

The Influence of College Attendance on Risk for Marijuana Initiation in the United States: 1977 to 2015

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Objectives. To examine a potential increase in marijuana initiation among US college students as compared with their age peers not in college before and after 2013, a watershed year for increasing tolerance of marijuana use in the United States.

Methods. Data come from the Monitoring the Future study, which has followed longitudinal panels drawn from annual nationally representative, baseline samples of 12th-grade students starting with the class of 1976. We studied panel members aged 19 to 22 years who had never used marijuana by 12th grade between 1977 and 2015.

Results. College as a risk factor for marijuana initiation has increased significantly since 2013. The increased probability of past-year marijuana use for those enrolled versus not enrolled in college was 51% in 2015, 41% in 2014, and 31% in 2013; it averaged 17% to 22% from 1977 to 2012 among youths who had never used marijuana by 12th grade.

Conclusions. College has grown as a risk factor for marijuana initiation since 2013.

Public Health Implications. College students are in position to usher in new increases in population marijuana use unless colleges soon address the issue with new or modified programs for marijuana prevention and intervention. (*Am J Public Health.* 2017;107:996–1002. doi:10.2105/AJPH.2017.303745)

 See also Gruzca, p. 833.

We examined college enrollment as a risk factor for the initiation of marijuana use before and after 2013, a turning point for tolerance of recreational marijuana use in the United States. This was the first full year after 2 US states spearheaded the legalization of recreational marijuana use.^{1,2} These acts and the wide publicity they generated were indicators of and catalysts for a spreading wave of acceptability of recreational marijuana use across the entire country, and recent polls show a majority of US adults now support legal marijuana use for adults.³ Whether these developments will lead to a new set of users who would not otherwise use marijuana is an open question that we address.

To our knowledge, this is the first study to focus on marijuana initiation among college students before and after 2013. College students are uniquely sensitive to changes in social attitudes toward marijuana use. They have higher levels of autonomy than do younger adolescents, which provides college students relatively more opportunity to act on new ideas about substance use. They are

more likely to experiment with marijuana than are older adults, who have substantially lower levels of use.⁴ And college students are less likely than are their same-aged peers not in college to have entered social roles that reduce marijuana use, such as employee, spouse, and parent.⁵

In the past the unique sensitivity of college students to changing mores toward marijuana put them at the vanguard of changes in its use. In the 1960s increases in marijuana use originated largely on college campuses⁶ and then later spread up the age spectrum when the college students of this era aged and continued their marijuana use.⁴ Analysis of marijuana initiation among today's college-aged students may help determine if they are in a position to play a similarly leading role today.

BACKGROUND

Whether new initiates to marijuana will result from the recent, loosening mores around marijuana use is a key question for policy and theory. New initiates can be expected on the basis of both the signaling hypothesis⁷ and work demonstrating that marijuana attitudes strongly predict marijuana use.⁸ The signaling hypothesis proposes that new laws making marijuana use more accessible send a signal to the population that marijuana use is safe and state sanctioned,^{9,10} a signal conveyed to all regardless of the legal status of marijuana use in an individual's home state. Of particular concern is that this signal lowers the perceived risk of harm from marijuana use, a leading indicator of future increases in marijuana use at both the individual and population levels.^{8,11,12} Since 2013, levels of perceived harm among college-aged students aged 19 to 22 years are at the lowest levels recorded in the past 3 decades,¹³ setting the stage for new users to initiate marijuana use.

In this scenario, signaling could be especially influential for college students, and college could become a substantial risk factor for marijuana use much as it currently is for binge drinking.¹⁴ The college experience with its unique combination of new freedoms, plenty of spare time, lack of parental supervision, and a party culture leads many college students to experiment with substance use as they had never done before. For example, the current college environment fosters binge drinking to such a degree that college students have higher levels of binge drinking than do their same-aged peers who are not in college, a reversal of the

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relative binge drinking levels of the same youths in these 2 groups when they were younger, in 12th grade.^{13,15–17} As a result of signaling, the college-related factors that encourage alcohol use could now foster new marijuana initiates, to the extent that marijuana's social reputation has become less injurious and more socially acceptable, like alcohol. Proponents of the signaling hypothesis emphasize that despite greater social acceptance of marijuana, its use can carry substantial adverse health and social effects, especially frequent and persistent use.^{18,19}

By contrast, the competing, null prediction is no change in levels of marijuana initiation at any age. Marijuana use did not increase among youths in middle or high school from 2013 to 2015 compared with the previous 3-year period.⁸ It is possible that any expected increase in marijuana initiation as a result of changing norms may be offset by newly arising, countervailing influences.

Furthermore, a prominent counterargument to the signaling hypothesis is that laws prohibiting the use of marijuana have actually had little deterrent effect,^{20,21} as evidenced by the high levels of lifetime use among today's 12th-grade students that currently reach 45%.⁸ If laws do not deter marijuana initiation and use, removing them should also have little effect on college students or anyone else.

We investigated the hypothesis that marijuana initiation among students in college, compared with their age peers not in college, has significantly increased since 2013. The counter, null hypothesis is that there have been no changes in marijuana initiation among college-attending young adults compared with their age peers not in college.

METHODS

Data come from the annual Monitoring the Future study, which includes data on college students and their age peers not in college. Since 1975, the study has administered questionnaires in classrooms to survey nationally representative samples of US 12th graders in the 48 contiguous states.⁸ Each year the study surveys about 15 000 12th-grade students in a randomly drawn

sample of approximately 130 public and private schools. The survey and sampling procedures are described in detail elsewhere.^{8,22} Every year since 1976, 2450 high school seniors are randomly selected from the baseline sample to participate in a longitudinal panel study via periodic mail surveys.

Data are from the baseline survey and first 2 follow-up waves, when the modal age of respondents was 19 to 22 years. The analysis used 12th-grade students with no lifetime use of marijuana, which constitutes between 64% and 66% of all 12th-grade students between 2010 and 2015, with more variation in earlier years.⁸ Each panel is randomly split into 2 groups of equal size that are resurveyed every 2 years throughout early adulthood, using a staggered design in which the initial resurvey occurs 1 year after 12th grade for half the panel and 2 years after 12th grade for the other half. Data from the 2013 to 2015 follow-up waves provide information on the key comparison group of respondents who were of college age in 2013 or later.

The analysis compares these respondents to same-aged youths in earlier waves. Panel data were collected every year starting in 1977, resulting in a total of 55 265 observations from 32 392 individuals who reported no lifetime use of marijuana by 12th grade and provided information on marijuana use in one or both of the first 2 follow-up surveys. The response rate is 73% among respondents who completed a baseline, 12th grade survey; 42% of these respondents provided information at both follow-up surveys.¹³

Table 1 lists all variables used in the analysis, their definition, response categories, and proportions and means.

We have presented results from generalized estimating equations.²³ Each individual contributes up to 2 follow-up observations to the analysis pool. The generalized estimating equation methodology adjusts for nonindependence of observations from the same individual. The main dependent variable of the analysis was the dichotomous variable of any marijuana use in the past 12 months at a follow-up, and the analysis used a binomial regression with a log link²⁴ to estimate relative risk of this outcome for respondents who were enrolled in a 4-year

college compared with those who are not. Frequency of marijuana use was also analyzed to examine if the distribution of frequent users among new marijuana initiates has changed over time.

We used multiple imputation to handle missing data, and we used the chained equations algorithm²⁵ with 20 imputed data sets. The final analyses excluded cases with imputed values for the dependent variable of marijuana use in the past 12 months. All variables in the analysis had item-specific missing values of 3% or less.

We tested the hypothesis of a gradual increase starting in 2013 for marijuana prevalence among college students compared with their age peers not in college. This test centered on a variable coded 0 for the years 2012 and before, coded 1 for 2013, coded 2 for 2014, and coded 3 for 2015. A positive, multiplicative interaction of this variable with college enrollment status would support the hypothesis of increasing prevalence among college students since 2013.

We compared results from 2013 to 2015 with those of 2 earlier periods. The first comparison was with results from 1977 to 2012 to test whether 2013 to 2015 stands out as a unique era in relation to the average for all 4 decades of the survey. The second comparison period was 2010 to 2012 to test whether any findings in 2013 to 2015 stand out as a unique effect that began in 2013 and then grew, as opposed to being an end portion of a process that had started earlier.

RESULTS

Figure 1 presents observed data on marijuana use among students enrolled in 4-year colleges (henceforth "college students") who had never used marijuana by 12th grade, which is 64% of the entire college sample. The observed data provide preliminary evidence that (1) college students had higher levels of marijuana use that first started after high school than did their age peers not in college, and (2) this difference increased in 2013 to 2015. Young adults not in college had the lowest levels of marijuana use that started after high school in all years, from about 9% for those aged 19 years to 15% for those aged 22 years, respectively.

TABLE 1—Means and Proportions for Respondents Aged 19–22 Years Who Had Never Used Marijuana by 12th Grade: Monitoring the Future Study, United States, 1977–2015

Variable	Mean or Proportion (SE)
Questions from follow-up surveys	
Used marijuana in the past 12 mo; coded 1 for response of ≥ 1 to the question: On how many occasions (if any) have you used marijuana during the last 12 months?	0.15 (0.0015)
Infrequent marijuana user; coded 1 for marijuana use on 1–5 occasions in the past 12 mo.	0.63 (0.0057)
Frequent marijuana user; coded 1 for marijuana use on ≥ 40 occasions in the past 12 mo.	0.10 (0.0035)
Currently enrolled in 4-y college ^a ; coded 1 for enrollment in a 4-y college, as indicated by a positive response to the question: Please look at each activity listed below, and mark the circle which shows how likely you are to do EACH (Mark 1 for each line).	
Attend a 4-year college: response category is “I’m doing this now.”	0.47 (0.0022)
Age at follow-up survey; centered at 19 y.	1.43 (0.0048)
Age at follow-up survey 2 ^b ; centered at 19 y.	3.30 (0.0150)
No. survey y since 2013; coded 1 for 2013, 2 for 2014, 3 for 2015, and 0 otherwise.	0.12 (0.0022)
Currently enrolled in 4-y college; no survey y since 2013; multiplicative interaction term.	0.07 (0.0017)
Questions from 12th grade, baseline surveys	
Woman; coded 1 for women and 0 for men.	0.59 (0.0021)
Parent with college degree; coded 1 if mother or father has a college degree and 0 otherwise.	0.47 (0.0022)
Black; coded 1 for race/ethnicity of solely “Black or African American.”	0.10 (0.0013)
Hispanic; coded 1 for race/ethnicity of “Mexican American or Chicano,” “Cuban American,” “Puerto Rican,” or “other Hispanic or Latino” and no other racial/ethnic categories.	0.07 (0.0011)
Other race; coded 1 for race/ethnicity of “Asian American,” “American Indian or Alaska Native,” or “Native Hawaiian or other Pacific Islander” and > 1 race/ethnicity.	0.08 (0.0012)
White; coded 1 for White.	0.75 (0.0019)

Note. The population size was $n = 55\,265$.

^aWe coded all students who did not report enrollment in a 4-y college 0 for this variable, including students in alternative academic settings, such as a 2-y associate’s program or trade school. In analyses not shown, we considered including combining these students with those in 4-y college students in an umbrella “college” variable and found the results became weaker and not stronger, likely because of increased heterogeneity in the characteristics and experiences of the individuals across various educational settings.

^bWe included this variable in the model to take into account any curvilinear association between age and marijuana initiation.

We observed slightly higher levels for college students from 1977 to 2012, which varied from 13% to 17%. The highest levels were among college students in 2013 to 2015, which varied from 18% to 21%. We next employed formal statistical models to examine these results in more detail.

Table 1 presents sample means and proportions. About half (47%) of the sample was enrolled in college at the time of the follow-up surveys and 15% reported using marijuana in the past 12 months. The demographic makeup of the sample closely resembles the levels for the US population

during this period, with the exception that the number of women is about 60% and not closer to 50%, in part because women are less likely to have used marijuana by 12th grade than are males. In more recent years, from 2010 to 2015, the percentage of the sample enrolled in college at the time of the follow-up survey was 54%, and the percentage reporting marijuana use in the past 12 months was 16% (these means not tabled).

Table 2 presents results from college enrollment as a predictor of marijuana use that started after high school and potential changes in this predictive power in 2013 to 2015 compared with the average of all earlier years. Figure 2 presents predicted probability results from the first model. Figure 2a presents results for 1977 to 2012 and shows that the predicted probability of marijuana that starts after high school was slightly higher for students in college than for their age peers not in college, by 22% (the 0.20 coefficient for college enrollment refers to the years 1977–2012 in the first model of Table 2, and $e^{0.20} = 1.22$).

This predictive power increased substantially in 2013 and afterward, as indicated in Figure 2 by a growing gap between the levels of past 12-month marijuana use for young adults enrolled versus not enrolled in college. Specifically, the probability of marijuana use for college students was higher than was the probability for their age peers not in college by 31% in 2013, 41% in 2014, and 51% in 2015 (we calculated these estimates as the college coefficient plus the coefficient for the interaction of this variable with survey year; $1.31 = e^{0.20+(1)(0.071)}$; $1.41 = e^{0.20+(2)(0.071)}$; $1.51 = e^{0.20+(3)(0.071)}$). The increase in new marijuana initiates after high school was concentrated solely among college students, as indicated by the non-significant coefficient for the variable “No. survey years since 2013.”

The second model presented in Table 2 adds demographic controls. After their inclusion the multiplicative interaction term of college enrollment and survey years since 2013 remained statistically significant and in the same direction. This indicates that the recent increase in the predictive power of college enrollment on marijuana use that starts after high school is general and not confounded by demographic characteristics.

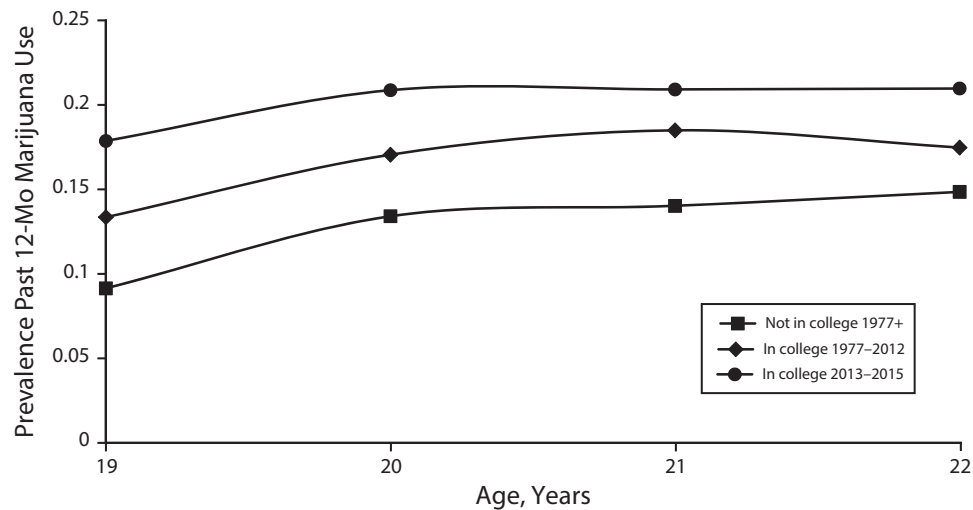


FIGURE 1—Observed Levels of Past-Year Marijuana Use Among Respondents Who Had Never Used Marijuana by 12th Grade, by Age, Survey Year, and College Enrollment: Monitoring the Future Study, United States, 1977–2015

The third and fourth models in Table 2 present results for a parallel model that compares 2013 to 2015 with the shorter, more immediate period of 2010 to 2012. As in the previous models, the year 2013 stands out as the year that marks the start of a gradual increase in the predictive power

of college enrollment on marijuana initiation. This is indicated by the significant, multiplicative interaction term of college enrollment and survey years since 2013, which is present in both models. In models not shown, this interaction was not statistically significant when using starting years of

2012 or 2011. These results support the year 2013 as the distinct, recent start of the upsurge in marijuana initiation among college youths (compared with same-aged peers not in college), and not an end portion of a process that commenced in earlier years.

The increase in marijuana initiation among college students took place in a context of changing demographic predictors of initiation, as indicated by a comparison of the results for models 2 and 4 of Table 2. Minority status has become a weaker predictor of marijuana initiation in recent years, as indicated by near-zero, nonsignificant coefficients for Blacks and Hispanics in model 4, which are strongly negative in models that include data from previous years (model 2). The influence of high parental education also diminished by 41%, from 0.17 to 0.10.

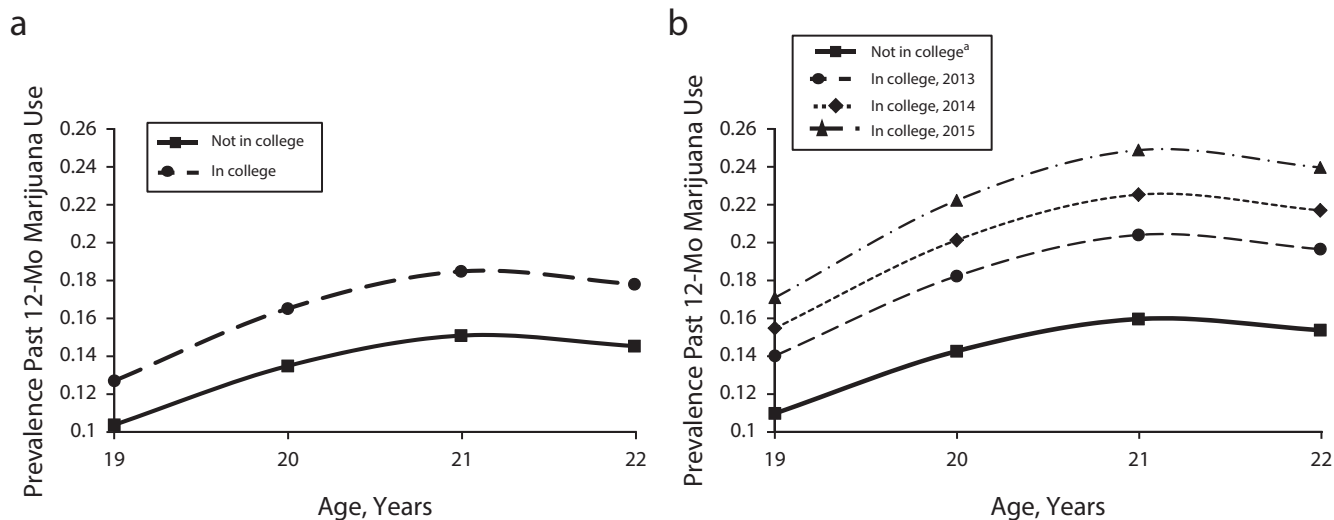
The frequency and intensity of marijuana use starting in 2013 was similar to the levels observed in earlier periods such as 2010 to 2012 (analyses not tabled). For both periods, about 60% of those aged 19 to 22 years who reported using marijuana in the past 12 months (but had not used marijuana by 12th grade) used it on 1 to 5 occasions (61% in 2013–2015 and 62% in 2010–2012). About 12% of those who used marijuana in the past 12 months reported more frequent

TABLE 2—Predictors of Past 12-Month Marijuana Use for Adults Aged 19–22 Years Who Had Never Used Marijuana by 12th Grade, by College Enrollment and Year: Monitoring the Future Study, United States, 1977–2015

Variable	1977–2015 (n = 55 265), coefficient (SE)		2010–2015 (n = 7316), coefficient (SE)	
	Model 1	Model 2	Model 3	Model 4
Currently enrolled in 4-y college	0.200** (0.022)	0.160** (0.023)	0.160* (0.069)	0.150* (0.071)
No. survey years since 2013 ^a	0.028 (0.036)	0.026 (0.030)	-0.010 (0.036)	-0.012 (0.036)
(In college) × (no. survey years since 2013) ^a	0.071* (0.036)	0.074* (0.036)	0.093* (0.045)	0.093* (0.045)
Age	0.340** (0.026)	0.340** (0.026)	0.300** (0.076)	0.300** (0.076)
Age ²	-0.076** (0.008)	-0.077** (0.008)	-0.053* (0.023)	-0.053* (0.023)
Woman		-0.150** (0.024)		-0.120* (0.058)
Parent with college degree		0.170** (0.025)		0.100 (0.062)
Black		-0.160** (0.043)		0.025 (0.110)
Hispanic		-0.190** (0.052)		-0.020 (0.098)
Other race		-0.250** (0.049)		0.099 (0.090)
Constant	-2.270** (0.023)	-2.200** (0.029)	-2.210** (0.070)	-2.190** (0.089)

^aThe variable “No. survey years since 2013” is coded 1 for the year 2013, 2 for 2014, 3 for 2015, and 0 otherwise.

* $P < .05$; ** $P < .01$.



^aThe line for “Not in college” represents 3 lines on top of each other (2013, 2014, and 2015).

FIGURE 2—Predicted Levels of Past-Year Marijuana Use Among Respondents Who Had Never Used Marijuana by 12th Grade, by Age, Survey Year, and College Enrollment for (a) 1977–2012 and (b) 2013–2015: Monitoring the Future Study, United States, 1977–2015

use and use on 40 or more occasions (12% in 2013–2015 and 13% in 2010–2012).

DISCUSSION

We examined whether college attendance has recently grown as a risk factor for marijuana initiation, much as college is a known risk factor for alcohol use. The year 2013 was of central interest because it marked a watershed year when tolerance for recreational marijuana use increased to an unprecedented high level and has since remained there. Less social proscription of marijuana use raises the possibility that since 2013 the college-related factors that promote use of substances such as alcohol may now extend their reach to marijuana initiation.

Results indicate that college has indeed become a substantially stronger risk factor for marijuana initiation since 2013. Before 2013 youths in college who had never used marijuana by 12th grade were 17% to 22% more likely to use marijuana in the past 12 months than were their age peers not in college. This higher relative risk steadily increased and more than doubled in the following years: to 31% in 2013, 41% in 2014, and 51% in 2015.

New marijuana initiates in 2013 and afterward used marijuana at similar frequencies

and intensity as did initiates from earlier years. The majority used marijuana just a handful of times, although about 12% reported a higher frequency of 40 or more occasions in the past year. These results suggest that within the group of new initiates are a percentage who will eventually become addicted to the drug to the extent that initiation opens the door for a small but substantial percentage to become dependent.²⁶ Other potential adverse effects of marijuana use, particularly high levels of use, include nonreversible neuropsychological decline,²⁷ heightened risk for progression to use of other drugs,²⁸ truncated educational attainment,²⁹ and respiratory disease.¹⁹

Our results serve as an early alert for a trend that is currently small but primed to grow. The significant increase in marijuana initiation among college students does not yet register in population surveillance systems of marijuana prevalence, nor would it be expected to register. Only about 33% of the total college-aged population aged 19 to 22 years consists of college students who enter without lifetime marijuana experience, because about 50% of college-aged young adults are in college, and of these about 65% entered without previous marijuana use ($33\% = 0.50 \times 0.65$).¹³ Consequently, even a large increase in marijuana initiation among college students over the past few years will

have a muted impact on change in prevalence for this overall age group.

In the coming years the trend could have an increasingly larger impact on population prevalence of marijuana to the extent that (1) it continues and (2) its impact cumulates over time. Current indications are that the trend will continue and possibly grow stronger. Population attitudes continue to grow increasingly accepting of recreational marijuana use, as indicated by current support for marijuana legalization at its highest level ever recorded at 60%.³ These high levels of support have resulted in the recent passage of marijuana legalization in California, Nevada, Massachusetts, and Maine. The more states that legalize recreational marijuana use the stronger the associated signal that marijuana is safe and state sanctioned, which may bolster the college-specific factors that foster marijuana initiation.

The impact of this trend on overall population marijuana prevalence could grow over time to the extent that it cumulates over successive cohorts. The level of marijuana use that a cohort develops by young adulthood follows it as it ages. This is demonstrated by the baby boom cohort, which developed a uniquely high level of marijuana use in college and then continued to register the highest levels of marijuana

use ever recorded for a birth cohort as it aged into adulthood.⁴ A substantial portion of youths who initiate marijuana use in college will likely continue to use marijuana as they age, which could result in a gradual, cumulative increase in the overall prevalence of marijuana use in the coming years.

In terms of theory, our results indicate a shift in the age range of marijuana initiation toward young adults; the research on marijuana initiation should therefore expect an increasing role for initiation predictors specific to young adulthood, such as living without parental supervision and peer influence in young adulthood.³⁰ An important direction for future research will be extending the existing work^{31,32} to specify in more detail the factors that lead college youths to initiate marijuana use, ideally factors that are actionable. Information on the factors that lead undergraduates to cross the psychological and social barriers involved in using marijuana for the first time can inform policy to help delay, perhaps permanently, a path that for some will lead to marijuana dependence.

In terms of policy, our results point to marijuana initiation as an outcome for current college substance abuse programs to consider. Most college-based efforts to reduce substance abuse focus on binge drinking, and recent work has begun to investigate the extent to which these efforts can be adapted to target marijuana use.³³ For example, the first 6 weeks of freshman year are a peak time for binge drinking and therefore also a key period for efforts to reduce alcohol use; whether the same is true for marijuana is an open question that warrants research. To the extent that marijuana initiation among college students continues to increase, the development and implementation of college-based prevention or intervention efforts to address this rise will become increasingly important.

Strengths and Limitations

We note 3 limitations of this study. First, the data do not include youths who dropped out of school by 12th grade. Consequently, although the results generalize to the more than 90% of the college-aged population that currently completes high school,³⁴ they do not generalize to high school dropouts, who warrant separate study with

other data to examine their recent trends in marijuana use.

A second limitation is that the composition of college students has changed substantially in the past 4 decades as college enrollment has increased, particularly for women, and these compositional changes will potentially affect study results. Confidence in the study findings is bolstered by robust results after controlling for sociodemographic characteristics and also when the analysis was restricted to the years 2010 to 2015, a short period not subject to large compositional changes of college student enrollment.

Finally, sample sizes in the panel surveys are too small to support analyses of specific states that have legalized recreational marijuana use, a topic for future examination with other data sources.

Conclusions

College has grown into a substantial risk factor for marijuana initiation since 2013. College students have played a central role in population marijuana use increases of the past, and our results show they are in position to usher in new increases for the US population in the coming years if efforts to address marijuana use are not soon made on college campuses. **AJPH**

CONTRIBUTORS

R. A. Miech conceptualized the study, performed all statistical analyses, and drafted the article. M. E. Patrick, P. M. O'Malley, and L. D. Johnston critically revised the article for important intellectual content. All authors interpreted the data and approved the final article as submitted.

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HUMAN PARTICIPANT PROTECTION

The University of Michigan institutional review board approved this study.

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