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The Growing Transition from Lifetime Marijuana Use to Frequent Use among 12th Grade Students: U.S. National Data from 1976 to 2019

Yvonne M. Terry-McElrath[a], **Patrick M. O'Malley**[a], **Lloyd D. Johnston**[a]

[a]Institute for Social Research, University of Michigan, PO Box 1248, Ann Arbor, MI 48106-1248 USA

Abstract

Background—More United States adolescents now report high-frequency marijuana use than similar use levels of alcohol or tobacco. Increased high-frequency use raises questions such as (a) is frequent use likelihood growing among adolescents who experiment with use? (b) Is such change observed equally across sex and racial/ethnic subgroups? (c) Have sociodemographic and other covariate associations with frequent use changed over time?

Methods—Data were obtained from 649,505 12th grade students participating in the cross-sectional, nationally-representative Monitoring the Future study from 1976–2019. Historical trends were modeled for any and frequent (20+ occasions) past 30-day marijuana use among all students and lifetime users, and lifetime user sex and racial/ethnic subgroups. Multivariable logistic regression estimates from 1989–1993 (lowest prevalence years) versus 2015–2019 (most recent years) were compared to examine covariate association changes with frequent use.

Results—Among all students, recent linear trends in any and frequent marijuana use were not significantly different from zero (0.023 [SE 0.156] and 0.036 [0.073], respectively); frequent use among lifetime users increased (0.233 [0.107], p=0.048). Among lifetime users, the increase was stronger for male than female students, and for minority versus White students. Significant association changes with race/ethnicity, parental education, and perceived risk were observed.

Conclusions—The proportion of adolescent lifetime marijuana users reporting current frequent marijuana use increased, and is now at near-record levels. Increases were particularly strong among males and minority students. There appears to be an increasing likelihood that adolescents who experiment with marijuana use may progress to frequent use.

*Corresponding author: Telephone: 734-647-9142. yterry@umich.edu.

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Keywords

Marijuana; cannabis; frequent use; sex; race/ethnicity; adolescent

1. Introduction

High frequency marijuana use is a recognized public health concern (National Academies of Sciences, Engineering, and Medicine [NASEM], 2017; Volkow et al., 2014), particularly if it begins during adolescence (Office of the Surgeon General, 2019). Changes in United States (U.S.) adolescent substance use patterns have resulted in marijuana prevalence now being second only to that for alcohol (Miech et al., 2019a). Since 2016, more U.S. 12th grade students have reported high frequency use of marijuana than similar use of cigarettes or alcohol (Miech et al., 2019a). Such relative increases in high frequency marijuana use may be associated simply with the changing adolescent substance use landscape (i.e., decreasing overall alcohol and cigarette use prevalence), but increased high frequency marijuana use also may indicate the likelihood of becoming a frequent marijuana user is growing among adolescents who ever experiment with use. If so, questions arise as to if such increases are observed across key demographic subgroups, and if the primary risk factors associated with high frequency marijuana use among lifetime users have changed meaningfully over time.

National U.S. trends indicate that current alcohol and cigarette use among adolescents has been decreasing since the early 2000s (Miech et al., 2019a; SAMHSA, 2019a); adolescent use of illicit drugs other than marijuana has declined since the mid-2000s (Miech et al., 2019a). Adolescent marijuana use has not followed a similarly consistent downward trend. For example, National Survey on Drug Use and Health data for past-year marijuana use among adolescents age 12–17 indicated no significant differences in prevalence between 2005–2008 and 2014–2018 (SAMHSA, 2019a); national Monitoring the Future (MTF) data showed that, among 12th grade students, past 30-day marijuana use fluctuated only about 3 percentage points across 2009–2018 (starting at 20.6%, rising to 22.9%, and ending at 22.2%; Miech et al., 2019a). Heavier use trends have followed similar patterns (Mauro et al., 2018); decreases in alcohol and cigarette use have far out-paced those for marijuana, leading to higher heavy marijuana use than heavy alcohol or cigarette use. MTF data indicate that, as of 2018, 5.8% of 12th grade students reported frequent (hereafter defined as use on 20+ occasions in the past 30 days) marijuana use, compared with 3.6% reporting daily cigarette use and 1.2% reporting frequent alcohol use (Miech et al., 2019a).

Many of the recognized health concerns related to marijuana use are particularly problematic during adolescence, a period of dramatic change in biological, cognitive, psychosocial, and emotional development (NASEM, 2019). There is moderate or substantial evidence that cannabis use is associated with cognitive impairment (in domains of learning, memory, and attention), poor respiratory symptoms, and motor vehicle crashes (NASEM, 2017). High frequency cannabis use is particularly associated with increased suicidal ideation and suicide attempts, development of schizophrenia or other psychoses, social anxiety disorder, and development of problem cannabis use (NASEM, 2017). To the degree that adolescents who initiate marijuana use may be increasingly likely to progress to frequent marijuana use, these

negative health outcomes and associated public health burdens may become more likely among lifetime users.

Change in the likelihood of becoming a frequent marijuana user may reflect meaningful change in risk factors associated with such use. There is a substantial literature on sociodemographic risk factors associated with adolescent marijuana use (any and frequent use), including sex; race/ethnicity; socioeconomic status; family structure; social ties such as evenings out per week, religiosity, academic involvement, and truancy; perceived risk; population density; region; etc. (Bachman et al., 2008; Johnston, 1981; Johnston et al., 2019; Miech et al., 2019a; Peters et al., 2018; Romano et al., 2019; Terry-McElrath et al., 2017b; Varma et al., 2017). Research during the late 1970s indicated that frequent use risk among 12th grade students was higher among males (vs. females), White students (vs. Black students), employed students, those with lower academic grades and higher truancy, lower religiosity, and more frequent weekday evenings out for fun (Johnston, 1981). There is some evidence for change over time in these associations, particularly for sex and racial/ethnic differences. While adolescent males consistently reported higher marijuana use prevalence than females in the past, sex differences have decreased (Johnson et al., 2015; Johnston et al., 2019; Miech et al., 2019a; SAMHSA, 2019b). Regarding race/ethnicity, from the 1970s-1990s, current marijuana use prevalence was consistently and significantly lower among Black than White adolescents (Miech et al., 2019a, 2019b). Since the mid-2000s, adolescent marijuana use has increased significantly among racial/ethnic minorities (particularly for adolescents identifying as either Black or Hispanic) while remaining generally stable among White adolescents (Johnson et al., 2015; Johnston et al., 2019; Miech et al., 2019a). Current marijuana use prevalence is now at similar or significantly higher levels for Black than White adolescents, depending on the age ranges examined (Kann et al., 2018; Miech et al., 2019a). The degree to which trends in the likelihood of frequent marijuana use among lifetime users may be changing between males and females, and between different racial/ethnic groups, is unknown. In addition, significant policy changes have occurred that may affect the likelihood of progression from any lifetime use to frequent use, particularly state-level legalization of adult recreational use.

The current study focuses on change over time in both frequent marijuana use likelihood among adolescents who ever experiment with use, and in risk factor associations with frequent use among lifetime users. Specifically, this study uses national data from U.S. 12th grade students: (1) to model and compare historical change from 1976–2019 in any and frequent past 30-day marijuana use among all students and lifetime marijuana users; (2) to model and compare frequent use trends among lifetime users by sex and race/ethnicity; and (3) to examine historical change in covariate associations with frequent use among lifetime users using two five-year subgroups: 1989–1993 (years of lowest prevalence) and 2015–2019 (most recent years).

2. Methods

2.1. Sample

Analyses used data from the MTF study; detailed methodology is available elsewhere (Bachman et al., 2015; Miech et al., 2019a). MTF annually surveys nationally representative

cross-sectional samples of 12th grade students in the coterminous U.S., resulting in approximately 15,000 students from 125 schools surveyed per year. Informed consent was obtained; a University of Michigan Institutional Review Board approved the study. Surveys were administered in classrooms by study personnel; students self-completed items during a normal class period. Data from were collected from 1976–2019. Student response rates averaged 82.4% (range 77%−86%); absenteeism was the primary reason for nonresponse (<2% refused participation; Miech et al., 2019a). A total of 679,724 12th grade students responded to MTF surveys during 1976–2019. Valid data on past 30-day marijuana use were available for 649,505 students (95.6%); 311,168 reported lifetime marijuana use. See Supplement Figure 1 for analytic sample flowchart.

2.2. Measures

2.2.1. Substance use—Respondents were asked about the number of occasions (if any) they used marijuana/hashish during their lifetime and the last 30 days. Response options included 0 occasions, 1–2, 3–5, 6–9, 10–19, 20–39, and 40+ occasions. Two dichotomous measures were coded for analysis: (1) any 30-day use, and (2) any frequent (20+ occasions) 30-day use. Use of a 20+ occasion definition for frequent use was based on the national and international literature examining risks of daily or almost daily marijuana use (e.g., EMDCCA, 2013; Johnston, 1981; Terry-McElrath et al., 2017a; van der Pol et al., 2011; Volkow et al., 2014). Sensitivity analyses explored other coding options (i.e., 10+ occasions). Trends for 10+ occasions were generally similar to those observed for 20+ occasions, but with notably larger variance estimates.

2.2.2. Other covariates—Covariates were selected based on prior research examining correlates of adolescent marijuana use (Bachman et al., 2008; Brown et al., 2001; Miech et al., 2019a; Johnson et al., 2015; Johnston, 1981; Johnston et al., 2019; Peters et al., 2018; Romano et al., 2019; Terry-McElrath et al., 2017b; Varma et al., 2017). All measures except population density, U.S. census region, legalization state, and year were self-reported. Sex was coded as male or female. Race/ethnicity was coded as Black or African American, Hispanic, White, or Other (combined due to sample size limitations; from 2006 onward, “Other” includes all students identifying as multi-racial). Parental education (used as a proxy for socioeconomic status) indicated at least one parent completed college. Number of parents in the home indicated that the student lived with two parents. Religious commitment (high, medium, or low) was a combination of two items: importance of religion (responses of not important, a little important, pretty important, very important) and frequency of attendance at religious services (responses of never, rarely, 1–2 times/month, weekly or more). College plans indicated that the student responded “definitely will” to being asked how likely they were to graduate from a four-year college program. Average grades indicated that students reported their high school grades to date averaged B or higher. Hours of work indicated that students reported they usually worked any weekly hours (vs. none) at either paid or unpaid jobs. Weekly income combined responses to how much money during an average week students obtained from job/other work and other sources (allowances, etc.), was adjusted to 2018 dollars using the CPI-US-RS, and was scaled by $10s for analysis. Evenings out indicated that students reported an average of 3+ evenings out per week for fun and recreation. Truancy indicated any days of school skipped or “cut” within the past four

weeks. Perceived risk indicated that students responded great risk (vs. no/slight/moderate risk) to the question, “how much do you think people risk harming themselves (physically or in other ways) if they use marijuana regularly?” Population density was based on the location of the high school attended, and coded as large metropolitan statistical area (MSA), other MSA, or non-MSA. Region was coded as Northeast, Midwest, South, or West. Legalization state was a dichotomy indicating if the high school attended was in a state that had legalized adult recreational marijuana use as of August 2019 (AK, CA, CO, DC, IL, MA, ME, MI, NV, OR, VT, WA). For trend models, year was coded in 2-year increments (beginning with 1976–1977, ending with 2018–2019). For the 5-year subgroup models, individual year dummies were used.

2.3. Analysis

Analyses used SAS 9.4 (SAS Institute, Inc., Cary NC) and Joinpoint 4.7.0.0 (National Cancer Institute, Bethesda, MD), accounted for the MTF complex sample design, and were weighted to account for differential selection probability. To model historical trends in any and frequent 30-day marijuana use (Research Questions [RQ] 1 and 2) for each subpopulation of interest, the proportion of students reporting the specified use level in each 2-year period was estimated using SURVEYMEANS in SAS. Using the obtained estimates, trends were modeled using Joinpoint, wherein trend lines are connected together at “joinpoints,” where a significant change in linear slope occurs (Kim et al., 2000). Model selection (i.e., number and placement of joinpoints for each trend line) was based on permutation testing (NCI, n.d.a) with the goal of selecting the most parsimonious model. Joinpoint has been used to model MTF substance use and related risk behaviors in prior publications (e.g., Faden and Fay, 2004; Keyes et al., 2015; Patrick et al., 2017; Terry-McElrath and Patrick, 2018).

To examine historical change in covariate associations with frequent marijuana use (RQ3), cases were limited to the five years of lowest prevalence (1989–1993) and latest five years (2015–2019). First, logistic regression models examined covariate associations with frequent marijuana use using SURVEYLOGISTIC for each 5-year subgroup separately. Then, both subgroups were combined, and a single logistic regression model was run including all covariates, a dichotomous indicator for subgroup membership, and interaction terms of subgroup membership and each covariate. Missing data on covariates were addressed by using multiple imputation (PROC MI) with fully conditional specification and PROC MIANALYZE with 20 multiply-imputed datasets.

3. Results

3.1. Trends in any and frequent past 30-day marijuana use

Trends in past 30-day prevalence of any and frequent marijuana use among all students and lifetime marijuana users are provided in Figure 1; slope estimates and *p*-values are provided in Table 1. A marked decrease in the modeled prevalence of any 30-day use among lifetime users was observed from 1976–1977 through 1986–1987; similar decreases for frequent use among lifetime users, and for both any and frequent 30-day use among all students, were observed from 1976–1977 through 1990–1991. For example, Slope 1 for any 30-day use

among lifetime users was −4.311, indicating that estimated use decreased by a rate of 4.3 percentage points per 2-year grouping from 1976–1977 to 1986–1987 (see Table 1). The modeled slope of any 30-day prevalence among lifetime users then increased from 1986–1987 through 2018–2019 (Slope 2), indicating that across these years, a decreasing number of lifetime users desisted from current use. Frequent use among lifetime users, and both any and frequent use among all students, increased to some degree from 1990–1991 through the late 1990s (Slope 2). From the late 1990s through 2018–2019, trends in any and frequent use among all students were essentially flat (Slope 3 values of 0.023 and 0.036, respectively, not significantly different from zero). In contrast, the percentage of lifetime users reporting frequent use increased from 1996–1997 through 2018–2019 (Slope 3=0.233). By 2018–2019, 6.1% (SE 0.33) of all students reported frequent use. Among lifetime users, the percentage reporting frequent use in 2018–2019 was 14.0% (SE 0.62)—the highest observed since the late 1970s—representing an almost three-fold increase from the low of 5.4% (SE 0.30) observed in 1990–1991 and an 80% increase from the 11.3% (SE 0.50) observed in 1996–1997.

3.2. Sex and racial/ethnic trend differences: lifetime users

Frequent marijuana use prevalence trends among lifetime users are presented by sex in Figure 2 and race/ethnicity in Figure 3. Slope estimates and *p*-values are provided in Table 1.

Frequent use among both male and female lifetime users followed the general pattern observed among lifetime users combined: decreasing from 1976–1977 through the end of the 1980s (1988–1989 for females; 1990–1991 for males), and sharply increasing over the next 10 years for females (through 1998–1999) and the next six years for males (through 1996–1997). From then through 2018–2019, frequent use continued to increase (but at lower rates) for both males and females. Males showed a significant increase from the late 1990s through 2018–2019 (Slope 3= 0.309); females increased but not significantly so (Slope 3= 0.139). By 2018–2019, 9.3% (SE 0.63) of females and 17.4% (SE 0.74) of males who were lifetime users reported frequent use.

Frequent use trends among lifetime users for all four racial/ethnic groups exhibited strong decreases from 1976–1977 through the late 1980s/early 1990s. Among Black, Hispanic, and White students, frequent use then increased sharply for the next six to ten years (through 1988–1989 for Hispanic students; through 1990–1991 for Black and White students). Modeled trends for frequent use then increased consistently through 2018–2019 for both Black and White students, but at a stronger rate of increase for Black students (Slope 3 values of 0.582 and 0.229, respectively). Among Hispanic students, frequent use decreased from 1998–1999 through 2006–2007 (Slope 3= −0.395), but then increased through 2018–2019 (Slope 4=0.500). Among Other racial/ethnic students, the modeled trend for frequent use increased consistently from 1988–1989 through 2018–2019 (Slope 2=0.421). By 2018–2019, the percentage of lifetime users reporting frequent use was 10.9% (SE 1.14) among Hispanic students, 13.2% (SE 0.81) among White students, 15.1% (SE 1.25) among Other racial/ethnic students, and 15.4% (SE 1.63) among Black students (the highest percentage ever observed among Black students).

3.3. Historical change in covariate associations with frequent use

As noted in section 2.3, analyses focusing on covariate associations were limited to two five-year subgroups: 1989–1993 and 2015–2019. Descriptive statistics for 2015–2019 among lifetime users are reported in Table 2 (see Supplement Table 1 for all students). Table 3 provides multivariable logistic regression model results for 2015–2019 and 1989–1993 as well as results of testing for significant differences in covariate association strength between the two 5-year subgroups for lifetime users (see Supplement Table 2 for all students).

Several covariate associations with frequent marijuana use among lifetime users were consistent in both direction and overall significance for both 1989–1993 and 2015–2019. No significant year group interactions (Table 3 Comparison p [Cp] >0.05) were observed, indicating the associations were robust across time. Frequent use likelihood was significantly higher for students reporting the following: being male (vs. female), low or medium religious commitment (vs. high), no definite plans to graduate from a 4-year college (vs. having such plans), grades below a B (vs. B or higher), any weekly work (vs. none), 3+ evenings out per week (vs. 0–2), and any truancy (vs. none). No significant differences in frequent use likelihood were observed between White or “other” racial/ethnic students, or based on population density or region.

For two covariates (White vs. Hispanic students; students living in legalization vs. non-legalization states), no significant year group interactions were observed (Cp>0.05), but association significance varied between year subgroups. Such findings indicate no clear implications regarding association change/stability across time can be derived. In 2015–2019, Hispanic students reported significantly lower odds of frequent use than White students; no significant differences in the odds of frequent use were observed based on residence in legalization states.

For the remaining covariates, significant year group interactions were observed (Cp<0.05), indicating a significant change across time in the covariate’s association with frequent marijuana use among lifetime users. Association strengthening was observed for number of parents in the household (Cp=0.045) and weekly income (Cp=0.002). In both 1989–1993 and 2015–2019, the likelihood of frequent marijuana use was significantly higher for lifetime marijuana-using students in households with fewer than two parents (vs. two parents) and students with higher total weekly incomes. However, these associations were significantly stronger in 2015–2019 than in 1989–1993. Association weakening was observed for perceived risk (Cp<0.001). In both 1989–1993 and 2015–2019, the likelihood of frequent marijuana use was significantly lower for lifetime marijuana-using students who perceived great risk in using marijuana regularly; however, this weakened from AOR 0.15 (1989–1993) to AOR 0.43 (2015–2019). Association reversal was observed for White versus Black students (Cp<0.001) and parental education (Cp=0.002). In 1989–1993, the likelihood of frequent use among those with a history of lifetime marijuana use was significantly lower for Black than White students (AOR 0.55); by 2015–2019, Black students were significantly more likely to report frequent use (AOR 1.33). Students reporting at least one parent with a college degree in 1989–1993 were significantly more likely to report frequent use than students without a parent with a college degree (AOR 1.15); by 2015–2019, the likelihood of

frequent use was significantly lower for students with at least one parent with a college degree (AOR 0.89).

4. Discussion

This study provides evidence that while any and frequent marijuana use among all U.S. 12th grade students have remained statistically stable over the last two decades, the proportion of lifetime users reporting frequent use by 12th grade has been increasing, and is now at the highest levels observed since the late 1970s. Increases have been particularly strong among males and non-White students. Frequent use among Black lifetime marijuana-using students is at the highest level recorded since data collection began in the mid-1970s. Covariate associations with frequent use reversed between Black versus White students, and higher versus lower parental education; associations with perceived risk weakened significantly. Marijuana use prevention and intervention efforts may need to address the increased likelihood that adolescents who ever initiate marijuana use will go on to frequent use.

The data indicated that 12th graders who ever initiated marijuana use not only grew less likely to desist from current use, but also more likely to report frequent use. Such changes may be associated with decreasing social stigma and increasing marijuana potency. The perceived risk of using marijuana has decreased markedly among adolescents (Miech et al., 2019a; Sarvet et al., 2018; Terry-McElrath et al., 2017b). The current study indicates that, among students who do perceive regular marijuana use as risky, the protective association between risk perceptions and frequent use has weakened significantly. Changes in perceived risk (a marijuana use stigma indicator) have coincided with state and local cannabis policy changes (Santaella-Tenorio et al., 2019; Schuermeyer et al., 2014; Terry-McElrath et al., 2018). Growing social acceptance of marijuana use has been evidenced by movement away from strong prohibition policies of the 1980s to an increasing number of policies supporting marijuana diversion to treatment and medicalization (beginning in the 1990s), decriminalization (the late 2000s) and recreational legalization (the 2010s) (McBride et al., 2017). Along with increasing social acceptance, policy change also has brought decreased legal risk of arrest, prosecution, and penalty severity for those over age 21 (Terry-McElrath et al., 2018). Such changes may result in adolescents not only feeling less pressure to desist from use, but also being more likely to progress to frequent use. At the same time, average marijuana potency has increased (ElSohly et al., 2000, 2016). Increased potency may be associated with tolerance and dependence, which may result in a lowered likelihood of desisting from use and a higher likelihood of progressing to frequent use. Continued policy movement toward legalization of adult recreational use, as well as marketing and advertising efforts associated with both legalized medical and recreational marijuana markets, makes it likely that frequent use among lifetime adolescent users will continue to increase. These results highlight the importance of preventing marijuana use initiation, improving interventions supporting adolescents attempting to lower or quit use, and development of effective policies regulating product potency and marketing, particularly marketing attractive to youth.

The current study found frequent use trend increases were stronger for males than females, and for minority than White students. To the extent that frequent marijuana use among

lifetime adolescent users—particularly Black users—may be increasing, related outcomes may reflect coinciding increases as well. From 2004–2011, trends in marijuana-associated hospital emergency visits increased significantly; the largest increase occurred among Black individuals and adolescents age 12–17 (Zhu and Wu, 2016). Prior research has found stronger increases over time in any marijuana use prevalence among minority (particularly Black) versus White adolescents (Johnson et al., 2015; Johnston et al., 2019; Kann et al., 2018; Miech et al., 2019a).

Explanations of such differences have been hypothesized to relate to a variety of factors, including a narrowing of racial/ethnic differences in cigarette smoking—a strong predictor of later marijuana use (Miech et al., 2019b). Research among adults has found an increased risk of transition from first use to dependence for minorities (Lopez-Quintero et al., 2011). Among both adolescents and adults, cannabis use disorder is higher among minority individuals than White individuals (Han et al., 2017; Wu et al., 2016), but the likelihood of marijuana treatment program completion is significantly lower for Black and Hispanic users than White users (Mennis and Stahler, 2106; Saloner et al., 2014). Thus, the stronger increase in frequent marijuana use among adolescent racial/ethnic minorities observed in the current study may reflect an additive association of (a) stronger increases over time in any marijuana use among minorities due to growing similarities between racial/ethnic groups in behaviors such as cigarette use, and (b) an increased likelihood of transition to dependence/use disorder for minorities once marijuana use has been initiated. There is also some support for racial/ethnic and sex differences in response to marijuana policy change that may influence differences in frequent use likelihood trends among lifetime users. Williams et al. (2019) examined the likelihood of desisting from marijuana use among adult users based on (a) only the presence of, or (b) legal protection of retail medical marijuana dispensaries (RMMD). They found that desisting from use was not significantly associated with RMMD for females but was for males: minority males were likely to delay quitting if legal protections for RMMD were in place, while White males were found to delay quitting if RMMDs were present regardless of legal protections. Williams et al. (2019) hypothesized that such findings may extend to the potential impact of legal marijuana markets on the likelihood of continued marijuana use. If so, then males—particularly minority males—may be more likely to not desist from marijuana use in the presence of policies that support legal medical or recreational marijuana markets.

The reversal of association direction between parental education and frequent marijuana use has been observed in MTF data as a trend beginning at the end of the 1990s (Miech et al., 2019a). Research on associations between family socioeconomic status and adolescent marijuana use is mixed in regards to strength and direction (Hanson and Chen, 2007). One possibility behind the reversal observed in the current study may relate to the specific measure used: having at least one parent with a college degree. Twelfth-grade students from the 1989–1993 cohorts would likely have parents who were young adults during the mid-1960s to early 1970s: years of high young adult marijuana use, particularly among college students (Aikins, 2015). In contrast, 12^{th} grade students from the 2015–2019 cohorts would likely have parents who were young adults during the 1990s, years of comparatively high marijuana use disapproval (Keyes et al., 2011) and low use prevalence among both college and non-college young adults (Schulenberg et al., 2019). Research has shown

significant links between the marijuana use of parents (while they were adolescents) and that of their own adolescent children (Kerr et al., 2015). Further, research has found that the more parents share communications regarding their own use behaviors (present or past) or permissive attitudes with their emerging young adult children, the lower the likelihood of abstinence and higher the likelihood of more frequent use (Napper et al., 2016). Having at least one parent with a college education during 1989–1993 may be a marker for possibly more lenient parental attitudes toward marijuana use and actual use behavior, which may, in turn, have been associated with higher likelihood of frequent use among adolescents.

4.1. Strengths and Limitations

The results of the current study are subject to limitations. Results may not generalize to non-U.S. settings or to individuals who drop out of high school; lower educational attainment is associated with higher substance use, including marijuana use (Tice et al., 2017). While all data were obtained via self-report, self-report substance use data have been found to be reasonably reliable and valid under appropriate conditions, which the MTF study has striven to provide (Miech et al., 2019a; Brener et al., 2003; O'Malley et al., 1983). All data were cross-sectional; results cannot be interpreted as causal. Further, the current study does not examine the extent to which 12th grade frequent users may or may not desist from use after 12th grade. Limitations notwithstanding, the current study contributes significantly to understanding changes in the likelihood of adolescent frequent marijuana use among lifetime users, and covariate associations with such use, by using data from large, nationally representative samples of 12th grade students over more than four decades, from 1976–2019.

4.2. Conclusions

A shrinking percentage of adolescent lifetime marijuana users is desisting from current marijuana use, while a growing percentage is reporting frequent marijuana use in 12th grade. Subgroups with particularly strong rates of change in frequent marijuana use include males and minority students. Marijuana use prevention and intervention efforts need to address the increased likelihood that adolescents who ever initiate marijuana use may progress to frequent use.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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Highlights

- Frequent marijuana use has increased among U.S. 12th grade lifetime users.
- Males and minority students have shown the greatest increases in frequent use.
- Frequent use among Black students is at historically high levels.
- Associations between some covariates and frequent use have changed over time.

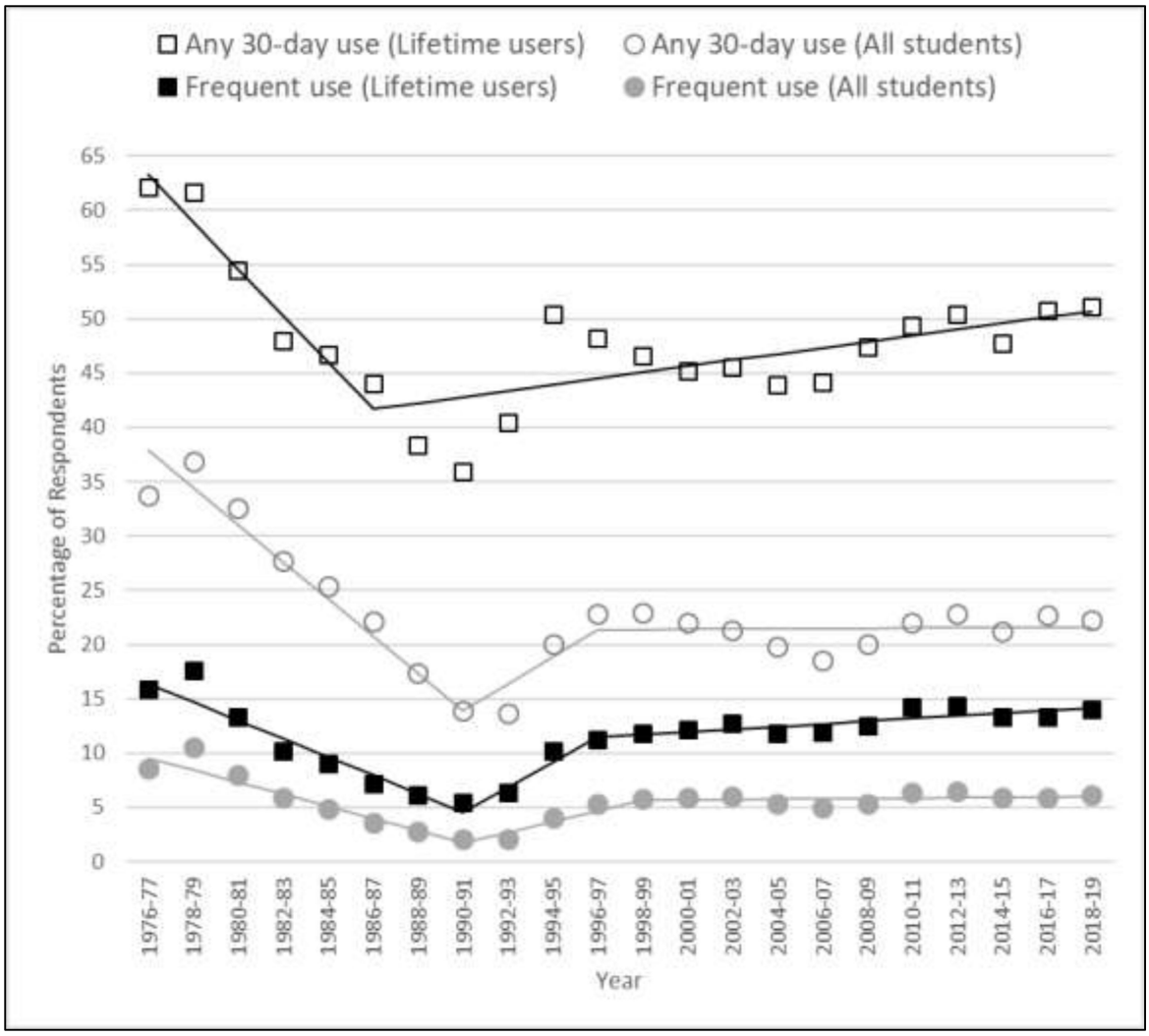

Figure 1. Modeled Trends in Past 30-Day Marijuana Use among 12th Grade U.S. Students, 1976–2019

Notes: Data reported using 2-year groupings. Frequent marijuana use defined as use on 20+ occasions in the past 30 days. Ns (unweighted) = 649,505 for all students; 311,168 for lifetime users.

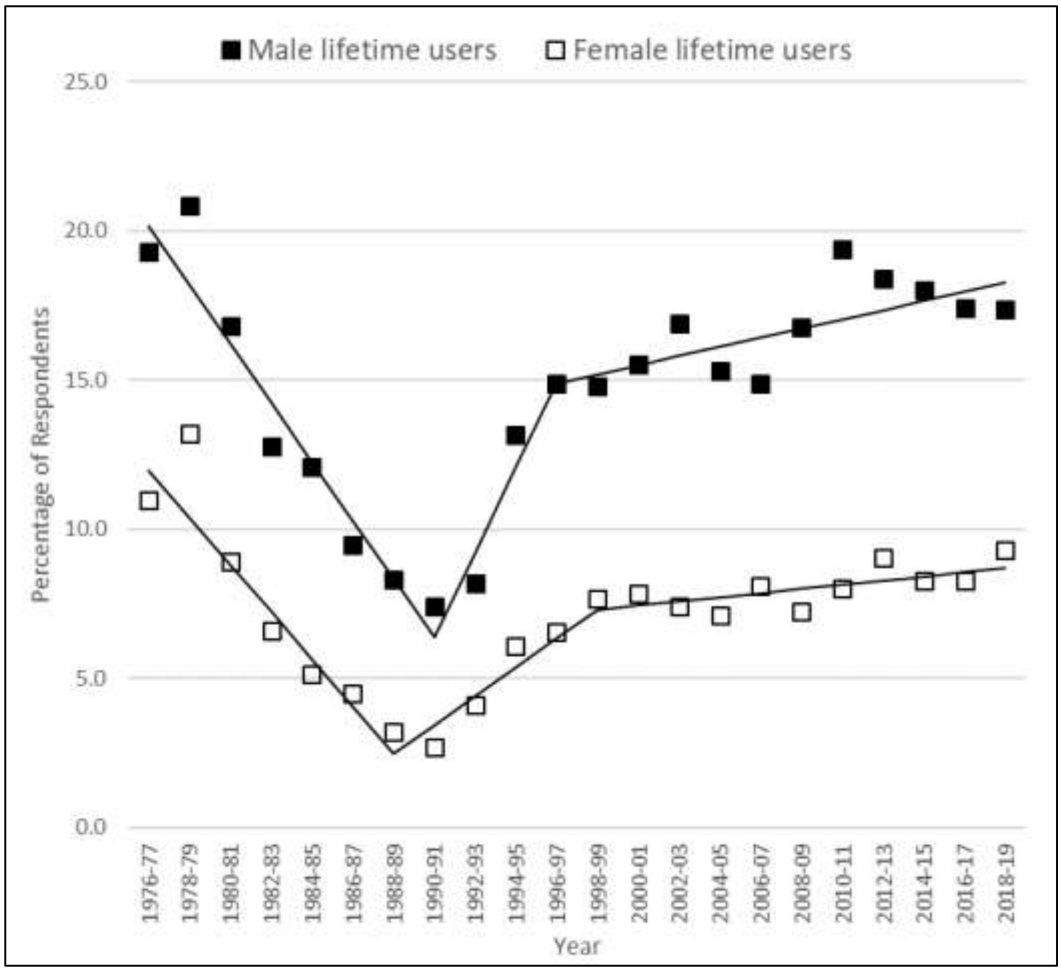

Figure 2. Modeled Trends in Frequent Marijuana Use Prevalence among Lifetime Marijuana Users by Sex: U.S. 12th Grade U.S. Students, 1976–2019

Notes: Data reported using 2-year groupings. Ns (unweighted) = 154,189 males; 143,375 females.

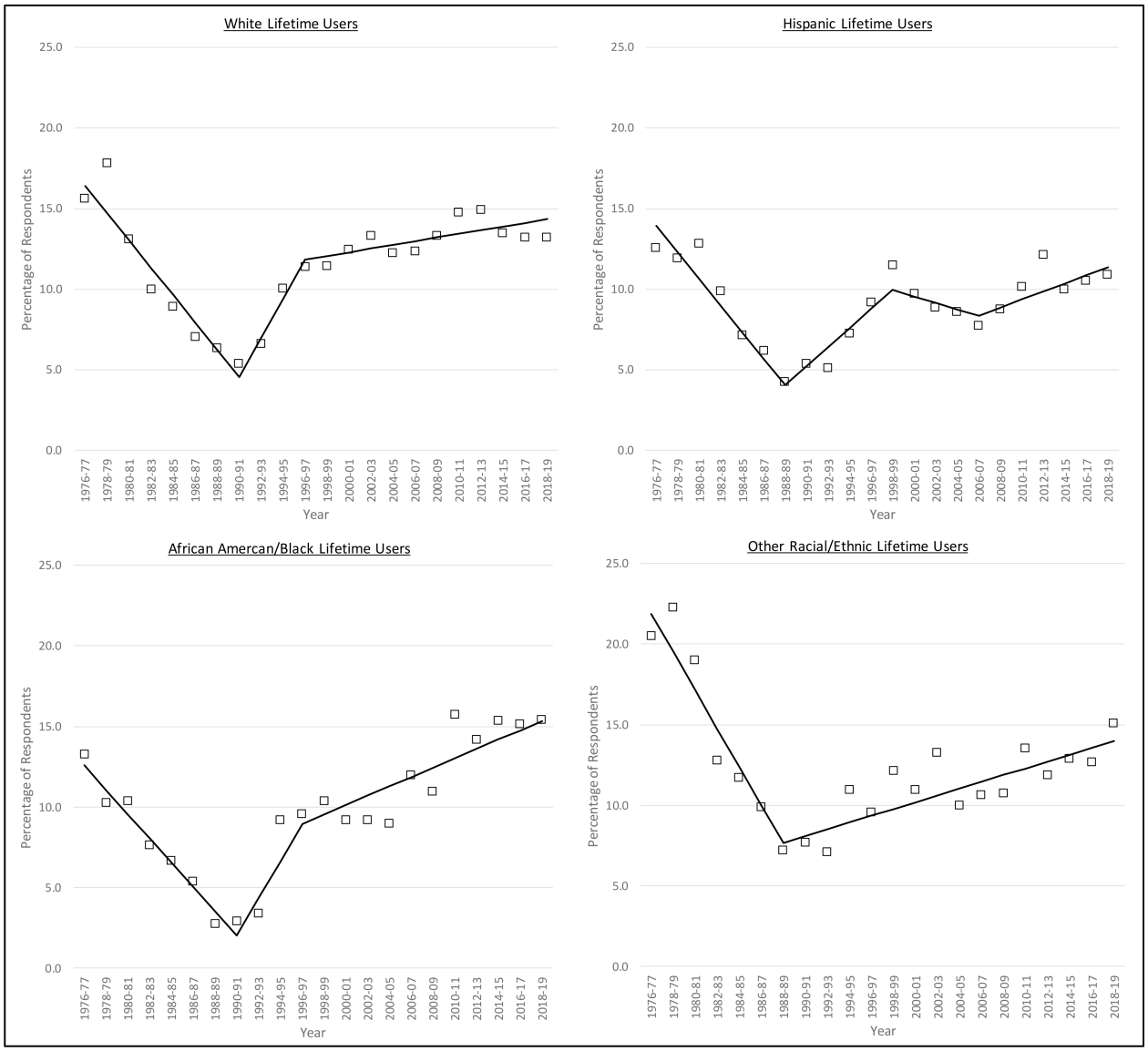

Figure 3. Modeled Trends in Frequent Marijuana Use Prevalence among Lifetime Marijuana Users by Race/Ethnicity: 12th Grade U.S. Students, 1976–2019

Notes: Data reported using 2-year groupings. Frequent marijuana use defined as use on 20+ occasions in the past 30 days. Ns (unweighted) = 216,733 White lifetime users; 28,188 Hispanic lifetime users; 31,913 African American/Black lifetime users; 22,689 Other racial/ethnic group lifetime users.

Table 1.

Slope Estimates for Historical Trends in Past 30-day Marijuana Use among 12th Grade U.S. Students, 1976–2019

	$N_{(total)}$	Slope 1 (SE) p [a]	JP [b]	Slope 2 (SE) p	JP	Slope 3 (SE) p	JP	Slope 4 (SE) p
All students								
Any 30-day use	649,505	**−3.429 (0.322) <*0.001***	1990–91	2.480 (1.941) *0.222*	1996–97	0.023 (0.156) *0.885*		
Frequent use [c]	649,505	**−1.114 (0.103) <*0.001***	1990–91	**0.972 (0.338) *0.012***	1998–99	0.036 (0.073) *0.630*		
Lifetime users								
Any 30-day use	311,168	**−4.311 (0.860) <*0.001***	1986–87	**0.563 (0.179) *0.006***				
Frequent use	311,168	**−1.689 (0.154) <*0.001***	1990–91	2.321 (1.279) *0.091*	1996–97	**0.233 (0.107) *0.048***		
Lifetime users by sex								
Females	143,375	**−1.581 (0.180) <*0.001***	1988–89	**0.965 (0.292) *0.005***	1998–99	0.139 (0.109) *0.224*		
Males	154,189	**−1.967 (0.203) <*0.001***	1990–91	2.835 (1.797) *0.137*	1996–97	**0.309 (0.135) *0.039***		
Lifetime users by race/ethnicity								
Black	31,913	**−1.510 (0.154) <*0.001***	1990–91	2.315 (1.377) *0.115*	1996–97	**0.582 (0.130) <*0.001***		
Hispanic	28,188	**−1.646 (0.283) <*0.001***	1988–89	**1.180 (0.428) *0.019***	1998–99	−0.395 (0.697) *0.582*	2006–07	**0.500 (0.183) *0.019***
White	216,733	**−1.695 (0.183) <*0.001***	1990–91	2.428 (1.542) *0.138*	1996–97	0.229 (0.143) *0.131*		
Other	22,689	**−2.366 (0.397) <*0.001***	1988–89	**0.421 (0.088) <*0.001***				

Notes: Bold font indicates slopes with t-test *p*-values <0.05.

[a] *p*-values of the slope changes are calculated from *t*-tests based on asymptotic normality; the number of joinpoints is calculated using a permutation test procedure not requiring asymptotic normality and maintaining correct Type I error probability.

[b] JP = Joinpoint, or year grouping in which significant change in slope occurred.

[c] Frequent use defined as use on 20+ occasions in the past 30 days.

Table 2.

Sample Descriptives for U.S. 12th Grade Lifetime Marijuana Users, 2015–2019

	% or Mean	(SE)		% or Mean	(SE)
Frequent marijuana use[a] (%)			Weekly work during school year (%)		
No	86.3	(0.39)	No hours	32.2	(0.70)
Yes	13.7	(0.39)	Any hours	67.8	(0.70)
Sex (%)			Weekly income from job/other sources[b] (mean)		
Female	50.5	(0.59)	In $10s	10.5	(0.12)
Male	49.5	(0.59)	Evenings out during week (%)		
Race/ethnicity (%)			0 to 2	56.5	(0.55)
White	52.6	(1.73)	3 or more	43.5	(0.55)
Black	12.1	(0.95)	Past 4-week truancy (%)		
Hispanic	21.2	(1.65)	No skipping	59.4	(0.86)
Other	14.1	(0.57)	Any skipping	40.6	(0.86)
Average parental education (%)			Perceive great risk in regular marijuana use (%)		
No college completion	51.2	(1.15)	No	83.8	(0.37)
1+ parent(s) completed college	48.8	(1.15)	Yes	16.2	(0.37)
Number of parents in household (%)			Population density (%)		
Fewer than two	40.2	(0.75)	Large MSA	34.0	(2.69)
Two	59.8	(0.75)	Other MSA	46.7	(2.64)
Religious commitment (%)			Non-MSA	19.3	(1.05)
Low	53.4	(0.80)	Region (%)		
Medium	27.8	(0.46)	Northeast	16.4	(1.22)
High	18.8	(0.53)	Midwest	21.8	(1.28)
4-Year college plans (%)			South	40.1	(1.69)
Other	46.1	(0.83)	West	21.6	(1.50)
Definitely plan to graduate	53.9	(0.83)	Legalization state[c] (%)		
Average grades (%)			No	70.1	(1.89)
Less than B	31.8	(0.68)	Yes	29.9	(1.89)
B or higher	68.2	(0.68)			

Notes: N (unweighted) = 28,188.

[a]Defined as use on 20+ occasions in the past 30 days.

[b]Range=$0 to $37.3 (given that this is reported in increments of $10, actual range is $0–$373).

[c]Defined as states with policy legalizing recreational marijuana use for individuals age 21 as of August 2019. Includes the following states: CA, CO, DC, IL, MA, ME, MI, NV, OR, VT, WA (because the MTF survey is not administered in Alaska, it is not included in this list).

Table 3.

Associations between Covariates and Frequent Marijuana Use among U.S. 12th Grade Lifetime Marijuana Users: 2015–2019 versus 1989–1993

	2015–2019 (*n* = 28,188)		1989–1993 (*n* = 29,875)		Comparison
	%[a]	AOR[b] (95% CI) *p*	%	AOR (95% CI) *p*	*p*[c]
Sex					
Female	9.2	(ref)	3.5	(ref)	
Male	18.2	1.72 (1.54, 1.91) *<0.001*	8.2	1.76 (1.49, 2.07) *<0.001*	*0.824*
Race/ethnicity					
White	13.7	(ref)	6.3	(ref)	
Black	16.4	1.33 (1.13, 1.56) *0.001*	3.5	0.55 (0.41, 0.75) *<0.001*	*<0.001*
Hispanic	11.2	0.71 (0.60, 0.84) *<0.001*	5.3	0.95 (0.74, 1.22) *0.668*	*0.058*
Other	14.8	1.05 (0.91, 1.21) *0.510*	7.3	1.11 (0.88, 1.41) *0.368*	*0.667*
Average parental education					
No college degree	14.8	(ref)	5.9	(ref)	
College degree	12.4	0.89 (0.81, 0.98) *0.015*	6.2	1.15 (1.00, 1.31) *0.043*	*0.002*
Number of parents in household					
Less than 2	17.0	(ref)	6.9	(ref)	
Two	11.4	0.71 (0.64, 0.78) *<0.001*	5.6	0.84 (0.73, 0.97) *0.017*	*0.045*
Religious commitment					
Low	16.5	1.89 (1.61, 2.23) *<0.001*	7.9	1.78 (1.42, 2.23) *<0.001*	*0.662*
Medium	12.0	1.37 (1.16, 1.62) *<0.001*	5.3	1.44 (1.15, 1.81) *0.002*	*0.740*
High	7.9	(ref)	2.8	(ref)	
4-Year college plans					
Other	17.8	(ref)	7.6	(ref)	
Definitely plan to graduate	10.1	0.68 (0.60, 0.76) *<0.001*	3.8	0.58 (0.50, 0.68) *<0.001*	*0.125*
Average grades					
Less than B	19.1	(ref)	7.4	(ref)	
B or higher	11.1	0.75 (0.68, 0.84) *<0.001*	4.5	0.86 (0.75, 0.75) *0.028*	*0.116*
Weekly work during school year					
No hours	12.5	(ref)	6.2	(ref)	
Any hours	14.2	0.74 (0.65, 0.83) *<0.001*	6.0	0.68 (0.55, 0.82) *<0.001*	*0.479*
Weekly income from job and other sources (average)					
In $10s		1.04 (1.04, 1.05) *<0.001*		1.03 (1.02, 1.04) *<0.001*	*0.002*
Evenings out during week					
0 to 2	9.5	(ref)	2.9	(ref)	
3 or more	19.1	1.97 (1.78, 2.17) *<0.001*	8.1	2.22 (1.87, 2.63) *<0.001*	*0.215*
Past 4-week truancy					
No skipping	10.4	(ref)	4.1	(ref)	
Any skipping	18.4	1.64 (1.49, 1.81) *<0.001*	8.7	1.57 (1.37, 1.80) <0.001	*0.604*
Perceive great risk in regular marijuana use					

	2015–2019 (*n* = 28,188)		1989–1993 (*n* = 29,875)		Comparison
	%[a]	AOR[b] (95% CI) *p*	%	AOR (95% CI) *p*	*p*[c]
No	15.2		12.8		
Yes	5.8	0.43 (0.35, 0.53) *<0.001*	1.7	0.15 (0.12, 0.18) *<0.001*	*<0.001*
Population density					
Large MSA	13.6	(ref)	5.9	(ref)	
Other MSA	13.1	0.91 (0.77, 1.07) *0.254*	5.9	1.07 (0.88, 1.29) *0.493*	*0.210*
Non-MSA	15.0	1.06 (0.88, 1.28) *0.540*	6.4	1.16 (0.92, 1.47) *0.209*	*0.549*
Region					
Northeast	14.4	1.15 (0.96, 1.37) *0.131*	6.6	0.99 (0.80, 1.23) *0.929*	*0.304*
Midwest	13.6	1.04 (0.86, 1.27) *0.673*	6.0	0.95 (0.75, 1.20) *0.664*	*0.545*
South	12.5	(ref)	5.4	(ref)	
West	14.9	1.19 (0.88, 1.60) *0.256*	6.4	0.88 (0.65, 1.19) *0.418*	*0.164*
Legalization state[d]					
No	13.0	(ref)	5.6	(ref)	
Yes	15.0	1.10 (0.87, 1.38) *0.426*	6.9	1.29 (1.00, 1.66) *0.048*	*0.351*

Notes: *ns* provided are unweighted. Frequent marijuana use defined as use on 20+ occasions in the past 30 days.

[a]% = Weighted unadjusted percentage of respondents reporting frequent marijuana use in each subgroup; i.e., 9.2% of female lifetime marijuana users reported frequent past 30-day marijuana use during 2015–19.

[b]AOR = adjusted odds ratios from models run separately for each 5-year subgroup simultaneously including all covariates shown as well as year (using dummy indicators).

[c]Comparison *p*-values from the interaction terms of group (0=1989–93, 1=2015–19) and each covariate from a single multivariable model including cases from both 5-year subgroups, simultaneously including direct effects of group, all covariates, and interaction terms.

[d]Defined as states with policy legalizing recreational marijuana use for individuals age 21 as of August 2019. Includes the following states: CA, CO, DC, IL, MA, ME, MI, NV, OR, VT, WA (because the MTF survey is not administered in Alaska, it is not included in this list).