 days at each follow-up (none to 40+ times). A dichotomized variable was created for marijuana use (1 = any use in the past 30 days, 0 = no use).

2.2.4. Alcohol use disorder and marijuana use disorder reported at age 35

Eight items asked at age 35 were used to measure alcohol use disorder (AUD) and marijuana use disorder (MUD). These items included problems caused by the use of alcohol and marijuana, respectively, over the last five years, including: failure to fulfill role obligations; continuous use despite hazards to physical health; continuous use despite recurrent or persistent social problems; needing more of the drug to get the same effect; withdrawal; desire to cut down or quit but could not; health issues; and inability to resist use (all responses *no* or *any*). These measures are not a clinical diagnosis but are comparable with

Diagnostic and Statistical Manual of Mental Disorders, 4th Edition (American Psychiatric Association, 2000) criteria and are consistent with AUD and MUD items used in other surveys (e.g., Harford and Muthén, 2001; Muthén, 1996; Muthén et al., 1993; Nelson et al., 1998). Responses for both alcohol use and marijuana use were trichotomized into (1) *abstinence* (no use in the past five years), (2) *non-disordered use* (use in the past five years, reported 0–1 problem), and (3) *AUD/MUD* (use in the past five years, reported 2+ problems) (Jang et al., 2018; Patrick et al., 2011, 2016a; Schulenberg et al., 2015).

2.2.5. Confounders in the propensity score model

All potential confounders for college attendance type were measured in 12th grade, prior to college attendance. Demographic variables included *sex* (male, female) and *race/ethnicity* (White, Black, Hispanic, and Other). High school characteristics included respondents' *high school GPA* (1 = D [69 or below] to 9 = A [93–100]), *truancy* (1 = none to 7 = 11+ during the last four weeks), *evenings out* (1 = less than one to 6 = 6–7 during a typical week), *high school program* (1 = academic or college preparation, 0 = other programs), *college intention* (1 = definitely will go to college, 0 = other), and *religiosity* (1 = not important to 4 = very important). *Cohort* indicated 12th grade class year (1990–1998). Family characteristics included *parents' educational attainment* (1 = at least one parent had a college degree, 0 = no parent with a college degree) and *living with two parents at age 18* (1 = yes, 0 = other). Age 18 substance use behaviors included *cigarette use in the past 30 days* (1 = none to 7 = two packs or more per day), *binge drinking in the past two weeks* (1 = none to 6 = 10+ times), *marijuana use in the past 30 days* (1 = none to 7 = 40+ times), and a binary indicator of *any other illicit drug use in the past 12 months* (i.e., LSD, other hallucinogens, cocaine, heroin, other narcotics, amphetamines, barbiturates, and tranquilizers) (1 = yes, 0 = no).

2.3. Analytic plans

2.3.1. Propensity score weighting

Propensity score weighting was used to adjust for potential confounders that differed across types of college attendance. Propensity scores were estimated using generalized boosted models (GBM), a machine learning algorithm which has been shown to outperform logistic regression for estimation of propensity scores in the context of a large number of pre-exposure covariates (Lee et al., 2010; McCaffrey et al., 2004, 2013). GBM estimation was performed using the Toolkit for Weighting and Analysis of Nonequivalent Groups (*twang*) package, as implemented through the SAS macro (Cefalu et al., 2015; Ridgeway et al., 2015). Since the exposure had 3 categories (i.e., 4-year college full-time attendance, other college attendance, and non-attendance), *twang* was used to estimate multinomial propensity scores (Burgette et al., 2017). Estimated propensity scores were used to generate inverse probability of treatment weights (IPTW) (Lunceford and Davidian, 2004; Robins et al., 2000). For all covariates, missingness was low (ranged from 0.04% to 3.07%). To address missing data, missingness indicators for all covariates were included in the propensity score regression model, thereby balancing exposure groups both on observed covariate values and degree of missingness (Cefalu et al., 2015). The number of iterations of the GBM algorithm was selected to optimize covariate balance across exposure groups (McCaffrey et al., 2013). The absolute standardized mean difference (ASMD) value was used to assess whether IPTW provided sufficient balance across groups (Austin, 2011; Stuart, 2010). Smaller ASMD values indicate that the exposure and control groups are more similar with regard to a specific covariate. In general, ASMD values less than 0.20 indicate a good balance between exposure and control groups (Cohen, 1992).

2.3.2. Outcome models

We first implemented multilevel logistic regression models to estimate the effects of college attendance at age 19/20 on alcohol and marijuana use behaviors at age 21/22, 25/26, and 29/30. Multilevel models were used to account for repeated observations for individuals across survey waves. To estimate wave-specific effects of college attendance on alcohol and marijuana use, we calculated predicted probabilities at each wave and converted these into odds ratios. Analyses were weighted using a composite weight that was the product of IPTW, MTF sampling weights and wave-specific attrition weights (DuGoff et al., 2014). Second, we implemented multinomial regression models to estimate the effects of college attendance at age 19/20 on alcohol and marijuana use disorders at age 35. Similarly, regression models were weighted using a composite weight that was the product of IPTW, MTF sampling weights and age 35 attrition weights (DuGoff et al., 2014). Wald tests were used to test for differences in the magnitude of effects across college attendance type. All models included age 18 covariates that remained imbalanced after IPTW (i.e., college preparation program and college intention at age 18). This is a form of "double-robust" estimation (Bang and Robins, 2005; Robins, 2000); estimates will be unbiased if either the propensity score regression or outcome regression is correctly specified.

3. Results

3.1. Sample characteristics

Sample characteristics by college attendance type before and after IPTW are presented in Table 1. Before weighting, significant differences were observed across groups on most baseline characteristics as ASMD values were greater than 0.2. Specifically, non-attendees reported greater frequency of cigarette smoking, binge drinking, and marijuana use at age 18 as well as greater likelihood of other illicit drug use, compared to 4-year college full-time attendees or other college attendees. Compared to non-attendees, both 4-year college full-time attendees and other college attendees had higher GPAs, lower truancy and were more likely to be enrolled in college preparation courses/program and to report college attendance intention. A greater proportion of both 4-year college full-time attendees and other college attendees had parents with a college degree and a two-parent home compared to non-attendees. After IPTW, the groups were similar with regard to age 18 characteristics with the exception that 4-year college full-time attendees still exceeded non-attendees in terms of college preparation and college intention. In order to adjust for remaining imbalances, these covariates were additionally included in outcome models, as described in the analysis section.

Description of key college contextual variables at age 19/20 is included in Supplemental Table 1, by college attendance. Relative to non-attendees and other college attendees, 4-year college full-time attendees were significantly less likely to be married (1.2% of 4-year college full-time attendees vs. 5.1% of other college attendees vs. 11.7% of non-attendees), to be a parent (1.2% vs. 7.5% vs. 16.4%), to be employed full-time (8.9% vs. 38.1% vs. 67.7%), to live with parents (23.0% vs. 69.4% vs. 59.2%), and to live on a military base (0.3% vs. 1.4% vs. 4.2%) at age 19/20. A significantly greater proportion of 4-year college full-time attendees were involved in a fraternity/sorority system (16.7%) than other college attendees (2.2%). These variables measured at age 19/20 were not included in our propensity score weights or outcome models because of the concern for post-exposure adjustment (McCaffrey et al., 2013).

3.2. Effects of college attendance at age 19/20 on later binge drinking and marijuana use

After adjusting for pre-existing differences across three college attendance groups, 4-year college full-time attendance at age 19/20 was associated with significantly higher odds of binge drinking at age 21/22 (Adjusted Odds Ratio (aOR) [95% CI] = 1.20 [1.12,1.29]) and 25/26 (aOR = 1.12 [1.07,1.18]) and marginally higher odds at age 29/30

Table 1
Sample Characteristics by College Attendance at Age 19/20 Before and After Inverse Probability of Treatment Weights.

	Unweighted				Inverse Probability of Treatment Weighted			
Total n = 12,188	Non-attendance n = 2693	4-year college full-time n = 5382	Other college n = 4113	Max ASMD*	Non- attendance –	4-year college full-time –	Other college –	Max ASMD
Age 18 drug use								
Cigarette use (mean, range: 1-7)	2.22	1.44	1.83	**0.61**	1.80	1.63	1.74	0.13
Binge drinking (mean, range: 1-6)	1.91	1.55	1.75	**0.30**	1.67	1.64	1.68	0.03
Marijuana use (mean, range: 1-7)	1.96	1.41	1.67	**0.38**	1.65	1.54	1.60	0.07
Illicit drug use (%)	34%	18%	29%	**0.37**	28%	23%	25%	0.12
Male (%)	46%	40%	42%	0.10	42%	42%	41%	0.02
Race/ethnicity (%)								
Black	8%	7%	8%	0.03	9%	8%	8%	0.02
Hispanic	8%	5%	10%	0.20	8%	7%	8%	0.02
Others	7%	8%	9%	0.06	7%	8%	8%	0.03
GPAs (mean, range: 1–9)	5.27	7.19	5.83	**1.01**	6.09	6.47	6.30	0.20
Truancy (mean, range: 1–7)	1.92	1.47	1.77	**0.36**	1.74	1.64	1.66	0.08
Evenings out (mean, range: 1–6)	3.68	3.43	3.53	0.18	3.54	3.53	3.51	0.02
College preparation (%)	27%	85%	48%	**1.26**	55%	65%	59%	**0.22**
College intention (%)	27%	84%	59%	**1.30**	59%	68%	63%	**0.21**
Religiosity (mean, range: 1–4)	2.55	2.75	2.68	0.19	2.70	2.70	2.70	0.002
Parent college education (%)	48%	82%	65%	**0.78**	65%	72%	68%	0.16
Two-parent family (%)	68%	81%	73%	**0.31**	74%	77%	75%	0.08
Cohort (%)								
1990	13%	11%	12%	0.08	11%	11%	11%	0.01
1991	13%	11%	14%	0.10	13%	11%	12%	0.06
1992	13%	12%	13%	0.03	12%	12%	12%	0.01
1993	12%	11%	11%	0.03	11%	11%	11%	0.02
1994	11%	11%	12%	0.01	11%	12%	12%	0.01
1995	11%	12%	11%	0.03	12%	11%	11%	0.03
1996	9%	12%	10%	0.09	11%	12%	10%	0.03
1997	9%	11%	9%	0.05	10%	10%	10%	0.02
1998	9%	10%	10%	0.05	9%	10%	10%	0.03

Note: * ASMD = absolute standardized mean difference. In general, ASMD values less than 0.2 indicate a good balance between exposure and control groups (Cohen, 1992). Bold indicates ASMD > 0.2. Unweighted and IPTW weighted descriptive statistics do not include survey sampling weights.

Table 2
Effects of College Attendance at Age 19/20 on Later Binge Drinking and Marijuana Use at Ages 21/22, 25/26, and 29/30, After Inverse Probability of Treatment Weights.

	Binge Drinking (Past 2 weeks)		
	at age 21/22 aOR [95% CI]	at age 25/26 aOR [95% CI]	at age 29/30 aOR [95% CI]
Non-attendance (ref.)			
4-year college full-time	**1.20 [1.12, 1.29]** [a]	**1.12 [1.07, 1.18]** [a]	1.06 [1.00, 1.12]†
Other college	**1.08 [1.03, 1.12]**	**1.04 [1.01, 1.07]**	1.01 [0.97, 1.05]
	Marijuana Use (Past month)		
	at age 21/22 aOR [95% CI]	at age 25/26 aOR [95% CI]	at age 29/30 aOR [95% CI]
Non-attendance (ref.)			
4-year college full-time	**1.07 [1.06, 1.07]** [a]	**1.02 [1.01, 1.03]** [a]	**0.99 [0.98, 1.00]** [a]
Other college	1.00 [0.99, 1.01]	**0.98 [0.98, 0.99]**	**0.97 [0.96, 0.98]**

Note: Adjusted odds ratios (aOR) and 95% confidence intervals are reported. Bold indicates significant odds at $p < 0.05$ and † for marginal significance at $p < 0.10$. [a] Indicates significant differences in the effects between 4-year college full-time attendees and other college attendees. For each outcome, estimates were generated from a multilevel logistic regression model; observations were weighted using a composite weight (product of IPTW, survey sampling weight and wave-specific attrition weights). Covariates with ASMD (absolute standardized mean difference) greater than 0.2 were included in the models.

(aOR = 1.06 [1.00,1.12]), relative to non-attendance (top panel of Table 2). Other college attendance was also associated with higher odds of binge drinking at age 21/22 (aOR = 1.08 [1.03,1.12]) and 25/26 (aOR = 1.04 [1.01,1.07]) compared to non-attendance. Notably, the magnitude of the effects of 4-year college full-time attendance on binge drinking was stronger at age 21/22 and 25/26 than those of other college attendance.

Regarding marijuana use, after adjusting for pre-existing differences, 4-year college full-time attendance was significantly associated with higher odds of marijuana use at age 21/22 (aOR = 1.07 [1.06,1.07]) and 25/26 (aOR = 1.02 [1.01,1.03]) and lower odds at age 29/30 (aOR = 0.99 [0.98,1.00]), compared to non-attendance (bottom panel of Table 2). Other college attendance was significantly associated with lower odds of marijuana use at age 25/26 (aOR = 0.98 [0.98,0.99]) and 29/30 (aOR = 0.97 [0.96,0.98]), relative to non-attendance. The magnitude of the effects of 4-year college full-time

Table 3
Effects of College Attendance at Age 19/20 on Alcohol Use Disorder and Marijuana Use Disorder at age 35, After Inverse Probability of Treatment Weights.

Alcohol use at age 35	Alcohol abstinence (ref: any alcohol use, no AUD)	Alcohol use disorder (AUD)
	aOR [95% CI]	aOR [95% CI]
Non-attendance (ref.)		
4-year college full-time	**0.51 [0.36, 0.73]** [a]	1.26 [0.99, 1.61]†
Other college	**0.70 [0.52, 0.96]**	1.10 [0.88, 1.38]
Marijuana use at age 35	**Marijuana abstinence (ref: any marijuana use, no MUD)**	**Marijuana use disorder (MUD)**
	aOR [95% CI]	aOR [95% CI]
Non-attendance (ref.)		
4-year college full-time	0.82 [0.60, 1.10]	0.73 [0.43, 1.24]
Other college	1.03 [0.79, 1.35]	1.03 [0.65, 1.64]

Note: Adjusted odds ratios (aOR) and 95% confidence intervals are reported. Bold indicates significant odds at $p < 0.05$ and † for marginal significance at $p < 0.10$. [a] Indicates significant differences in the effects between 4-year college full-time attendees and other college attendees. For each outcome, estimates were generated from a multinomial logistic regression model; observations were weighted using a composite weight (product of IPTW, survey sampling weight and age 35 attrition weight). Covariates with ASMD (absolute standardized mean difference) greater than 0.2 were included in the models.

attendance on marijuana use were consistently stronger at all ages than those of other college attendance.

3.3. Effects of college attendance at age 19/20 on alcohol/marijuana use disorder at age 35

Adjusting for pre-existing differences across three college attendance groups, both 4-year college full-time attendance and other college attendance were associated with lower odds of abstinence from alcohol at age 35 (aOR = 0.51 [0.36,0.73] and 0.70 [0.52,0.96], respectively) relative to non-disordered alcohol use (Table 3). Four-year college full-time attendance was marginally associated with greater odds of AUD (aOR = 1.26 [0.99,1.61]) compared to non-disordered use at age 35. The magnitude of the effects of 4-year college full-time attendance on alcohol abstinence at age 35 was significantly stronger than those of other college attendance.

No significant associations between college attendance type and age 35 marijuana use were found.

4. Discussion

This novel and methodologically rigorous study uses national survey data to examine the association between distinct types of college attendance and subsequent alcohol and marijuana use behaviors during young adulthood and adulthood. By using propensity score weighting to account for pre-existing differences across college attendance groups, we were able to adjust for potential selection effects that may confound the effects of college attendance on later substance use. We found that both 4-year college full-time attendees and other college attendees had increased risk of binge drinking up to age 25/26, relative to non-attendees; notably, odds of binge drinking were significantly higher for 4-year college full-time attendees than other college attendees. Additionally, both 4-year college full-time attendees and other college attendees had lower odds of alcohol abstinence at age 35 compared to non-attendees. Four-year college full-time attendance was associated with significantly elevated risk of marijuana use up to age 25/26; lower odds of marijuana use were found for 4-year college full-time attendees at age 29/30 and other college attendees at ages 25/26 and 29/30 compared to non-attendees.

Our study added to the existing literature by demonstrating that college attendance was associated with binge drinking in early adulthood as well as alcohol use status at age 35. Prior studies suggest that environmental factors at college (e.g., fraternity/sorority involvement, living away from parents) may contribute to the high risk of alcohol use during college (e.g., Evans-Polce et al., 2017; McCabe et al., 2018), yet our findings suggest that elevated risk may persist into young adulthood after departure from the college environment. Our findings also showed that the magnitude of the association between college attendance and alcohol use decreased with age. It is possible that this association may continue to attenuate after age 35, even becoming protective at older ages as previous studies with cross-sectional data have suggested (Cutler and Lleras-Muney, 2010). Furthermore, the effects of 4-year college full-time attendance on binge drinking were significantly larger than those for other college attendance across all ages; these differences may be due to both differential risk factors for binge drinking experienced in college environments as well as differential risk trajectories post-college. Specifically, 4-year college full-time attendees may differ from other college attendees in young adulthood with respect to employment status, income and occupation type, factors which are associated with alcohol consumption (Barnes and Zimmerman, 2013; Casswell et al., 2003; Martin et al., 1992). Rates of marriage, parenthood and social support in young adulthood may significantly differ by college attendance type and may contribute to the observed differences in the proportions of binge drinking.

We found significant associations between college attendance and marijuana use, yet the association was less persistent across age than that for alcohol, as 4-year college full-time attendance was associated with increased marijuana use only through age 25/26. Elevated marijuana use in young adulthood among 4-year college full-time attendees may reflect college-specific risk factors similar to those related to alcohol use, including fraternity/sorority involvement and living away from parents. However, after accounting for selection effects between college attendees and non-attendees, our findings suggest a protective effect of college attendance post-college, as 4-year college full-time attendees and other college attendees had significantly reduced odds of marijuana use relative to non-attendees at age 29/30 and at both 25/26 and 29/30, respectively. Prior studies that did not rigorously adjust for confounding demonstrated that individuals who did not attend college were more likely to use substances in young adulthood (White et al., 2005). Through the use of IPTW, our findings suggest that non-attendees with the same characteristics as college attendees may have lower marijuana use in early adulthood. In other words, the greater risk of marijuana use among non-attendees observed in previous studies may be due to social/contextual factors before college that differ by college

attendance type. Further, while college-specific factors may increase the risk of marijuana use during college years, college attendance may be protective with regard to marijuana use after college. For example, college attendees may experience differential employment and family formation trajectories relative to non-attendees (e.g., Yamaguchi and Kandel, 1985) which may contribute to the observed declines in marijuana use.

There are a few limitations in the current study. First, while we used IPTW to control for baseline differences between different types of college attendance on numerous covariates at age 19/20, group differences may persist with respect to unobserved confounders (e.g., social support, personality, mental health conditions). Second, we assessed college attendance only at age 19/20; given that individuals may drop out, transfer or enroll in college at later ages, this classification may not fully characterize lifetime college experiences. Third, while we used attrition weights to account for observable differences between responders and non-responders across survey waves, group differences may persist with respect to unobservable factors. Fourth, as AUD and MUD status was only assessed at age 35 in MTF, we cannot determine whether AUD and MUD status represented onset or continuation from young adulthood. Additionally, changes in state legalization of marijuana may have influenced marijuana use across study waves; confounding may be present if legalization differentially influenced use for college attendees compared to non-attendees. Finally, MTF is a school-based survey and thus our results may not generalize to individuals who dropped out of high school.

Despite the limitations, after adjusting for potential selection effects across 4-year college full-time attendees, other college attendees and non-attendees, our findings provide robust evidence of the effects of college attendance on binge drinking and marijuana use in early adulthood, post-college. Notably, the magnitude and timing of risk for binge drinking and marijuana use differed for 4-year college full-time attendees and other college attendees. Relative to their non-attendee peers, 4-year college full-time attendees may be at particular risk for binge drinking and marijuana use in early adulthood. Yet the elevated odds of binge drinking in early adulthood among other college attendees indicates that prevention and intervention efforts should be inclusive of all college students. Furthermore, as the risk appears to attenuate across age, additional research is needed to fully understand differential risk pathways of alcohol and marijuana use by college attendance over the life-course.

Role of funding source

The analyses and manuscript preparation were funded by grants R01 DA037902 from the National Institute on Drug Abuse and R01 AA023504 from the National Institute on Alcohol Abuse and Alcoholism to M. E. Patrick. Data collection and manuscript preparation were funded by grants R01 DA001411 and R01 DA016575 from the National Institute on Drug Abuse.

Contributors

Joy Bohyun Jang drafted the manuscript and conducted the statistical analysis.

Megan S. Schuler consulted with statistical analysis, drafted critical sections of the manuscript, and provided critical feedback on manuscript drafts.

Rebecca J. Evans-Polce drafted critical sections of the manuscript, and provided critical feedback on manuscript drafts.

Megan E. Patrick supervised data collection and statistical analysis, drafted critical sections of the manuscript, and provided critical feedback on manuscript drafts.

Declaration of Competing Interest

None.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.drugalcdep.2019.107580.

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