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The Academic Consequences of Marijuana Use during College

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Abstract

Although several studies have shown that marijuana use can adversely affect academic achievement among adolescents, less research has focused on its impact on post-secondary educational outcomes. This study utilized data from a large longitudinal cohort study of college students to test the direct and indirect effects of marijuana use on college GPA and time to graduation, with skipping class as a mediator of these outcomes. A structural equation model was evaluated taking into account a variety of baseline risk and protective factors (i.e., demographics, college engagement, psychological functioning, alcohol and other drug use) thought to contribute to college academic outcomes. The results showed a significant path from baseline marijuana use frequency to skipping more classes at baseline to lower first-semester GPA to longer time to graduation. Baseline measures of other drug use and alcohol quantity exhibited similar indirect effects on GPA and graduation time. Over time, the rate of change in marijuana use was negatively associated with rate of change in GPA, but did not account for any additional variance in graduation time. Percentage of classes skipped was negatively associated with GPA at baseline and over time. Thus, even accounting for demographics and other factors, marijuana use adversely affected college academic outcomes, both directly and indirectly through poorer class attendance. Results extend prior research by showing that marijuana use during college can be a barrier to academic achievement. Prevention and early intervention might be important components of a comprehensive strategy for promoting post-secondary academic achievement.

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Marijuana use is common among college students in the United States, with one in three using within the past year (Johnston, O'Malley, Bachman, Schulenberg, & Miech, 2014) and 19.8% reporting past-month use (Substance Abuse and Mental Health Services Administration, 2014). The proportion of adolescents and young adults who perceive risk associated with smoking marijuana has been decreasing quite dramatically during the past ten years (Johnston et al., 2014; Substance Abuse and Mental Health Services Administration, 2014). These trends parallel the timing of legislative actions to relax or eliminate legal penalties for either use or possession (Hopfer, 2014). For example, the expansion of medical marijuana in Colorado has been linked to declining risk perceptions and increasing prevalence of marijuana abuse and dependence (Schuermeyer et al., 2014).

Marijuana use can impact educational achievement. Cross-sectional and longitudinal research studies have demonstrated the negative influence of marijuana on high school grades (Ellickson, Tucker, Klein, & Saner, 2004; Homel, Thompson, & Leadbeater, 2014), high school degree completion (Bray, Zarkin, Ringwalt, & Qi, 2000; Horwood et al., 2010; van Ours & Williams, 2009), and the likelihood of entering college (Fergusson, Horwood, & Beautrais, 2003; Homel et al., 2014; Horwood et al., 2010). A few studies have focused on the association between marijuana use and post-secondary educational outcomes. A recent study by Homel et al. (2014) on trajectories of marijuana use from ages 15 to 25 found that, relative to non-users, occasional marijuana users were more likely to delay enrollment in or drop out of post-secondary education, and frequent users were significantly less likely to enroll. Hunt, Eisenberg, and Kilbourne (2010) analyzed national epidemiologic data and observed that individuals with marijuana use disorder were more likely to drop out of college (OR=1.26). Furthermore, heavy marijuana users who do enroll in college are more likely to experience gaps in enrollment (Arria et al., 2013b), even when controlling for a number of potentially confounding variables.

The mechanisms underlying the association between marijuana use and poor educational outcomes are most likely very complex and not completely understood. Marijuana use, particularly heavy use, has been shown to affect working memory, learning, and information processing; functions that are necessary for academic performance (Crean, Crane, & Mason, 2011; Jager, Block, Luijten, & Ramsey, 2010; Solowij et al., 2011). Additionally, long-term, heavy use of marijuana has been linked to long-term changes in the structure of the brain, including the hippocampus, prefrontal cortex, and amygdala (Battistella et al., 2014; Churchwell, Lopez-Larson, & Yurgelun-Todd, 2010; Hall, 2015; Volkow, Baler, Compton, & Weiss, 2014; Yücel et al., 2008). These changes are associated with impairments in information processing, IQ, memory, attention, and neurocognitive performance (Block et al., 2002; Bolla, Brown, Eldreth, Tate, & Cadet, 2002; Fontes et al., 2011; Medina et al., 2007; Meier et al., 2012; Solowij et al., 2002), and these effects can remain even after several weeks of abstinence (Bolla et al., 2002; Medina et al., 2007; Schweinsburg et al., 2008).

It is possible that these neurocognitive effects of marijuana could contribute to academic problems among marijuana-using students, especially if use begins during adolescence and is regular and heavy (Fontes et al., 2011; Volkow et al., 2014). Brook, Stimmel, Chenshu, and Brook (2008) found that early onset of marijuana use was associated with lower levels of academic functioning at age 27. A possible link between marijuana use and amotivation has been suggested (Bloomfield et al., 2013; van Hell et al., 2010), which could contribute to a lack of engagement in college and difficulties in sustaining a focus on academic pursuits. Skipping classes is a possible manifestation of the lack of commitment to one's academic life during college and could also be exacerbated by the acute neurocognitive effects of marijuana smoking or withdrawal symptoms associated with more regular use. Changes in such academic behaviors (i.e., missing classes, studying less) appear to play a role in explaining the relationship between excessive drinking and academic performance (Powell, Williams, & Wechsler, 2004; Williams, Powell, & Wechsler, 2003; Wolaver, 2002), and it is plausible that similar mechanisms might occur with marijuana use. Evidence from an earlier study of our longitudinal cohort of college students indicated that, as students' marijuana use problems intensified over time, they tended to experience associated declines in class attendance and, consequently, GPA (Arria et al., 2013c). Nevertheless, this phenomenon remains largely unexplored, as we could find no other studies examining the possible role of class attendance or other academic behaviors as mediators underlying the relationship between marijuana use and academic performance problems.

Research has consistently shown that marijuana use and heavy drinking tend to co-occur (Jones, Oeltmann, Wilson, Brener, & Hill, 2001; O'Grady, Arria, Fitzelle, & Wish, 2008; Wechsler, Dowdall, Davenport, & Castillo, 1995), and use of other drugs is common among marijuana users (Mohler-Kuo, Lee, & Wechsler, 2003). When examining the complex relationship between marijuana use and academic performance, it is therefore critical to account for the concurrent use of alcohol and other drugs.

Moreover, mental health problems often co-exist with marijuana and other substance use, especially anxiety and depression (Armstrong & Costello, 2002; Pottick, Bilder, Vander Stoep, Warner, & Alvarez, 2007; Sheidow, McCart, Zajac, & Davis, 2012). These mental health problems have been found to independently contribute to academic problems among college students (Arria et al., 2013a; Eisenberg, Golberstein, & Hunt, 2009; Hunt et al., 2010). Eisenberg et al. (2009) found that depression, and especially depression-anxiety comorbidity, was associated with decreased GPA among college students, and Arria et al. (2013a) found that depressive symptoms were associated with a gap in enrollment during the first two years of college.

Finally, the educational research literature has highlighted numerous non-substance-use-related factors that impede academic achievement. First-generation, minority, and male students tend to experience worse academic outcomes (Conger & Long, 2010; Pascarella, Pierson, Wolniak, & Terenzini, 2004; Steele-Johnson & Leas, 2013). Participation in living-learning programs is associated with positive academic experiences (Inkelas et al., 2006; Pike, 1999; Pike, Kuh, & McCormick, 2011), whereas the effect of extracurricular involvement is largely unstudied but might depend on the specific type of activity (Baker, 2008).

High priority is placed on academic achievement by parents, educational institutions, and policymakers, and understanding the factors that hinder academic performance is essential for promoting college student success. For this reason, research evidence clarifying the nature of the relationship between marijuana use and academic performance and possible underlying mechanisms is critically needed for college administrators and policymakers, and would be especially useful for developing prevention and intervention programs.

The present study builds on prior research by evaluating a latent variable growth curve model (LVGCM) that specified the possible impact of marijuana use frequency on two academic outcomes during college—semester GPA and time to graduation—and the extent to which skipping class might mediate those associations in the context of the role of a set of first-year risk factors thought to predict academic outcomes (i.e., other substance use, demographics, college engagement, and psychological functioning). Importantly, our longitudinal design permitted us to evaluate these associations both cross-sectionally during the first year of college (i.e., baseline) and longitudinally by modeling the repeated measures of marijuana use, skipping class, and semester GPA as latent variables representing slope, or rate of change over time. Thus, we evaluated a structural equation model to test the following hypotheses: (a) marijuana use intercept and slope will be inversely related to GPA intercept and slope; (b) marijuana use intercept and slope will be directly related to time to graduation; and (c) skipping class intercept and slope will mediate the above hypothesized associations. Specifically, we hypothesized that marijuana intercept will be directly related to skipping class intercept, which in turn will be directly related to GPA intercept and graduation time, and that marijuana slope will be directly related to skipping class slope, which in turn will be directly related to GPA slope and graduation time. The structural model also included the direct and indirect effects of several baseline covariates, including alcohol use, psychological risk factors, demographics, and college engagement variables, in order to isolate the unique effect of marijuana use on the hypothesized mediators and outcomes.

Method

Design

Data were collected during eight annual assessments with a cohort of 1253 young adults. Participants were originally recruited as incoming first-time, first-year students at one large public university in the mid-Atlantic region (Arria et al., 2008a). The baseline assessment (Year 1) was conducted sometime during their first year of college (i.e., 2004 to 2005) and consisted of a two-hour personal interview and self-administered questionnaires covering substance use, academic behaviors, and a broad range of other health-related information. Subsequent annual follow-up assessments (Years 2 through 8) were similar in format and content. All of the original baseline participants were followed up regardless of continued college attendance. Follow-up rates ranged from 76 to 91% annually (Vincent et al., 2012). Cash incentives were provided for completion of each assessment. Informed consent was obtained. The study received IRB approval. Interviewers were trained extensively in confidentiality protections, and a federal Certificate of Confidentiality was obtained.

Participants

For the present analysis, the sample was restricted to the 1117 individuals for whom valid data on college graduation were available from either administrative data from the university or self-report by Year 8 of the study (see below). Individuals who did not complete a four-year college degree (n=34) or were missing data on graduation (n=102) were necessarily excluded because the distal outcome of interest was time to graduation. Characteristics of the inclusion sample are presented in Table 1. Compared with excluded individuals, those in the inclusion sample were slightly more likely to be female (54% vs. 31%), involved in living-learning programs (54% vs. 38%) or fraternity/sorority organizations (28% vs. 11%), and earned higher GPAs during their first semester of college [*M* (*SD*) 3.15 (.64) vs. 2.46 (.89), all *p*s<.05]; however, they were similar with respect to race, parents' education, and baseline alcohol and marijuana use frequency. Missing data within each assessment was minimal (see Table 2).

Measures

A description of the measures used in this study is presented in Table 2. Participants provided informed consent for the researchers to access their academic data from the home university, which was the sole source of data on semester GPA, and the primary source of data on graduation for individuals who graduated from the home university. For the present study, GPA data were rescaled by a factor of ten in order to facilitate interpretation of model results. In order to retain the 50 individuals who had left the home university and graduated from another institution, we supplemented administrative data on college graduation with participants' self-report data collected in Years 5 through 8. A dichotomous variable on the school of graduation (home institution vs. elsewhere) was used as a control variable. Substance use measures were adapted from standard surveys (Substance Abuse and Mental Health Services Administration, 2003).

Analysis

Because time to graduation was the long-term outcome variable of interest in this study, data on marijuana use that were collected for the period after graduation were considered missing for the purposes of the present analyses, and data on skipping class and GPA were necessarily missing after the student's graduation. See Table 2 for available sample sizes at each time point for each variable. For the 58 participants who graduated after their fifth year in college, data from their first five years were included, and all subsequent observations were omitted from all analyses, because the sample sizes for graduation in years 6 (n=49), 7 (n=7), and 8 (n=2) were insufficient to allow estimation.

Our hypothesized conceptual model was fit using a latent variable model (LVM; Muthén, 2002; Muthén & Muthén, 2012) that included three latent variable intercepts and three latent variable growth curves as elements of the LVM. Our LVM can be considered a structural equation model that included as a component a latent variable growth curve model (LVGCM; Duncan, Duncan, Strycker, Li, & Alpert, 1999; Muthén, 2008). LVGCM itself can be viewed as an extension to repeated measures analysis of variance because it examines mean differences over time. It can also be viewed as an extension to confirmatory factor analysis, because the rates of change over time in a variable are considered to be unmeasured, or latent. The goal of a LVGCM is to estimate the growth trajectory (rate of change over time) of a latent variable (Duncan et al., 1999; Muthén, 2008). The LVGCM component of our model consisted of the latent endogenous variables that represented linear rates of change in frequency of marijuana use, skipping class, and semester GPA, each of which were hypothesized to predict time to graduation, as well as the latent intercepts for these same three variables, which represented first-year marijuana use, first-year skipping class, and first-semester GPA. In addition to the LVGCM component of the model, our LVM also included exogenous variables—namely, the baseline substance use (i.e., alcohol and drugs other than marijuana), demographics, college engagement, and psychosocial risk factors—all of which were hypothesized to predict both the endogenous intercept and slope variables for marijuana use, skipping class, and GPA, as well as the distal outcome of time to graduation. Figure 1 depicts the putative model under examination.

Our approach tested the possible direct relationship between rate of change over time in frequency of marijuana use and rate of change over time in skipping classes, and the possible direct relationship between rates of change over time in skipping classes and semester GPA, together with the possible direct and indirect relationships between rates of change over time in frequency of marijuana use and rate of change over time in semester GPA. Moreover, within the context of this model it was possible to parameterize the three trajectories (see Figure 3A for detailed information regarding parameterization of the LVGCM component of the LVM) such that the intercept terms for each trajectory represented marijuana use frequency and skipping class during the first year of college, and semester GPA during the first semester, respectively. Thus, these three intercept terms represent behavior during the first year of college. Additionally, we tested all possible direct paths from the intercept and slope variables to the distal outcome, time to graduation, and all possible direct paths from the baseline covariates to the three intercept and three slope variables.

The three latent variables were parameterized in the same manner, in which the intercept was fixed to represent the first-semester behavior, and the slope parameter was defined by a first-degree polynomial (i.e., a linear term; see Figure 3A for greater detail regarding the parameterization of the three trajectories). The omnibus test of model fit and the test of competing models used the Satorra-Bentler scaled χ^2 goodness-of-fit tests (Satorra & Bentler, 1988). Robust methods were used to estimate the standard errors associated with the free parameters (Chou, Bentler, & Satorra, 1991). Given that Hu and Bentler (1999) have indicated the need to use joint criteria to determine adequacy of model fit, with suggestions for cutoff values for the comparative fit index (CFI; ≥.95) and the standardized root mean square residual (SRMR; ≤.09), any model needed to meet these criteria to be considered acceptable. All paths remaining in the model had to be statistically significant at α=.05. Our approach was to test our hypothesized model and then modify the model as needed based on examination of the parameter estimates and overall model fit. Therefore, our approach was to test our hypothesized model, and then modify it on the basis of examination of the results, first deleting non-significant paths from the model, refitting the revised model, and then allowing paths with significant modification indices to enter the revised model. Finally, the MacKinnon and Lockwood asymmetric distribution of products method was used to test the significance of the mediation effects, with estimates, standard errors, and confidence intervals based on 1,000 bootstrap samples (MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002). The dichotomous variable assessing graduation from the home university versus any other school was held constant in all models. Analyses were performed using M*plus* 7.1 (Muthén & Muthén, Los Angeles, CA).

Results

Marijuana Use

When assessed during their first year of college, more than one-third (37.4%) of the sample had used marijuana once or more during the past month, with an average frequency of 6.5 days during the past month among those who used (data not shown in a table). In subsequent years, marijuana use was similarly prevalent (e.g., past-month use was 38.0%, 37.9%, 33.0% in Years 2 through 4, respectively) but more frequent, with average frequency of use between 7.7 and 8.8 days during the past month among those who used in Years 2 through 4 (data not shown in a table). More information on longitudinal patterns of marijuana use in this cohort is available elsewhere (Caldeira, O'Grady, Vincent, & Arria, 2012).

Model Selection

The model selection process resulted in a final model that fit the data reasonably well (χ^2=957.5, *df*=468, *p*<.0001, *RMSEA*=.034, *CFI*=.939). The final model included all the baseline covariates shown in Figure 1, with the exception of self-reported ADHD diagnosis at baseline, which did not contribute to any significant pathways and was therefore omitted from the final model. Figure 2 depicts the pathways related to the intercepts and slopes for marijuana use, skipping class, and academic outcomes that were significant and therefore retained in the final model, and are discussed in detail below. Results pertaining to the baseline covariates are available in a supplementary online table (see Table 3A).

Overall Results

In general, results supported the hypothesized mediation effect in that, at baseline, marijuana use frequency predicted skipping class, which in turn predicted GPA, which in turn predicted time to graduation. Additionally, over time, marijuana slope was inversely associated with GPA slope. The final model accounts for moderate amounts of variance in the skipping class intercept (R^2=.37), GPA intercept and slope (R^2=.24 and .57, respectively), and time to graduation (R^2=.32; see Figure 2). However, interestingly only one of the exogenous variables (i.e., parents' education) and none of the endogenous variables predicted rate of change in skipping class over time, and thus the model accounted for comparatively little variance in the slope of skipping class (R^2=.04).

Effects of Marijuana Use on First-semester GPA

Although there was no direct path from marijuana intercept to GPA intercept (see Figure 2), marijuana use at baseline contributed indirectly to lower baseline GPA through its positive influence on skipping class (*b*=−.07, *SE*=.02, *p*=.002; see Table 3).

Effects of Marijuana Use on GPA Slope

Marijuana intercept had no net effect on GPA slope, despite having a negligible contribution via one significant indirect pathway (i.e., marijuana intercept to skipping intercept to GPA intercept to GPA slope). With respect to rate of change in marijuana use over time, marijuana slope was directly and negatively associated with GPA slope (b=−.05, SE=.02, p=.030), but there was no corresponding indirect path through skipping slope. Thus, increases in marijuana use frequency over time contributed directly to decreases in GPA, without any associated indirect effect via rate of change in skipping class.

Effects of Marijuana Use on Time to Graduation

No significant direct paths were observed between marijuana intercept and graduation time (see Figure 2), yet the net effect of marijuana intercept on graduation time was positive (b=.008, SE=.003, p=.005), which was the net result of two competing indirect paths. The more predominant (positive) path was from marijuana intercept to skipping intercept to GPA intercept to graduation time (b=.005, SE=.002, p=.003), which overshadowed a smaller negative effect from the indirect path from marijuana intercept to skipping intercept to GPA intercept to GPA slope to graduation time (b=−.002, SE=.001, p=.010). The other two possible indirect paths (i.e., marijuana intercept to skipping intercept to graduation time, and marijuana intercept to marijuana slope to GPA slope to graduation time) were not statistically significant.

The marijuana slope latent variable had no effect on graduation time, either directly or indirectly. Although the indirect pathway from marijuana slope to GPA slope to graduation time trended toward a positive effect, it was not statistically significant (b=.025, SE=.013, p=.056).

Effects of Baseline Alcohol and Other Drug Use on Academic Outcomes

There were no direct paths from any of the baseline substance use variables (i.e., alcohol frequency, alcohol quantity, other drug use) to any of the academic outcome variables (i.e., GPA intercept, GPA slope, graduation time). Indirectly, however, all three substance use covariates were significantly associated with lower GPA intercept via paths involving the intercepts of skipping and/or marijuana (see Table 3A, online supplemental materials). The seemingly contradictory finding that the baseline substance use variables were associated with lower baseline GPAs but higher increases in GPA over time is consistent with a ceiling effect, in that the individuals with minimal substance use and high grades at baseline had little if any opportunity to improve their grades over time. Because the hypothetical model did not include slopes of alcohol and other drug use, it was not possible to evaluate the impact of rates of change in use of these substances on GPA over time. Finally, with respect to graduation time, both baseline alcohol quantity and other drug use—but not alcohol frequency—had positive net effects via indirect paths involving the intercepts of skipping class and GPA.

Discussion

In this sample of college graduates, students who used marijuana more frequently during the first year of college tended to skip more of their classes, which, in turn, contributed to their tendency to earn lower grades. Similar effects were also observed for baseline measures of alcohol use and other illicit drug use. Moreover, these findings were significant even in the context of a broad range of baseline covariates encompassing college engagement, psychological functioning, and demographic characteristics. These results provided support for our first hypothesis that marijuana use during the first year of college would contribute to poorer academic outcomes, and that these effects would be mediated by skipping class.

Results also confirmed the hypothesized longitudinal relationships between marijuana use and academic outcomes. Specifically, increases in marijuana use over time predicted declines in GPA, although this did not necessarily translate to a later graduation. Perhaps more strikingly, however, baseline marijuana use frequency during the first year of college had an enduring effect on delaying graduation several years later, via its influence on the path from skipping class to GPA at baseline. In fact, any additional contributions to delayed graduation arising from longitudinal changes in marijuana use and/or skipping class were either mixed or negligible, as can be seen through examination of the specific indirect and total effects in Table 3. This pattern of findings highlights the importance of the first year of college as a critical period in which students' long-term academic trajectories begin to take shape, based in part on how they balance engagement in academic life—especially class attendance—with marijuana use.

The present findings extend our prior research on the mediating role of skipping class on the relationship between nonmedical prescription drug use and GPA by the end of the first year of college (Arria, O'Grady, Caldeira, Vincent, & Wish, 2008c). Findings are also largely consistent with an earlier study of this cohort spanning their first four years of college, in which skipping class mediated the relationship between marijuana use problems (as defined by self-reported DSM-IV criteria) and GPA (Arria et al., 2013c). Whereas that study and the present analyses support the mediation effect of skipping class at baseline, the present model, unlike the prior study, revealed a direct relationship between rate of change in marijuana use and GPA over time (but no mediation effect from changes in skipping class). This discrepancy is likely attributable to methodological differences such as differences in our marijuana use measures or the present study's inclusion criteria being more restrictive (than in the aforementioned study) in order to focus on time to graduation among the subset who graduated.

Results must be interpreted in light of the study's limitations. Although our model accounted for race/ethnicity in a broad way, we did not have sufficient numbers of individuals in any specific minority groups to explore race/ethnicity differences in detail. Because participants were all recruited from one university, results might have limited generalizability to students in other areas or at other types of colleges. Generalizability is also limited by our decision to restrict the sample to individuals who completed their college degree; however, given that individuals with the most severe levels of marijuana involvement were at high risk for dropping out of college (Arria et al., 2013a; Arria et al., 2013b), the fact that we were still

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able to detect more subtle academic consequences even among a relatively successful sample lends further confidence to our findings. Administrative data on GPA and graduation were available only from the home university; therefore, we could not fully account for how GPA changed among the students who left the home university, and we cannot say how the results might have been affected by this omission. We attempted to mitigate this limitation by controlling for graduation from the home institution or elsewhere. It is also possible that some of the 102 students who were excluded due to missing graduation data actually completed a college degree from another institution. Although we acknowledge that both academic behaviors and outcomes are likely to vary by choice of major, given that some majors are intrinsically more demanding than others, the number of distinct majors in our sample was large (>100) and therefore difficult to analyze in a meaningful way. Our model did not include other factors that are associated with academic achievement, namely financial stress, having a job, and academic self-efficacy (Joo, Durband, & Grable, 2008; Krumrei-Mancuso, Newton, Kim, & Wilcox, 2013; Mattern & Shaw, 2010; Pike, Kuh, & Massa-McKinley, 2009; Robb, Moody, & Abdel-Ghany, 2012). We cannot say how the results might have differed if marijuana use frequency had been modeled assuming a non-normal distribution (i.e., Poisson or zero-inflated Poisson); unfortunately, model convergence became possible only after we specified a normal distribution, after exhausting other specification options. Finally, although we used standard substance use measures, past-month behaviors might not reflect typical use patterns, and the temporal correspondence between semester-level GPA data and annually assessed behavioral measures was imperfect.

Despite the above limitations, the study's strengths include its longitudinal design and superior response rates and follow-up rates. This study also demonstrates the utility of a novel measure of academic behaviors (i.e., percent of classes skipped). Another important advantage of this study is its integration of self-report behavioral data with administrative data on academic outcomes, which is not always available in college student studies. Finally, the impact of the findings is enhanced by the breadth of risk factors that were assessed in multiple domains.

With respect to research implications, the present findings underscore the importance of enhancing our understanding of the mechanisms underlying the relationship between substance use and academic performance during college. Baseline marijuana, alcohol, and other drug use had both short-term and long-term impacts on academic outcomes among this sample. Prior research has demonstrated that college drinking patterns are often a continuation of patterns that were established before college entry (Arria et al., 2008b; Sher & Rutledge, 2007). More extensive longitudinal research is warranted to understand the possible impact of marijuana use on motivation to pursue academic goals, preferably starting in middle and high school. It is possible that marijuana use contributes to the deterioration of academic values and motives, and thereby has potential to deflect students away from an otherwise promising academic trajectory. Long-term rewards associated with academic pursuits can be overshadowed by short-term rewards associated with marijuana use, thereby leading to lower academic achievement during college. Finally, even though this study statistically adjusted for a number of covariates such as impulsive sensation-seeking, whether underlying neurocognitive factors predisposed individuals to both marijuana use and lower GPAs during college remains to be determined.

Looking beyond the first year of college, results provide strong evidence that as students use marijuana more frequently over time, their GPA tends to decline. The finding that this association was not mediated by rate of change in class attendance—which itself also contributed negatively to GPA slope—was unexpected and highlights the importance of alternative underlying mechanisms that might be responsible for marijuana-related declines in academic performance. While it is tempting to speculate that the cognitive effects of chronic marijuana use might account for this pattern of findings, we cannot rule out the possible contribution of any number of factors, such as the onset of a mental health condition, perhaps exacerbated by marijuana use, or some other stressful event. In prior research with this sample, time spent studying did not mediate the relationship between marijuana use and GPA (Arria et al., 2013c), but it might be important in other samples. Future research should include these variables as possible influences on academic achievement in college.

The present findings regarding marijuana use, if replicated in future studies, could have important implications for college administrators and parents of college-bound students. Despite the popular view that heavy drinking and marijuana use are a normal “rite of passage” endemic to the college experience, as well as decreasing perceptions of risk from marijuana use, marijuana use was far from innocuous in this sample. Rather, heavier patterns of marijuana use were incompatible with regular class attendance, with clear consequences for students’ grades. Future research should focus on specifically evaluating the possible impact of recovery or cessation of marijuana use on academic outcomes. The findings of this study suggest that recovery would have a beneficial impact. The research question in this analysis focused on the impact of marijuana use on time to graduation, and therefore all the students in the sample eventually graduated. Heavier marijuana use did contribute indirectly to delayed graduation, and results strongly suggest that when students engaged in heavier marijuana use patterns, they might have done so at the expense of their learning experience.

As an increasing number of states legalize marijuana, college administrators must decide how to address marijuana use on campus in a way that promotes student success. The present findings depict a clear trade-off between academic outcomes and marijuana use. College administrators interested in optimizing academic outcomes should acknowledge the role of marijuana use in possibly undermining students’ ability to succeed. Rather than acceding to trends in public opinion about marijuana use, administrators can point to the growing body of research evidence—including the present findings—as a solid rationale supporting their decision to maintain a strong stance on enforcing their school’s anti-drug policies. A commitment to prioritizing the implementation of evidence-based drug prevention and intervention is likely to promote higher levels of student engagement in academic life and ultimately might improve institutional measures of success such as retention and on-time graduation.

Students who are facing the dual challenges of both academic failure and marijuana use problems might be especially receptive to targeted interventions aimed at reducing their marijuana use if they are approached in the context of helping them stay in college. Screening students who visit academic assistance centers—whether by mandate or voluntarily—for both drug use and sporadic class attendance could be a novel approach to identifying and intervening with students whose academic difficulties are linked to their marijuana use. On the other hand, given that many substance use patterns are established before college entry (Arria et al., 2008b; Sher & Rutledge, 2007), it is also important to screen incoming students for existing marijuana use and intervene accordingly to promote long-term success.

Finally, given prior evidence supporting the importance of parental influences on college students' use of marijuana and alcohol (Abar & Turrisi, 2008; Abar, Turrisi, & Mallett, 2014; Napper, Hummer, Chithambo, & LaBrie, 2015), parents should actively stress the value of long-term rewards associated with academic engagement and regular class attendance over substance use during college.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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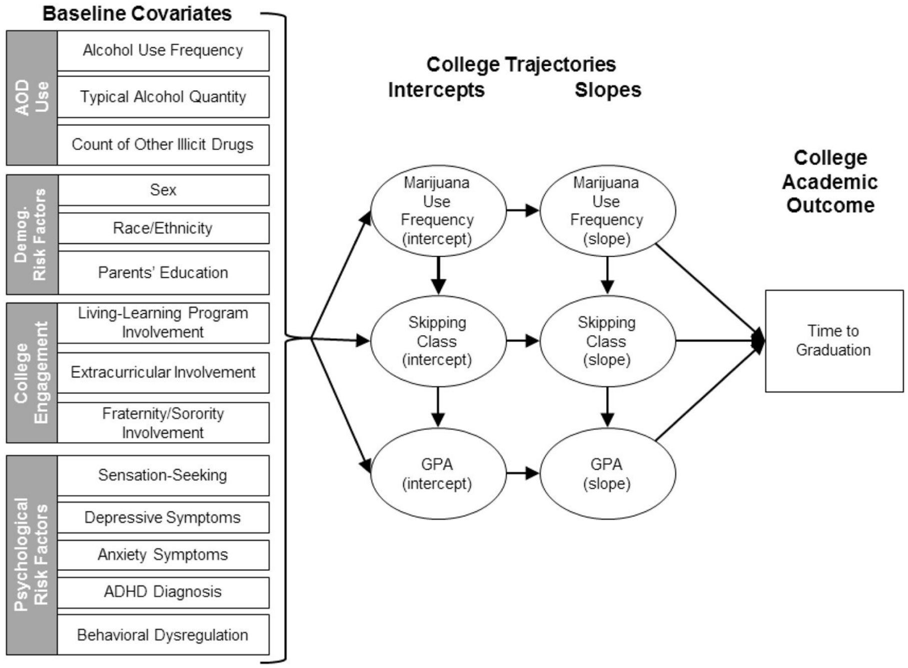

Figure 1. Schematic Depiction of Hypothesized Model of the Longitudinal Relationship between Marijuana Use, Skipping Class, GPA, and Time to College Graduation

Note. In addition to the mediation paths depicted here, we also tested all possible direct paths from the covariates to the intercept and slope variables (i.e., marijuana, skipping, GPA), and all possible direct paths from the intercept and slope variables to the distal outcome of time to graduation. The observed variables for the latent variables of intercept and slope for marijuana use frequency, skipping class, and GPA have been omitted from this figure for ease of presentation; refer to Figure 3A in the supplemental online materials for a more complete depiction of the trajectory component of the model and its parameterization.

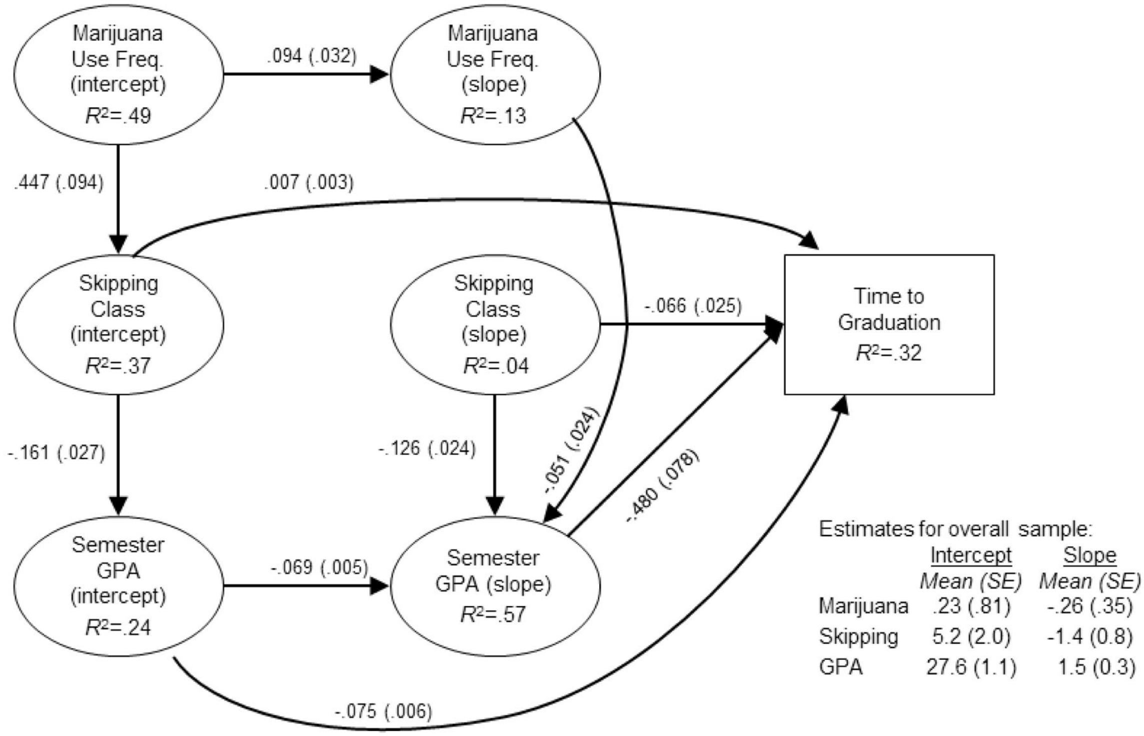

Figure 2. Structure Coefficients (Standard Errors) for the Latent Variable Model of the Relationship between Intercept and Slope for Marijuana Use, Skipping Class, GPA, and Time to College Graduation

Note. All paths shown are statistically significant (*p*<.05). Non-significant paths were dropped from the model. For ease of presentation, additional significant paths between the covariates and the intercepts, slopes, and outcome were omitted from this figure, although they were retained in the model (see Table 3A in supplemental online materials for estimates of the structure coefficients and their standard errors, for significant paths that are not shown here). Baseline covariates that were included in the model were alcohol quantity and frequency, number of other drugs used during the past year, sex, race/ethnicity, parents' education, living-learning program involvement, fraternity/sorority involvement, number of other extracurricular activities, impulsive sensation-seeking, behavioral dysregulation, depressive symptoms, and anxiety symptoms.

Table 1

Sample Characteristics [n (%) or M (SD)] (N=1117)

Demographics	
Male	514 (46.0%)
White	823 (73.7%)
Parents with college degree	902 (86.2%)
College engagement	
Living-learning program	605 (54.3%)
Number of extracurricular activities	2.5 (2.1)
Fraternity/sorority involvement	291 (27.9%)
Baseline substance use	
Marijuana use frequency (days, past month)	2.4 (5.7)
Alcohol use frequency (days, past month)	6.3 (5.6)
Typical number of drinks/day	4.5 (2.9)
Number of other illicit drugs used (past year)	0.5 (1.1)
College academic behaviors	
Percent of classes skipped (Year 1)	9.8 (12.7)
Baseline psychological risk factors	
Behavioral dysregulation	27.9 (11.8)
Anxiety symptoms	7.5 (7.0)
Depressive symptoms	5.2 (4.9)
ADHD diagnosis (self-reported)	63 (5.6%)
Impulsive sensation-seeking	3.5 (2.2)
College academic outcomes	
First semester GPA (x 10)	31.5 (6.4)
Cumulative GPA (x 10) at graduation	33.1 (4.3)
Time to graduation	
Less than 4 years	71 (6.4%)
4 years	740 (66.2%)
5 years	248 (22.2%)
More than 5 years	58 (5.2%)
School of graduation	
Home university	1067 (95.5%)
Another institution	50 (4.5%)

Note. GPA data were rescaled by a factor of 10 to facilitate interpretation of model estimates.

Table 2

Measures Used in the Present Study

Construct	Description	Years (Source)	Items	Available *n*
Outcome Measures				
GPA	Semester GPA for coursework at home university, captured from administrative data for fall and spring semesters each year. Range 0.33 to 4.00 in first semester. Available sample sizes for semesters 1 through 10 were 1116, 1110, 1073, 1064, 1039, 930, 1020, 978, 213, and 93, respectively. Data from subsequent semesters were censored due to insufficient sample sizes ($n \leq 18$).	1–6 (A)		
Time to graduation	Computed initially as the number of semesters from college entry to completion of first four-year degree, either at the home university (administrative data) or other institution (self-report). To create a more even distribution, data were then consolidated into an ordinal variable coded as less than four years (1); four years (2); more than four years, up to five years (3); and more than five years (4).	5–8 (A, I)		
Hypothesized Mediator				
Skipping class	Computed as the percentage of classes skipped, based on responses to "How many class sessions per week do you routinely skip?" and their total number of class sessions per week. Range 0.0 to 87.5 in Year 1. Available sample sizes for years 1 through 5 were 1116, 1037, 1000, 964, and 151. Data from subsequent assessments were censored due to insufficient sample size ($n \leq 22$).	1–8 (I)		
Primary Explanatory Variable				
Marijuana use	Frequency of marijuana use in the past 30 days (range 0 to 30). Available sample sizes for years 1 through 5 were 1116, 1042, 1018, 977, and 151. Data from subsequent assessments were censored due to insufficient sample size ($n \leq 23$).	1–8 (I)		
Baseline Covariates				
Substance use				
Alcohol frequency	Frequency of alcohol use in the past 30 days (range 0 to 30).	1 (I)		1117
Alcohol quantity	Number of drinks consumed on a typical drinking day (range 0 to 20).	1 (I)		1111
Other drug use	Computed as the number of other illicit drugs that were used at least once in the past year, based on responses regarding past-year frequency of use for hallucinogens, inhalants, cocaine, heroin, amphetamine/methamphetamine, ecstasy, and nonmedical use of prescription stimulants, analgesics, and tranquilizers (range 0 to 8).	1 (I)	9	1116
College Engagement				
Extracurricular involvement	Computed as the sum of regular (2), irregular (1) and no (0) involvement in seven different activities (volunteer work, religious/church groups, exercise, athletics, and up to three other open-ended extracurricular activities). Range 0 to 12.	1 (I)	7	1116
Fraternity/sorority involvement	Dichotomized as irregular or regular involvement versus none, due to the very small number endorsing irregular involvement (<2%).	2 (I)	1	1043
Living-learning program involvement	Dichotomized as any versus none, based on administrative data obtained at college entry. Living-learning programs provide students with a specialized residential experience that is specifically tied to an academic unit, with the goal of fostering deeper integration of classroom material. A diverse range of living-learning programs were represented in our sample, including interests in community service and/or specific academic disciplines (e.g., foreign-language,	1 (A)		1115

Construct	Description	Years (Source)		
	humanities, engineering), many of which were focused on high-achieving (i.e., “honors”) students. Student athletes were not counted as living-learning program participants. humanities, engineering), many of which were focused on high-achieving (i.e., “honors”) students. Student athletes were not counted as living-learning program participants.			
<u>Psychological risk factors</u>				
Behavioral dysregulation	Subscale score from the Dysregulation Inventory (Mezzich, Tarter, Giancola, & Kirisci, 2001). Higher scores indicate higher levels of disinhibition and behavioral undercontrol. Range 2 to 91. Cronbach’s α=.90	1 (S)	34	1059
Impulsive sensation-seeking	Subscale score from the Zuckerman-Kuhlman Personality Questionnaire (Zuckerman, 2002). Higher scores reflect greater preference for novelty and excitement. Range 0 to7. Cronbach’s α=.74	1 (S)	7	1106
Depressive symptoms	Beck Depression Inventory (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961). For each item, participant selects one of four statements that is most applicable to their current feelings. Higher scores indicate higher levels of depressive symptoms. Range 0 to 34. Cronbach’s α=.84	1 (S)	21	1114
Anxiety symptoms	Beck Anxiety Inventory (Beck & Steer, 1990). Uses Likert-type response options for participant to indicate how much each symptom is bothersome (not at all, mildly, moderately, and severely). Higher scores indicate higher levels of anxiety symptoms. Range 0 to 51. Cronbach’s α=.88	1 (S)	21	1094
ADHD diagnosis at college entry	Dichotomous variable based on self-reported current health conditions.	1 (I)		1117
<u>Demographics</u>		1 (S)		
Sex	Dichotomized as male and female.	1 (I)		1117
Race/Ethnicity	Dichotomized as White versus non-White due to the preponderance of Whites in the sample (74%).	1,3 (S)		1117
Parents’ education	Highest level of educational attainment by either parent was dichotomized as college degree versus no college degree, to emphasize the distinction between students who were and were not first-generation college students.	1 (S)		1046

I=Interview data A=Administrative data S=Self-administered questionnaire data

Table 3

Specific Direct and Indirect Paths [b(SE)] between Marijuana Use, Skipping Class, and Academic Outcomes from the Final Model

Explanatory Variable	Mediating Path(s)	Outcome Variable	Specific Effect	Total Indirect	Total Effect
Marijuana intercept	Skipping intercept	GPA intercept	**−.072 (.023)**	**−.072 (.023)**	**−.072 (.023)**
Skipping intercept	*(Direct)*	GPA intercept	**−.161 (.027)**		*a*
Marijuana intercept	Skipping intercept, GPA intercept	GPA slope	**.005 (.002)**	.000 (.004)	.000 (.004)
	Marijuana slope		−.005 (.004)		
Marijuana slope	*(Direct)*	GPA slope	**−.051 (.024)**		*a*
Skipping intercept	GPA intercept	GPA slope	**.011 (.002)**	**.011 (.002)**	**.011 (.002)**
Skipping slope	*(Direct)*	GPA slope	**−.126 (.024)**		*a*
GPA intercept	*(Direct)*	GPA slope	**−.069 (.005)**		*a*
Marijuana intercept	Skipping intercept	Time to Graduation	.003 (.002)	**.008 (.003)**	**.008 (.003)**
	Skipping intercept, GPA intercept		**.005 (.002)**		
	Skipping intercept, GPA intercept, GPA slope		**−.002 (.001)**		
	Marijuana slope, GPA slope		.002 (.002)		
Skipping intercept	*(Direct)*	Time to Graduation	**.007 (.003)**	**.007 (.002)**	**.014 (.003)**
	GPA intercept		**.012 (.003)**		
	GPA intercept, GPA slope		**−.005 (.002)**		
GPA intercept	*(Direct)*	Time to Graduation	**−.075 (.006)**	**.033 (.007)**	**−.042 (.005)**
	GPA slope		**.033 (.007)**		
Marijuana slope	GPA slope	Time to Graduation	.025 (.013)	.025 (.013)	.025 (.013)
Skipping slope	*(Direct)*	Time to Graduation	**−.066 (.025)**	**.060 (.028)**	−.006 (.019)
	GPA slope		**.060 (.028)**		
GPA slope	*(Direct)*	Time to Graduation	**−.480 (.078)**		*a*

Note. Statistically significant results (p<.05) are shown in **bold**. All paths [b(SE)] are structure coefficients. All direct paths were estimated by maximum likelihood methods, while the direct and total effects were estimated using Monte Carlo bootstrapping estimation. See text for details. Results adjusted for all effects shown, and for the effects of the baseline covariates (alcohol quantity and frequency, other drug use, sex, race/ethnicity, parents' education, living-learning program involvement, fraternity/sorority involvement, number of other extracurricular activities, impulsive sensation-seeking, behavioral dysregulation, depressive symptoms, and anxiety symptoms). Results for paths involving the baseline covariates are presented separately in an online appendix (see Table 3A) and have been omitted from this table.

[a]The total effect was equivalent to the specific direct effect because no corresponding indirect paths were available.