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Recent rapid decrease in adolescents' perception that marijuana is harmful, but no concurrent increase in use

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Abstract

Background—National trends in adolescent's marijuana risk perceptions are traditionally used as a predictor of concurrent and future trends in adolescent marijuana use. We test the validity of this practice during a time of rapid marijuana policy change.

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Contributors

Aaron Sarvet and Melanie Wall had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. All authors participated in preparation and final approval of the manuscript.

Conflicts of Interest

There are no conflicts of interest declared by any author.

Role of Funding Source

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Methods—Two repeated cross-sectional U.S. nationally-representative surveys of 8th, 10th, and 12th-graders: Monitoring the Future (MTF) (1991–2015; N=1,181,692) and National Survey on Drug Use and Health (NSDUH) (2002–2014; N=113,317). We examined trends in the year-to-year prevalence of perceiving no risk of harm in using marijuana regularly, and prevalence of regular marijuana use within the previous month. A piecewise linear regression model tested for a change in the relationship between trends. Similar analyses examined any past-month use and controlled for demographic characteristics.

Results—Among MTF 12th-graders, the prevalence of regular marijuana use and risk perceptions changed similarly between 1991 and 2006 but diverged sharply afterward. The prevalence of regular marijuana use increased by ~1 percentage point to 6.03% by 2015. In contrast, the proportion of 12th-graders that perceived marijuana as posing no risk increased over 11 percentage points to 21.39%. A similar divergence was found among NSDUH 12th-graders and other grades, for any past month marijuana use, and when controlling demographic characteristics.

Conclusions—An increase in adolescent marijuana use has not accompanied recent rapid decreases in marijuana risk perceptions. Policy makers may consider broader prevention strategies in addition to targeting marijuana risk perceptions. Further monitoring of predictors of marijuana use trends is needed as states legalize recreational marijuana use.

Keywords

Adolescents; Marijuana; Epidemiology; Risk Perception

1. Introduction

In November 1996, California passed the first U.S. state law legalizing marijuana for medical use. Less than a year later, General Barry R. McCaffrey, Director of the Office of National Drug Control Policy (ONDCP), testified before the Senate Judiciary Committee on the Medical Marijuana Referenda Movement:

> "Whether intended or not, permitting the "medical" use of smoked marijuana will send the false and powerful message to our adolescents that marijuana use is beneficial. If pot is medicine, teenagers will rightfully reason, how can it hurt you? …No one should make the mistake of believing that increased societal acceptance of marijuana will not cause drug abuse to increase among our children" (1997).

The perceived harmfulness of marijuana is frequently cited as one of the most important protective factors preventing use among adolescents (Janz and Becker, 1984; Keyes et al., 2016; Piontek et al., 2013; Schmidt et al., 2016), which may pose deleterious risks to their health (Volkow et al., 2014) including addiction (Chen et al., 2009), altered brain development (Meier et al., 2012; Zalesky et al., 2012) and poor educational outcomes (Lynskey and Hall, 2000; Maggs et al., 2015), especially when use is frequent, i.e. nearly daily. During the decade after the ONDCP was established in 1988, increasing the perceived harmfulness of illicit drugs was the focus of multi-billion dollar national media campaigns (mandated by the National Narcotics Leadership Act of 1987) (1999) as well as large school-based substance use prevention programs (e.g., D.A.R.E.) (Rosenbaum, 2007). The Monitoring the Future Study – an ongoing national study of high school youth, launched in

1975 with the support of the National Institute of Drug Abuse director and former ONDCP director Robert Dupont – provided the earliest evidence of a strong inverse relationship between national trends in perceived harmfulness and marijuana use during the last quarter of the 20th century (Bachman et al., 1998; Bachman et al., 1988; Johnston et al., 1981). The national level of the perceived harmfulness of marijuana has been viewed as an important policy lever by law-makers and government executives (1986; 1997; 1999; 2000; Executive Office of the President of the United States, 2015).

However, since General McCaffrey's testimony in 1997, the legal context of U.S. marijuana use has changed dramatically. Twenty-eight states have now passed laws permitting individuals to receive marijuana for medical purposes legally, and as of 2016, eight of these states and the District of Columbia have additionally legalized adult recreational marijuana use. During these times of shifting legal policies towards marijuana, previous assumptions about the relationship between trends in the perceived harmfulness of marijuana and trends in adolescent use may no longer hold. One study recently observed divergence between trends in marijuana risk perceptions and marijuana use in Washington State (Fleming et al., 2016) but this relationship in the trends had not been systematically evaluated at the national level. In addition, the way in which perceived harm relates to marijuana use at the individual level may be changing. A recent study (Miech et al., 2017) concluded this relationship between perceived harm and any marijuana use was similar by year across the last two decades but did not consider more intense, risky levels of use.

National trends in adolescent marijuana use and risk perceptions are documented yearly in reports by the Monitoring the Future study (MTF) (Johnston et al., 2016) and the National Survey on Drug Use and Health (NSDUH) (Center for Behavioral Health Statistics and Quality, 2015b; Lipari et al., 2015). In the present study, using these two independent nationally representative samples of adolescents as replicable evidence, we directly examined whether the relationship between trends in perceived harmfulness of marijuana and concurrent trends in marijuana use has changed among high school seniors, a key transitional age representing the culmination of secondary school-based and parent-oriented substance use prevention efforts. Because of the potential differences in risk factors of marijuana use associated with the last year of high school, possibly due to preparation for college (Chen et al., 2016), we similarly examine whether these relationships have also changed for 8th and 10th-graders.

2. Methods

2.1 Sample

Responses from 8th, 10th, and 12th -grade students from the Monitoring the Future study (MTF) surveyed between 1991 and 2015 were analyzed (N=424,623 8th, N=387,170 10th, and N=369,899 12th-graders, ~15–17,000 per grade per year). The MTF is an annual nationally representative cross-sectional survey of substance use and health risk behaviors among students attending public and private schools in the 48 contiguous U.S. states with a participant response rate ranging from 79–91%. Consistent design methodology over time allows examination of historical trends. Data were collected from students at their schools during normal class periods via paper-and-pencil questionnaires. Participation was

confidential; some identifying information was collected from 12th-graders for follow-up purposes. Study administrators used standard procedures to maintain confidentiality. All study procedures are annually approved by University of Michigan's Institutional Review Board (Johnston et al., 2016).

For comparability with the MTF, 8th, 10th, and 12th -grade participants of the National Survey on Drug Use and Health (NSDUH) from the years 2002 to 2014 were also analyzed (N=38,339 8th, N=39,448 10th, and N=35,530 12th-graders, ~ 3,000 per grade per year). The school grade of NSDUH participants was identified based on the question, "What grade or year of school are you now attending?" If they were on vacation, then they were asked, "What grade or year of school will you be attending when your vacation is over?". The NSDUH is an annual cross-sectional national survey of the U.S. population over age 12 living in households and non-institutional group quarters, with consistent methodology on substance use from 2002 to 2014. This survey uses a multistage area probability sample for all 50 states and the District of Columbia with a response rate ranging 71–79%. Trained interviewers administered the survey using computer-assisted personal interviewing, supplemented by audio computer-assisted self-interviewing (ACASI) for questions on illicit drug use to provide participants with privacy and confidentiality when responding to questions about these and other sensitive behaviors (Substance Abuse and Mental Health Services Administration, 2003). Participants gave informed consent prior to being interviewed. Additional details on data confidentiality maintenance are provided elsewhere (Center for Behavioral Health Statistics and Quality, 2015b). Analyses in the current study are based on de-identified publicly available data exempt from Institutional Review Board approval.

2.2 Measures

Marijuana use within the previous 30 days was measured in MTF with the question: "On how many occasions (if any) have you used marijuana (weed, pot) or hashish (hash, hash oil) during the last 30 days?" Responses included, "0 occasions", "1–2 occasions", 3–5 occasions", "6–9 occasions", "10–19 occasions", "20–39 occasions", and "40 or more occasions." To capture daily (or near-daily) use, a binary individual-level variable was created for regular marijuana use (defined as 20–39 or 40 or more occasions of use) in the last 30 days vs. no or non-regular use. Of 8th, 10th, and 12th-grade students, 96.9% (N=411,274), 97.5% (N=377,491), and 95.8% (N=354,226) had non-missing marijuana use data, respectively. In NSDUH, marijuana use was ascertained by the ACASI question: "Have you ever, even once, used marijuana or hashish?" If yes then they were later asked: "How long has it been since you last used marijuana or hashish?" Responses included: "Within the past 30 days"; "More than 30 days ago but within the past 12 months"; and "More than 12 months ago". Another question asked about frequency: "During the past 30 days, on how many days did you use marijuana or hashish?" To harmonize with MTF frequency categories, a binary individual-level variable, was created as 20+ days of marijuana use in the last 30 days vs. no use or less than 20 days of use. Similar binary variables were constructed indicating any marijuana use during the last 30 days for both surveys. Missing values for past-month marijuana use in the NSDUH were imputed according to standard SAMHSA procedures (Center for Behavioral Health Statistics and Quality, 2015a).

Perceived harmfulness of regular marijuana use was measured in MTF with the question: “How much do you think people risk harming themselves (physically or in other ways) if they smoke marijuana regularly?” Response options included ‘no risk’, ‘slight risk’, ‘moderate risk’, and ‘great risk’. The MTF allowed responses of ‘can’t say, drug unfamiliar’, a response endorsed by an average of 2.72% of 12th-graders which remained relatively constant across the 25 years and was therefore treated as missing. Perceived harmfulness was included on four of six randomly assigned survey forms, and was available for N=380,971 8th, N=353,038 10th, and N=292,292 12th-grade students in the MTF. Perceived harmfulness of regular marijuana use was measured in NSDUH with the question: “How much do people risk harming themselves physically and in other ways when they smoke marijuana once or twice a week?” Response options similarly included ‘no risk’, ‘slight risk’, ‘moderate risk’, and ‘great risk’. We dichotomized the perceived harm item into those who perceived ‘no risk’ vs. ‘slight risk’, ‘moderate risk’ or ‘great risk’, enabling us to model the prevalence of those who perceived regular or weekly marijuana use to pose ‘no risk’ versus all others.

For comparing trends between “any” (as opposed to “regular”) past month marijuana use and marijuana risk perceptions, perceptions of risk in “occasional” (as opposed to “regular”) use of marijuana were chosen, since these perceptions more closely matched the “any marijuana use” behavior (12th-graders in MTF 1991–2015 who used marijuana at least once in the past month used it on a median of 3–5 occasions during that month). Perceived harmfulness of occasional marijuana use was measured in the MTF identically to perceptions about regular use, except the word “regularly” was replaced with the word “occasionally”. This question was asked on the same randomly assigned survey forms and was available for N=382,255 8th, N=353,643 10th, and N=292,578 12th-grade students in the MTF. Response options were identical, and the analytic variable was similarly dichotomized at ‘no risk’ vs. ‘slight risk’, ‘moderate risk’ or ‘great risk’. Similarly, a response of ‘can’t say, drug unfamiliar’ was endorsed by an average of 2.73% of 12th-graders across the 25 years and was therefore treated as missing. Perceived harmfulness of occasional marijuana use was measured in NSDUH with the question: “How much do people risk harming themselves physically and in other ways when they smoke marijuana once a month?” This question had identical response options and was similarly dichotomized.

The years of law passage for medical and recreational marijuana laws are included in figures to illustrate concurrent changes in state marijuana legislation over the study period. Designation of the year of passage for each of the 26 state medical marijuana laws is based on a review of state policies by a team of legal scholars, policy analysts and economists (Hasin et al., 2015; Pacula et al., 2014). Recreational laws were passed in Washington and Colorado in 2013, and in Oregon and Alaska in 2015. Several additional states passed medical and recreational marijuana laws in 2016 and after, but these were excluded from the figure because survey data were not yet available. Moreover, Alaska and Hawaii are not included in the MTF sample.

2.3 Statistical Analysis

Weighted prevalence and standard errors (SE) of 12th-graders' regular marijuana use in the past 30 days and perceptions that regular marijuana use poses no risk of harm were estimated in each year and plotted from 1991 to 2015 in MTF and from 2002 to 2014 in NSDUH. For each data source (MTF and NSDUH), the divergence of national trends between past-30-day regular marijuana use and perceived harm was tested by modeling the trend in the difference between the two and identifying the point at which the relationship between the two outcomes changed. A separate piecewise linear regression model (Marsh and Cormier, 2002) of the difference between use and perceived harmfulness was fit with a change point fixed at each year nearby the observed change in trend (each year from 2004 to 2009). The year was treated as continuous before and after the change point with the two linear slopes connected at the change point. For comparison, two more models were fit, one with a continuous year and no change point, and another with a categorical year. An optimal change point was identified to be the year corresponding to the model with the largest adjusted R-square.

To investigate whether the changing trend in the relationship between use and perceived harm also was present at different developmental ages (8^{th} and 10th-grade) and also at different levels of frequency of use, additional analyses were performed and compared: for 8^{th} graders, 10th-graders, and also among 12th-graders but replacing regular past-30 day marijuana use with any marijuana use in the past 30 days and replacing perceptions of risk in regular marijuana use with perceptions of occasional use.

Also to ensure that results of changing trends over time would not be explained by changing demographic makeup of the U.S. we performed additional analyses examining adjusted prevalence controlling for possible changes in the sample composition over time by including individual level gender (male vs. female), race/ethnicity (Hispanic vs. non-Hispanic white vs. non-Hispanic black vs. non-Hispanic Asian vs. non-Hispanic, more than 1 race vs. non-Hispanic other race), age (categorical, single-year groups), and urbanicity (within a standard metropolitan statistical area [SMSA] vs. not in a SMSA) as covariates. All statistical analyses were conducted using SUDAAN 11.0.1 (Research Triangle Institute, 2012).

3. Results

3.1 Monitoring the Future (1991–2015)

In 1991, the proportion of 12th-graders that used marijuana regularly in the past month (2.02% (SE=0.17%)) was nearly identical to the proportion that perceived its regular use to pose no risk of harm (2.77% (SE=0.21%). Over the next several years (Figure 1a), regular marijuana use increased nearly 4 percentage points, to a peak of 6.03% (SE=0.40%) in 1999. Over the same period, perceptions that regular marijuana use poses no risk increased similarly, to 6.35% (SE=0.37%). During the several years following 1999, regular marijuana use slightly decreased and regular marijuana use risk perception remained steady, such that by 2006, the prevalence of marijuana use in the past month and perceptions that regular

marijuana use poses no or slight risk were similar (4.96% (SE=0.35%) vs. 7.09% (SE=0.45%)).

Over the next 9 years, a striking divergence emerged between trends in perceived harmfulness of marijuana and trends in its use (Figure 1a). Regular marijuana use in the past month increased only slightly, by 1.07 percentage points to 6.03% (SE=0.43%) in 2015. In contrast, the prevalence of perceiving no risk of harm increased 3-fold, by more than 14 percentage points over this period. In 2015, more than one-fifth (21.39% (SE=0.97%)) of 12th-graders perceived regular marijuana use to pose no risk of harm. Hence, by 2015, about a third as many 12th-graders had regularly used marijuana in the past 30 days as had perceived regular marijuana use to pose no risk of harm.

All change point models fit better than a singular trend model. Each change point model indicated a statistically significant ($p<.001$) increased deviation in the trend in the relationship between prevalence of marijuana use and marijuana risk perception. Although several change point models fit similarly, the optimal fit was 2006 (Supplemental Figure 1 and Supplemental Table 1)[1].

3.2 National Survey on Drug Use and Health (2002–2014)

A similar recent divergence between trends in perception and use also emerged in NSDUH 12th-graders (Figure 1b). Between 2002 and 2008, the prevalence of past-month regular marijuana use decreased modestly from 6.02% (SE=0.56%) to 4.86% (SE=0.62%). Over this same period, the prevalence of perceiving no risk of harm in using marijuana once or twice a week changed similarly from 8.94% (SE=0.79%) to 8.84% (SE=0.69%). Between 2008 and 2014, the prevalence of past month regular marijuana use changed modestly, reaching 4.75% (SE=0.51%) in 2014, slightly less than levels in 2002. In contrast, the prevalence of perceiving no risk of harm in using marijuana once or twice a week increased slightly less than 3-fold by more than 15 percentage points. By 2014, almost one-quarter of 12th-graders (24.03%, SE=1.34%) perceived no risk of harm in using marijuana once or twice a week.

All change point models considered indicated a statistically significant increased change in trend ($p<.001$) in the later years and fit better than a single trend model. The optimal fit for the change-point models was found with change point in 2008 (Supplemental Figure 1 and Supplemental Table 1)[1].

3.3 Stratification at Different Developmental Ages and Frequency of Use

Results for 8th and 10th-graders (Supplemental Figures 2 and 3; Supplemental Tables 2 and 3)[2] were similar to 12th-graders, indicating the diverging trends are occurring at earlier developmental ages as well. When frequency of marijuana use was changed from daily/near-daily to just any past month use, and intensity of perception was changed from no risk of harm in regular use to no risk in occasional marijuana use, the diverging trends between use and perceived harm were similar (Supplemental Figure 4; Supplemental Table 4)[3].

[1]Supplementary material can be found by accessing the online version of this paper at http://dx.doi.org and by entering doi: ...
[2]Supplementary material can be found by accessing the online version of this paper at http://dx.doi.org and by entering doi: ...

Specifically, the prevalence of any marijuana use among MTF 12th-graders increased only very slightly between 2009 and 2015 (20.62% (SE=0.90%) vs. 21.25% (SE=0.95%)), while the proportion of MTF 12th-graders that perceived occasional use of marijuana as posing no risk of harm increased by more than 14 percentage points from 19.36% (SE=0.72%) to 33.5% (SE=0.88%) over that same period. Finally, adjusted prevalence was nearly identical to the unadjusted prevalence, and hence results were not being influenced by changing demographics.

4. Discussion

Using two independent, nationally representative samples of 12th-graders, we have demonstrated that over the past decade, the perception that marijuana is not harmful has increased rapidly, such that in 2014–15, one-fifth of high school seniors perceive that people who use marijuana regularly are posing no risk of harm to their health. At the same time, this large shift in concern about the physical harmfulness of marijuana was not accompanied by increased regular marijuana use among 12th-grade students. On the contrary, the national prevalence of regular use of marijuana in the last 30 days by 12th-graders have been consistently lower since 1999, when it was 6%; over the past decade, it has fluctuated between 5% and 6%. Patterns were nearly identical among 8th and 10th-grade students in both the MTF and the NSDUH and at different levels of frequency of use indicating the phenomena is occurring at different developmental ages and levels of use. Methodological differences in the MTF and NSDUH surveys may contribute to overall prevalence differences (Substance Abuse and Mental Health Services Administration, 2012) notable in the figures, and the smaller sample size in the NSDUH compared to MTF contributes to less precise estimates in NSDUH data. However, the overall pattern of divergence in the trends was very similar across MTF and NSDUH (ranging between 2006 and 2009 for all analyses); this replication of the overall pattern in two independent national samples increases confidence that the changing relationship between trends in perceived harmfulness and use of marijuana was not due to methodological artifacts of one survey or the other.

The reasons for the rapid change in national adolescent attitudes are not known. Much attention has focused on a causal role of state-level medical marijuana laws on adolescent risk perceptions and use of marijuana (Maxwell and Mendelson, 2016). However, contrary to expectations, several large multi-state epidemiological studies have shown that marijuana risk perceptions among adolescents have changed similarly in states that pass medical marijuana laws compared to those that have not (Keyes et al., 2016; Schmidt et al., 2016), and adolescent marijuana use has not increased differentially within states after they pass medical marijuana laws (Hasin et al., 2015; Wen et al., 2015). Further research is needed to understand why perceptions about the harmfulness of regular marijuana use have declined so dramatically in the past decade. Medical marijuana laws may still be implicated despite previous null results if the assumptions behind the individual state-by-state analysis designs employed in past studies are not valid. In particular, nationwide media coverage of medical marijuana law passage may have diffused attitudinal effects of these laws across state borders (Chen, 2016; Schmidt et al., 2016). Furthermore, additional study is needed to understand why the divergence in trends occurred in the second half of the 2000's as opposed to previous periods. Examination of changes in the ways ideas and perceptions are

spread among adolescents during this period, for example, due to the rapid uptake of social media, e.g., Facebook, by the US population, may have important implications for studying the effects of current social policy.

Perceived risk has served as a reliable predictor of trends in marijuana use as well as trends in the use of a number of other substances during past historical periods (Johnston et al., 2016). Although not considered the only risk factor for marijuana use, perceived risk continues to receive major focus as an indicator of the progress of national marijuana prevention efforts, including in the most recently published US National Drug Control Strategy (Executive Office of the President of the United States, 2015). Policy-makers may face pressure to combat publicly visible arguments by marijuana legalization proponents that minimize the health risks of marijuana use (Marijuana Policy Project). The results of this study do not inform the important question of whether the effect of interventions on individual risk perceptions has changed over this period. In fact, marijuana risk perception remains a strong correlate of marijuana use among adolescents (Supplemental Figure 5 and Supplemental Table 5)[4] although the odds ratio has fallen by nearly half (OR = 16.1 in 1991 vs. 7.9 in 2015). Still, the perception that marijuana is not harmful has increased rapidly both among users and non-users of marijuana, preserving the large difference in perceptions between these two groups. The contrast of the relatively stable rates of adolescent marijuana use over the past decade with the rapid erosion of marijuana adolescent risk perceptions calls into question the use of national trends in adolescent marijuana risk perceptions as an indicator of future trends in adolescent marijuana use. Over the same period, there has also been rapidly declining use of cigarettes and alcohol among adolescents (Miech et al, 2017) that has not tracked as expected with marijuana use suggesting that declines in the proportion of smokers may be contributing to the *lack* of increase in marijuana use otherwise expected by trends in perceived risk. The fact that recent rapid decreases in marijuana risk perceptions have not indicated an epidemic of adolescent marijuana use in this period highlights the multifactorial etiology of marijuana use.

5. Conclusions

If the divergence of adolescent marijuana use with marijuana risk perceptions persists, then trends in other marijuana use risk factors (e.g., perceived availability of marijuana and disapproval of marijuana use) may serve as more reliable indicators of marijuana use trends in the future (Johnston et al., 2016). Mixed findings by age group for trends in disapproval have been found, e.g., 12–14 year-olds showing an increase in disapproval from 2002–2013, while 15–17 year-olds showed no change (Salas-Wright et al., 2015). Strategies to curb adolescent marijuana use may continue to target perceptions of marijuana health risks, based on persistent demonstrations of the link between risk perception and use at the individual level. However, recent trends suggest the need for attention to other factors as well. Lessons may be learned from public health efforts to “denormalize” tobacco (1998; Bayer and Stuber, 2006), which sought to “deglamorize” tobacco use primarily through restrictions on smoking in a variety of venues (U.S. Dept. of Health and Human Services, 2006). Further monitoring of relationships between national trends in marijuana harm perceptions and

[4]Supplementary material can be found by accessing the online version of this paper at http://dx.doi.org and by entering doi: ...

marijuana use among adolescents is critical as additional states pass laws legalizing marijuana for recreational use (as seems likely), since evidence is mixed regarding the relationship of recreational marijuana laws to state-level changes in adolescent use and perceptions (Cerda et al., 2017). More generally, the notion that risk factors for teen substance use shift historically over a relatively short amount of time suggests the importance of ongoing monitoring of substance use and risk factors.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights

- Perception that marijuana is not harmful has increased rapidly among adolescents.
- The large shift in perception was not accompanied by increased marijuana use.
- Practices of predicting adolescent marijuana use trends should be updated.

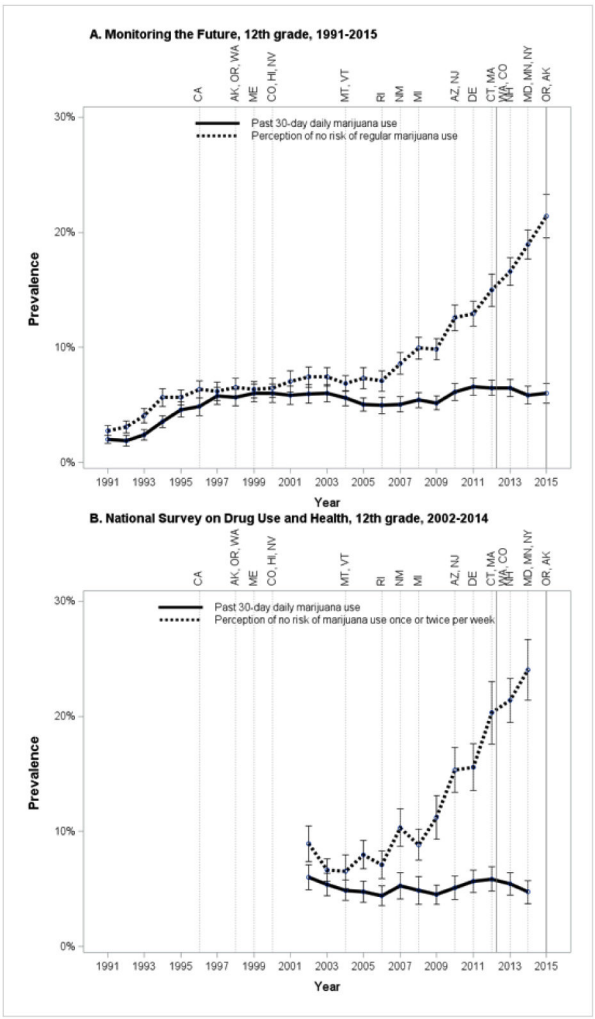

Figure 1.

U.S. High School Seniors (12th grade, modal age 17–18). Past 30-day daily or near daily marijuana use prevalence (solid line) and perception that regular/weekly marijuana use poses no risk of harm (dashed line). Vertical lines indicate year of passage of state laws legalizing marijuana for medical use (light grey) and non-medical use (dark grey). Error bars represent 95% confidence intervals.