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# A prospective study of newly incident cannabis use and cannabis risk perceptions: results from the United States Monitoring the Future study, 1976–2013

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## Abstract

**Background—**A prevailing epidemiological theory about drug use occurrence among secondary school students is that trends in perceived risk of drug-related harms can drive use. If so, cannabis risk perceptions during one school year should predict newly incident cannabis use in the same school the following year. We aimed to study trends in incidence and epidemiological clustering of cannabis use among United States (US) 12th-graders, and a novel prediction that incidence in school-year 't' is influenced by school-specific cannabis risk perceptions (CRP) of 12th-graders a year prior at 't-1'.

**Methods—**US schools sampled each year from 1976–2013 (~130 schools per year) yielded an annual nationally representative sample of ~15–16,000 12th-graders with questionnaire assessments. Analyses involved Alternating Logistic Regressions (ALR) to study trends in school-level clustering and slopes that estimate the degree to which CRP levels at 't-1' might predict newly incident cannabis use at 't'.

**Results—**School-level CRP levels at 't-1' predict newly incident cannabis use in the next year's 12th-grade class. For each unit CRP increment, the next year's class shows tangibly reduced incidence of starting to use cannabis (overall odds ratio, OR=0.10; 95% CI: 0.03, 0.33). Within-

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**Contributors**

Both authors contributed equally to this study. MAP and JCA, designed the study's analytic strategy, conducted literature review, contributed to writing all sections of the paper, prepared figures and tables, and reviewed drafts of the paper. MAP analyzed the data and JCA directed quality assurance and control. All authors read and approved the final manuscript.

**Conflict of Interest**

No conflict declared.

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school clustering of newly incident cannabis smoking also can be seen (e.g., pairwise odds ratio, PWOR=1.11; 95% CI: 1.07, 1.15).

**Conclusions—**Programmatic manipulation of perceived risk in one year's senior class via public health/school alliances might dampen the subsequent risk of newly incident cannabis use in the next year's class.

### Keywords

Cannabis; Incidence; Risk; Perception; Epidemiology; Clustering; Adolescents; Marijuana

## 1. Introduction

Twentieth-century social psychologists produced a novel theory about the rise and fall of drug epidemics. A basic observation is that drug use prevalence trends follow trend lines for changes in risk perceptions about drug use. The theory asserts the perceived risk trend drives subsequent use. If so, implications for public health action are clear. If population-level rates of newly incident drug use are determined, in part, by prior population-level risk perceptions, the public health leaders might be able to prevent and reduce incidence rates via deliberate campaigns to change risk perceptions (Bachman et al., 1998, 1988; Fleary et al., 2010; Hall and Weier, 2015; Kilmer et al., 2007; Lopez-Quintero and Neumark, 2010; Schuermeyer et al., 2014).

Literature review on this topic mainly discloses evidence from ecological analyses of annual survey data on drug risk perceptions in adolescent populations in the United States (US), with concurrent or time-lagged estimates for prevalence of being an active drug user (Bachman et al., 1998; Johnston et al., 2016; Keyes et al., 2016a; Miech et al., 2015). A few individual-level studies of adolescents over time show that risk perceptions of individuals are predictive of their later drug involvement, and there is one supportive prevention experiment with focus on cannabis and other drug risk perceptions, all with credible local area samples of school-attending adolescents (Ellickson et al., 2004; Grevenstein et al., 2015; Jungaberle and Nagy, 2015; Stacy et al., 1994; Terry-McElrath et al., 2017).

Analyzed in relation to epidemiology's clear distinctions between incidence and prevalence (Doull, 1962; Kramer, 1957; Lapouse, 1967), the mass of available evidence falls somewhat short because it has failed to draw a distinction between 'being an active drug user' and 'becoming a newly incident drug user'. For example, in any given year, the prevailing level of risk perception in a mix of never-users, past-onset users, and newly incident users might be heavily determined by the past-onset users with the shared view that drug use is not very risky. Hence, these users may well continue to use. This persistence of use, correlated with the user's view that drug use is not risky, might amplify the estimated drug use prevalence even when incidence is in steady state, and may create a feedback loop with risk perceptions influenced by the prevalence of use or by the persistence of use.

Despite critiques of this nature, it seems worthwhile to speculate that people who perceive higher risk in behavior will be less likely to start engaging in that behavior. As for the 'scale' of this hypothesized contextual influence, there is some evidence of local area social sharing

of risk perceptions in US neighborhoods, which may be more influential than risk perceptions studied at the level of a nation, a state, or a city (Petronis and Anthony, 2000). Nonetheless, we are unable to find any evidence of the degree to which such *socially shared risk perceptions* in a local area population might be predictive of future odds of becoming a newly incident drug user.

Seeing this gap in evidence about *incidence*, we set out to study the risk perception proposition in relation to the epidemiology of cannabis involvement. We selected cannabis (marijuana, hashish) because it is the most commonly used internationally regulated drug (World Health Organization, 2015), and because the causal influence of cannabis risk perceptions recently has been called into question in the media (Ingraham, 2015; Sullum, 2016).

Recent estimates suggest approximately 180–185 million current cannabis users worldwide, with apparent increasing prevalence among young people in many countries (United Nations Office on Drugs and Crime, 2015), largely based on nationally representative sample data on cannabis use and cannabis risk perceptions modeled after the US annual 'Monitoring the Future' (MTF) surveys of 12th-grade secondary school students from 1976 through 2013 (hereinafter, called 'high schools'; Johnston et al., 2016). In the US, this series of observations started some 15–20 years after cannabis incidence estimates showed a climb toward what has been a fairly stable 'endemic' level of cannabis use for most of the past four decades (Johnson and Gerstein, 1998).

An interesting but under-studied feature of the MTF project is that it has a two-year overlap in high schools sampled for its annual assessments (Johnston et al., 2014). The result is not a longitudinal study of individual 12th-graders assessed and then re-assessed one year later. Rather, it is a prospective study of the school as an entity, with an assessment of 12th-graders in one academic year followed by an assessment of the same school's new cohort of 12th-graders the next year. This school-wise prospective design has made it possible for us to estimate the degree to which the odds of becoming a newly incident cannabis user during school-year 't' might be influenced by cannabis risk perceptions that prevailed in that same school's 12th-grade class in the prior year 't-1'. Using this design, a predictive association can be estimated, and the feedback as mentioned earlier is constrained to the extent that the school sample of $12^{th}$-graders who answer risk perception questions in one year are not included in the school sample of $12^{th}$-graders in the next school year. Furthermore, incidence estimates for any given year can be derived by excluding from numerators and denominators all of the $12^{th}$-graders who had started cannabis use before $12^{th}$-grade so that there is a clear temporal sequence of one class's risk perceptions in one year to cannabis onsets during $12^{th}$-grade of the next year, conditional on no cannabis use prior to $12^{th}$-grade. Therefore, with the school as context, the odds of becoming a newly incident cannabis user can be estimated for 12th-graders at time 't' and regressed on levels of cannabis risk perceptions as observed for that same school's separate class of 12th-graders at time 't-1'.

We have framed this study's main aim in terms of a predictive question: "To what extent does a 12th-grader's risk of starting to smoke cannabis in a given year depend upon cannabis risk perceptions of 12th-graders in the prior school year?" Given the school-wise data

structure, we secondarily sought to estimate local area school-level clustering of newly incident cannabis smoking among 12th-graders, with an expectation that within-school processes (e.g., sharing of cannabis from student to student) might yield epidemiological clustering of newly incident cannabis users within schools. The ability to estimate the clustering of cannabis incidence between students in the same school compared to other schools is meaningful because it can motivate new research and insights into how incidence might be "spreading" within schools.

To the extent that any country, local jurisdiction, or school seeks to reduce cannabis-related health harms via school-based cannabis prevention programs, it may be of public health importance to estimate the degree to which a downward (or upward) shift in cannabis risk perceptions in one graduating class of students might be connected with an increased (or reduced) odds of future cannabis use in the next year's graduating class. To the extent that peer influence and peer-to-peer sharing of cannabis are salient influences, there also is value in the generalized estimating equations (GEE) clustering parameter in the form of the epidemiologically familiar pairwise odds ratio (PWOR; Bobashev and Anthony, 1998). The PWOR allowed us to address our secondary aim by quantifying the degree of association of 12th-graders' first cannabis use within schools. As is the case with the general odds ratio (OR) estimate, a PWOR=1.0 reflects no clustering (our null hypothesis). A PWOR estimate greater than 1.0 conveys tangible clustering, as when there is social sharing of an illness within a community (or peer-to-peer sharing of cannabis). An inverse PWOR less than 0.1 can be seen in some instances but is less common.

## 2. Methods

### 2.1 Study Population and Sampling

MTF represents a continuing study of US secondary school students and their behaviors and attitudes about drug use and other social issues. Each year between 1976 and 2013, the MTF research team sampled and recruited roughly 130 public and private high schools for a US nationally representative sample survey, with schools recruited for two years of participation as described in this paper's introduction. Each springtime, roughly 15–16,000 12th-graders have been assessed, using Institutional Review Board-approved self-report questionnaires administered in group settings, typically within normal classroom environments (Johnston et al., 2016).

As depicted in Figure 1, not all MTF schools have participated in the second year of assessment when invited to do so. In addition, MTF assessments have been organized into "questionnaire forms" to reduce the questionnaire length and broaden the topic areas. Six questionnaire forms are distributed to participants in an ordered sequence to ensure identical random subsamples (Johnston et al., 2014). Consequently, whereas essentially all students have been asked whether they have tried cannabis, only about half of the MTF participant-students have been asked about the grade of first cannabis use, which is required for estimation of the odds of becoming a newly incident cannabis user in the MTF context (Figure 1).

Evaluated in relation to sampled study populations, 2,142 schools participated in two successive school years. Each MTF year's student participation overall has been >75%, with missing and invalid individual survey items considered (Johnston et al., 2014). Resulting effective unweighted sample size for estimation of the odds of newly incident cannabis use in the second year of each school's MTF participation is 52,775, with n=4,415 newly incident cannabis users and n=48,360 never-users. For a focus on incidence estimates, experiences of past-onset cannabis users are set aside (i.e., students with cannabis onsets before 12th-grade).

### 2.2 Assessment and Measures

All newly incident users had cannabis onset in 12th-grade. This status was elicited by asking "When (if ever) did you FIRST do each of the following things?" Answer choices were Grade 6 or below; Grade 7…Grade 12 (Johnston et al., 2016).

Cannabis risk perceptions (CRP) for 'trial use' and 'regular use' are based on 105,019 $12^{th}$-graders, irrespective of cannabis use history, who answered these standardized items at 't-1': "How much do you think people risk harming themselves (physically or in other ways) if they try marijuana once or twice?" and "How much do you think people risk harming themselves (physically or in other ways) if they smoke marijuana regularly?" Answer options were: "No risk; Slight risk; Moderate risk; Great risk; Can't say (drug unfamiliar)." This study's 'trial use' score at 't-1' is the proportion of 12th-graders marking 'Great risk' for the 'once or twice' item. The 'regular use' score at 't-1' is the proportion marking 'Great risk' for the 'smoke regularly' item. Other covariates assessed in MTF questionnaires and included in models described below are: sex (male vs. female), age in years, and self-ascribed race-ethnicity (i.e., non-Hispanic White, non-Hispanic Black, Hispanic, Other; see Johnston et al., 2014).

### 2.3 Data Analysis

Analysis-weighted alternating logistic regressions (ALR) for analyzing/estimate steps, with the individual student as a unit of analysis, are from SAS Version 9.4 (SAS Institute Inc., 1999). ALR models are optimized for binary responses of individuals when peer-to-peer influences or other social processes might be in play. Here, ALR estimates show variation in odds of becoming a newly incident cannabis user during 12th-grade as observed at time 't', expressed as a function of school-level cannabis risk perception scores elicited from prior year's 12th-graders (at 't-1'). Repeated for each MTF year and for each risk perception item, the ALR model produced 74 estimates for each annually replicated predictive association, from which we derived overall 'pooled' and meta-analysis summary (MAS) estimates, as well as ALR estimates for each of four pre-specified stages of the US 'cannabis epidemic' years: (i) post-Vietnam War $12^{th}$-grade cohorts with relative higher cannabis prevalence (1976–86), (ii) cohorts with modestly declining prevalence (1987–1992), (iii) cohorts with rising and stabilizing prevalence (1993–2000), and (iv) the most recent cohorts with relatively stable cannabis prevalence (2001–2013).

Each ALR model also yields a PWOR for school-level clustering of newly incident cannabis use as observed at 't'. Unlike the conventional OR, the PWOR is defined for *pairs of*

*individuals* (Katz et al., 1993; Zeger et al., 1988). The PWOR works on similarity and differences of pairs of individuals within cluster units, quantifying the degree to which individuals are more or less similar within a unit as compared with what one would achieve by drawing pairs of individuals from different units. In this context, our null hypothesis is PWOR=1 (no clustering), versus PWOR not equal 1 (with PWOR>1 indicative of clustering). PWOR estimates are not margin-sensitive (e.g., not dependent on cannabis prevalence; Battistich et al., 1995).

Finally, in post-estimation exploratory data analysis steps, we shifted from our epidemic stage approach and formed evenly spaced year intervals: (i) 1976–1986, (ii) 1987–1995, (iii) 1996–2004, and (iv) 2005–2013. We used Stata Version 13 'metan' for meta-analyses of the ALR and PWOR estimates (Stata Corp, 2013). In this work, the precision of study estimates is stressed with a focus on 95% confidence intervals (CI).

## 3. Results

Table 1, is based on 105,019 $12^{th}$-graders at 't' cross-classified for 'newly incident users' versus 'never users' by Spring of $12^{th}$-grade (mean age, 17.5 years). In these unweighted sample cross-classifications, sex, age, and race-ethnicity do not vary appreciably (Table 1). Other observed distributions follow our pre-specification of stages of the US cannabis epidemic experience since 1976 and display a modest tendency for never-users to perceive cannabis use as a 'Great Risk' behavior (Table 1, bottom rows).

Figure 2, based on unadjusted meta-analysis summaries of the year-specific estimates, begins with presentation of an ALR-derived odds ratio estimate for the prediction from a school's 't-1' score for 'Great Risk' of trying cannabis 1–2 times to the school-level odds of becoming a newly incident cannabis user by Spring of the next school year at 't' as observed during the post-Vietnam stage. The MAS point estimate is inverse, at 0.34, signifying that the odds of becoming a newly incident cannabis user decline for every unit increase in the CRP score (95% CI: 0.17, 0.70). The MAS estimate for 1987–1992 is more strongly inverse, at 0.04, and also is statistically robust (95% CI: 0.01, 0.13). MAS estimates for 1993–2000 and 2001–2013 are 0.19 (95% CI: 0.06, 0.58) and 0.04 (95% CI: 0.01, 0.09), respectively. The overall MAS estimate (all years) is 0.10 (95% CI: 0.03, 0.33).

The right side of Figure 2 shifts attention to risk perceptions about regular cannabis smoking. As in the 'trial use' analyses, inversely predictive OR estimates can be seen, starting with the post-Vietnam OR estimate of 0.39 (95% CI: 0.26, 0.58). In later years, corresponding estimates fall in a range from 0.13 to 0.21. The MAS estimate (all years) for this predictive relationship is 0.21 (95% CI: 0.12, 0.38). Estimated with covariate adjustment for age, sex, and race-ethnicity, the corresponding OR summary estimate is 0.09 for CRP about 'trying cannabis once or twice' (95% CI: 0.05, 0.14) and is 0.22 for CRP about 'smoking cannabis regularly' (95% CI: 0.17, 0.29).

Stage-specific PWOR estimates in Figure 3 convey trends in the degree of within-school clustering of newly incident cannabis use among $12^{th}$-graders. The meta-analysis summary PWOR estimate for all years is 1.11 (95% CI: 1.07, 1.15, from models based on 't-1' trial

use CRP) and is 1.14 (95% CI: 1.07, 1.21, from models based on 't-1' regular use CRP). All PWOR estimates reflect statistically robust departures from the null hypothesis of no within-school clustering of newly incident cannabis use (i.e., PWOR=1.0). Estimated with covariate adjustment for age, sex, and race-ethnicity, the corresponding PWOR summary estimate is 1.13 for trying cannabis once or twice (95% CI: 1.09, 1.17) and is 1.14 for smoking cannabis regularly (95% CI: 1.10, 1.17). Table 2 synthesizes information from both Figures 2 and 3. In post-estimation exploratory data analysis, the MAS estimates using evenly spaced year intervals did not differ appreciably from the 'epidemic stages' we had specified in advance. Supplementary Figures 1 and 2[1] show details.

## 4. Discussion

Based upon this prospective research, with 12$^{th}$-grade cohorts studied in paired years, the main empirical observations do not seem to contradict the social psychological theory that the rise and fall of drug epidemics might be determined, in part, by school-level variations in drug risk perceptions. From the standpoint of public and school health prevention research, it may be of special interest that the occurrence rates for becoming a newly incident cannabis user in a school's cohort of rising 12th-graders can be predicted by cannabis risk perceptions of that same school's graduating 12th-graders of the prior school year.

What is novel about this study's estimates is the focus on the occurrence of newly incident cannabis use (i.e., becoming a cannabis user), with a population-averaged GEE/ALR approach that makes the individual student its unit of analysis in estimation of each school's incidence parameter. Moreover, the analysis plan deliberately excluded past-onset cannabis users from the incidence numerators and denominators. Coupled with other details of research approach, the result was a constraint on feedback loops and other sources of uncertainty.

Readers not familiar with population-averaged GEE/ALR multi-level modeling approaches might appreciate the value they add when the study aim is to use individual-level data to estimate effects of either individual-level or group-level predictors on population-level public health parameters such as incidence rates, group-level odds of starting to use a drug, and prevalence proportions (Bobashev and Anthony, 2000, 1998; Delva et al., 2000; Petronis and Anthony, 2003). In contrast, subject-specific multi-level models (e.g., Hierarchical Linear Models) use the same individual-level data to estimate effects on individual-level parameters such as a student's chance of starting drug use. Here, we chose the GEE/ALR approach because we wished to estimate the degree to which differences in a school-level characteristic (level of cannabis risk perceptions) might predict and account for school-level occurrence rates for newly incident cannabis use, much as Petronis and Anthony (2003) previously used GEE/ALR to estimate effects of socially shared neighborhood disadvantage on incidence rates of cocaine use.

The observed predictive associations were statistically robust with 95% CI that did not entrap null OR values. Ancillary findings included the PWOR estimates of school-level

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

clustering of cannabis onsets. The size of the PWOR estimates can be characterized as 'modest' relative to prior research on clustering of cannabis use in US neighborhoods (PWOR=1.3–2.0; Bobashev and Anthony, 1998). Even so, the cannabis clustering PWOR estimates are not too different from the lower end of reported PWOR for clustering of childhood diarrheal illnesses in villages of low-income countries, one of the first applications of the ALR approach. In these studies of diarrheal illness clustering, the social sharing of infections and contagion processes clearly are at play – even when the clustering is modest (PWOR=1.03–2.2; Katz et al., 1993). In future multi-wave longitudinal research, it may be possible to clarify whether a social influence process can explain the observed clustering of newly incident cannabis use in schools, social sharing of cannabis products from classmate to classmate, or social sharing of cannabis risk perceptions, as suggested in Keyes et al. (2016b).

Other studies speak more directly to the issue of whether the individual-level probability of becoming a drug user might change when individuals change their risk perceptions (Ellickson et al., 2004; Grevenstein et al., 2015; Stacy et al., 1994). Our investigation speaks more directly to whether the school-level odds of newly incident cannabis use might change when there is a school-level change in cannabis risk perceptions, with the ALR approach used to take into account and to estimate interdependence of observations within schools. Unlike the interclass correlation coefficient (ICC) derived from generalized linear mixed models for multi-level binary responses, the PWOR estimate from ALR has advantages: (1) it does not depend on the relative frequency of a disease or behavior (Battistich et al., 1995); (2) it is free to vary across its range, whereas the ICC for binary data faces constraints that complicate its interpretation (Fitzmaurice et al., 2011).

Before a detailed discussion of these results, several of the more important study limitations merit attention. Of central concern, MTF cannabis use data are self-reported; students fearing legal or social consequences might not report accurately (Bachman et al., 2011; Gfroerer et al., 2002). Hence, greater specificity of survey questions about cannabis risk perceptions would help. There now is no assessment of the nature of the anticipated harm. To the extent that 12$^{th}$-graders appreciate liberalization of cannabis policies, they might show reduced cannabis risk perceptions as these domains of harmful consequence become less salient, relative to possibly more stable domains of health-related harms. Nevertheless, Keyes and colleagues (Keyes et al., 2016b) offered evidence to suggest that 8$^{th}$-graders might respond to medical marijuana laws with an elevation of risk perceptions; they noted that 8$^{th}$-graders might decide that cannabis is an unappealing medicine used by sick patients and not for fun or recreation, or that parents in liberal policy states might up-regulate anti-cannabis messages. In consequence, the interplay of social and psychological processes in this area of epidemiological research on cannabis might be described as 'complex' such that this study's predictive associations should not yet be interpreted as cause-effect relationships. Nevertheless, the study's estimates are statistically robust and of sufficient magnitude to be used in planning of deliberate experiments to investigate whether public health workers can reduce school-level cannabis *incidence* rates by focusing attention on cannabis-attributable damage to adolescent brain development or health generally versus an alternative intervention directed toward social and legal consequences of using cannabis just once or twice.

Notwithstanding limitations such as these, we hope that the study results offer encouragement to the public and school health officials responsible for prevention of cannabis use before and during the high school years. The novel research design and focus on 12th-graders serves as a proving ground for the idea that perceived risk in one school's 12th-grade class can predict future onsets of cannabis use in the next 12th-grade class of that same school. Building from evidence of this type, investigators should be able to use experimentation to gain more definitive evidence on characteristics accounting for school-level variation in degree of clustering of cannabis use, with models that encompass attributes of both schools and classrooms, as well as attributes of individuals, social groups, and peer influence (Tucker et al., 2014). In future MTF survey years, more useful datasets for estimation of cannabis clustering can be created via the addition of encrypted indicators for students' classrooms, as well as already standard survey items on month, year, and age of first use. Classroom indicators would enable more probing research on newly incident drug use and related health behaviors, and most likely would yield larger and more robust PWOR clustering estimates.

## 5. Conclusions

In conclusion, studying 12th-graders in US high schools, we have discovered that the odds of becoming a newly incident cannabis user during the final year of high school can be predicted from, and may depend upon, the degree to which the previous 12th-grade student cohort has perceived cannabis use to be a risk-laden behavior. The predictive association can be seen not only in relation to survey assessment of harmfulness of 'smoking marijuana regularly,' but also in relation to trying it 'once or twice' in one's lifetime. Modest but noteworthy estimates of within-school clustering of newly incident cannabis use are suggestive of between-student transactions that might well include social sharing of herbal cannabis or other 'marijuana' products now becoming available in a relatively unregulated US cannabis marketplace.

It should become possible to craft school-level manipulations to shift perceptions about cannabis-attributable harms as described by others working at the individual and classroom level (Ellickson et al., 2004; Grevenstein et al., 2015; Jungaberle and Nagy, 2015; Stacy et al., 1994). These school-level manipulations may prove to be more effective than prior 'scare tactics' and already-evaluated national mass media campaigns of uncertain beneficial impact (Hornik et al., 2008).

Evaluated using group-randomized controlled trials and later implementation science approaches, school-level interventions of this type may make it possible to prevent or delay onset of cannabis product use, and to reduce school-level incidence rates during the high school years (Botvin and Griffin, 2007; Tobler and Stratton, 1997), even when cannabis policies are being liberalized in the local jurisdictions (Keyes et al., 2016b). Components of interventions designed to encourage social sharing of perceptions about cannabis-attributable harms might prove to be important in this context of public health intervention and prevention program development for the 21st century.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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## Highlights

- We focus on first-time cannabis use and quantify clustering of use in high schools.
- We estimate if school-level cannabis risk perceptions predict cannabis incidence.
- Cannabis risk perceptions predict cannabis use in the next year's 12th-graders.
- Within-school clustering of newly incident cannabis smoking also is seen.

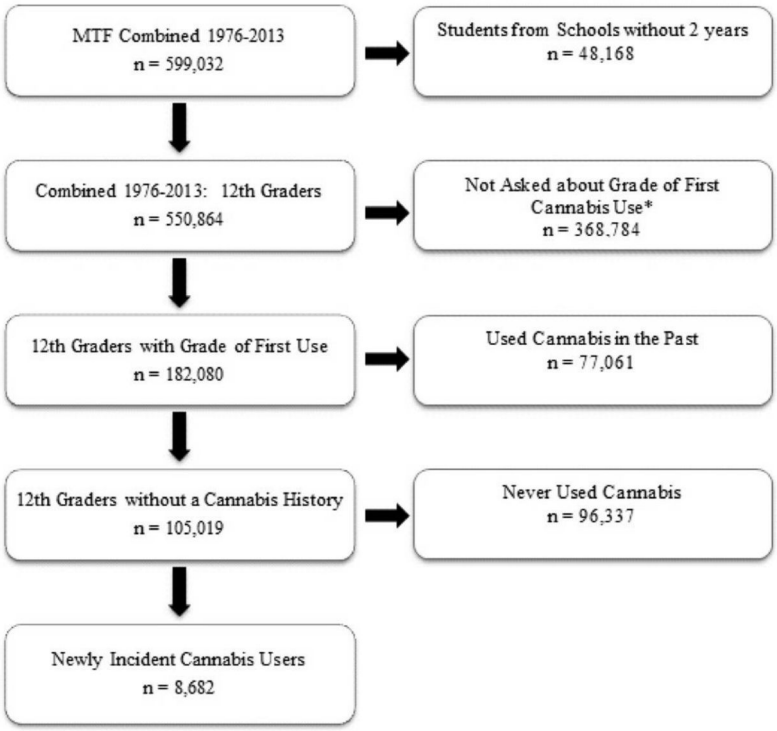


**Figure 1.**

Flow chart showing the process used to construct samples of newly incident cannabis users and never users among 12th-graders participating in the study. Data from "Monitoring the Future: Secondary School Students," United States, 1976–2013.

Note: Grade of first cannabis use asked on only 3 of 6 questionnaire forms (i.e., Forms 1, 3, 6).

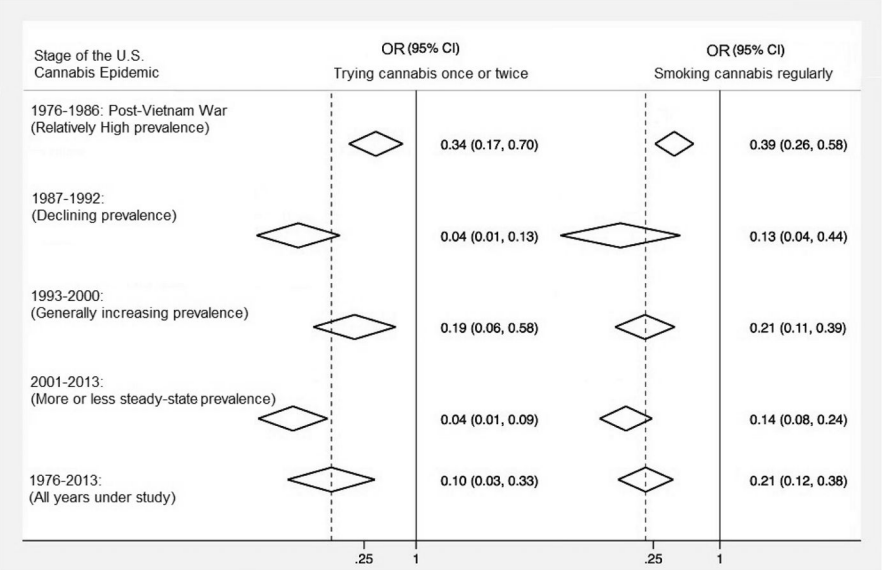


**Figure 2.**

Estimated stage-specific meta-analysis summary odds ratios (OR) and 95% confidence intervals (CI) for the predictive association from a school-level ‘great risk’ perception about trying cannabis once or twice to the school-level odds of becoming a newly incident cannabis user (left column) and for the corresponding prediction based on ‘great risk’ of smoking cannabis regularly (right column), based on unadjusted Alternative Logistic Regressions.* Data from “Monitoring the Future: Secondary School Students,” United States, 1976–2013.

Note: Estimates from covariate-adjusted models are described in the text. Post-estimation exploratory data analysis estimates based on alternative specifications with equally spaced intervals are shown in Supplementary Figures 1 and 2. Year-specific estimates are available upon request.

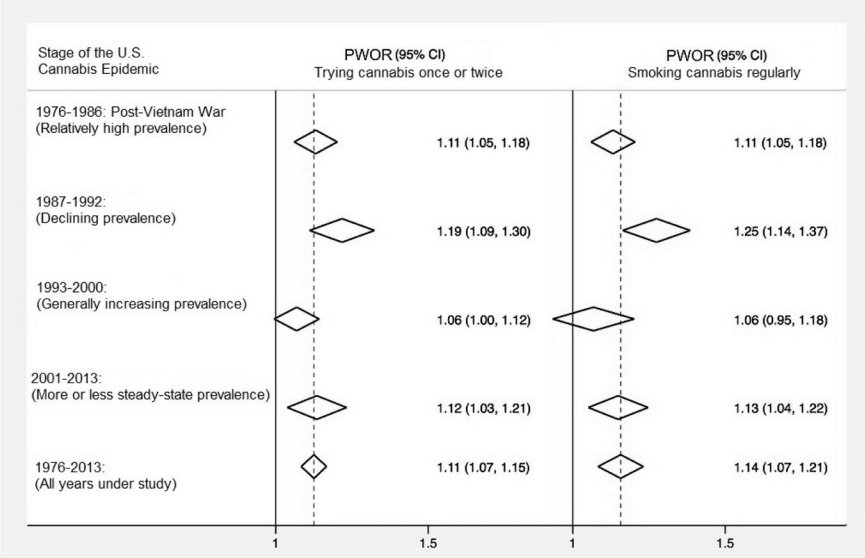


**Figure 3.**

Estimated stage-specific meta-analysis summary pairwise odds ratios (PWOR) and 95% confidence intervals (CI) for school-level clustering of newly incident cannabis use among 12th-graders, based on ALR models for ‘great risk’ perceptions about trying cannabis once or twice (left) and smoking cannabis regularly (right), without other covariates. * Data from “Monitoring the Future: Secondary School Students,” United States, 1976–2013.

Note: Estimates from covariate-adjusted models are described in the text. Post-estimation exploratory data analysis estimates based on alternative specifications with equally spaced intervals are shown in Supplementary Figures 1 and 2. Year-specific estimates are available upon request.

## Table 1

Selected characteristics of newly incident cannabis users and never users in 12th-graders (n = 105,019). Unweighted sample data from "Monitoring the Future: Secondary School Students," United States, 1976–2013.*

| | Newly incident users (n = 8,682) % | Never users (n = 96,337) % |
|---|---|---|
| Sex: | | |
| Male | 45.5 | 44.5 |
| Female | 54.5 | 55.5 |
| Age when assessed, mean (SD) | 17.5 (0.6) | 17.5 (0.6) |
| Race-ethnicity:[a] | | |
| Non-Hispanic White | 73.3 | 69.7 |
| Non-Hispanic Black | 12.2 | 13.0 |
| Hispanic | 8.1 | 8.7 |
| Other Non-Hispanic | 6.3 | 8.7 |
| Pre-specified stages of the US cannabis epidemic: | | |
| 1976–86 post-Vietnam higher prevalence/incidence | 30.5 | 24.5 |
| 1987–1992 prevalence declined | 16.5 | 23.1 |
| 1993–2000 prevalence rose & stabilized | 25.1 | 24.0 |
| 2001–2013 steady state | 27.9 | 28.5 |
| Cannabis risk perceptions, 'trial use': | | |
| 'Great risk' to try it just once or twice, % | 14.7 | 17.1 |
| All other responses to 'trial use' item, % | 85.3 | 82.9 |
| Cannabis risk perceptions, 'regular use': | | |
| 'Great risk' to 'regular use' item, % | 59.6 | 63.7 |
| All other responses to 'regular use' item, % | 40.4 | 36.3 |

[a] Due to rounding, these unweighted percentages do not add to exactly 100%. Other non-Hispanic included Asian, Native American/American Indian, Hawaiian/Pacific Islander, and other.

* The newly incident users were identified on the basis of responses to questionnaire forms 1, 3, and 6; never-users were identified irrespective of the form, based on items about ever-never use of cannabis.

**Table 2**

Estimated stage-specific meta-analysis summary odds ratios (OR), pairwise odds ratios (PWOR), and 95% confidence intervals (CI) for school-level clustering of newly incident cannabis use among 12th-graders, based on ALR models for 'great risk' perceptions about trying cannabis once or twice (left) and smoking cannabis regularly (right), without other covariates. * Data from "Monitoring the Future: Secondary School Students," United States, 1976–2013.

| | Trying cannabis once or twice | | Smoking cannabis regularly | |
|---|---|---|---|---|
| **Stage of the U.S. Cannabis Epidemic** | **OR (95% CI)** | **PWOR (95% CI)** | **OR (95% CI)** | **PWOR (95% CI)** |
| 1976–1986 | 0.34 (0.17, 0.70) | 1.11 (1.05, 1.18) | 0.39 (0.26, 0.58) | 1.11 (1.05, 1.18) |
| 1987–1992 | 0.04 (0.01, 0.13) | 1.19 (1.09, 1.30) | 0.13 (0.04, 0.44) | 1.25 (1.14, 1.37) |
| 1993–2000 | 0.19 (0.06, 0.58) | 1.06 (1.00, 1.12) | 0.21 (0.11, 0.39) | 1.06 (0.95, 1.18) |
| 2001–2013 | 0.04 (0.01, 0.09) | 1.12 (1.03, 1.21) | 0.14 (0.08, 0.24) | 1.13 (1.04, 1.22) |

* Estimates from covariate-adjusted models are described in the text.