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Examination of the Divergence in Trends for Adolescent Marijuana Use and Marijuana-specific Risk Factors in Washington State

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Abstract

Purpose—As marijuana laws have become more permissive, survey data on adolescents in the United States have shown an increase in marijuana-specific risk factors, particularly in the proportion of youth who do not perceive marijuana use as harmful. Prevalence of marijuana use among youth, however, has changed little. Using representative data from Washington State, which has legalized medical and nonmedical marijuana for adults, we examined two competing hypotheses to account for this divergence in population trends.

Methods—Data were from 2000 – 2014 biennial Washington State surveys of 10th-grade students. First, we assessed whether associations between marijuana use and marijuana-specific risk factors have weakened over time. Second, we examined whether decreases in alcohol and cigarette use can account for the lack of expected increase in marijuana use prevalence.

Results—Despite stability in marijuana use prevalence, there were increases in marijuana-specific risk factors of low perceived harm, youth favorable attitudes about use, and perceived community attitudes favorable to use. Associations between marijuana use and marijuana-use predictors varied little across time; if anything, the positive association between low perceived harm and marijuana use grew stronger. Decreases in prevalence of alcohol and cigarette use largely accounted for stability in marijuana use during a period when marijuana risk factors increased.

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Conclusions—Decreases in other types of substance use or in the underlying, common risk for substance use may have mitigated effects of increases in marijuana-specific risk factors.

Keywords

marijuana; risk factors; adolescent

For most of the past 40 years, national trends in prevalence of adolescent marijuana use and perceived harmfulness of marijuana use have mirrored one another [1], which has made low perceived harm a target in a risk factor-based approach to prevention [2, 3]. Recently, however, trends in perceived harm and marijuana use have diverged. The percentage of youth reporting that there is little harm from using marijuana increased steadily and markedly since 2006; meanwhile, the prevalence of marijuana use increased slightly between 2006 and 2010, but changed little in the most recent waves of national data [1, 4–7]. Other indicators of risk may have also increased in the context of liberalization of marijuana laws and increasing public approval of marijuana legalization. Other marijuana-specific risk factors include favorable attitudes about marijuana use, perception of community attitudes favorable to marijuana, and easy access to marijuana [e.g., 8, 9–11]. National data on 15- to 17-year-olds indicate a decline in disapproval of marijuana use between 2009 and 2013 [11], while evidence regarding change in access and perception of community norms is mixed [1, 5, 12]. In this study, we examined trends in these risk indicators and adolescent substance use in Washington State.

Adolescent marijuana use in Washington State, although higher than the national average, has followed national trends, declining from the late 1990s to mid-2000s, increasing modestly until 2010, and then declining slightly through 2014 [13]. The Washington State data also show a large increase in low perceived harm of marijuana use during the past decade and a half [13]. Notably, Washington State legalized medical marijuana in 1998, with a loosely regulated medical marijuana market that expanded greatly after the federal justice department's 2009 Ogden memo, and legalized recreational marijuana in 2012 [14]. States allowing medical marijuana have, on average, higher prevalence of adult and adolescent marijuana use than states without medical marijuana [7, 15, 16], but research on the impact of medical marijuana laws on *change* in adolescent marijuana use has found small or no effects [7, 17, 18]. Some research indicates, however, that impact of marijuana laws depends on variation in those laws [19], and states where medical marijuana markets expanded rapidly after 2009 may have experienced particularly large increases in marijuana risk factors for adolescents [20, 21]. The divergence in trends for low perceived harm and marijuana use raises the possibility that low perceived harm is no longer a strong risk factor for marijuana use and, more generally, calls into question the stability in relationships between risk factors and substance use. Weakening of marijuana-specific risk factors could be rooted in exposure to medical marijuana advertising [22] and acceptance of marijuana as a treatment for some medical conditions. This may have led to a decoupling wherein how youth answer questions about harm, their own or others' attitudes, or availability no longer strongly predicts use.

Although divergence in marijuana-specific risk factors and reported use has occurred at the population level, the individual-level association may remain strong [23, 24]. An alternative explanation for divergence in trends is that concurrent changes in other factors counteracted increases in marijuana-specific risk factors. Candidates for these types of changes include decreases in adolescent alcohol and cigarette use in recent years [1, 6]. Although some research has found evidence of substitution between marijuana and alcohol use among adult populations [21, 25], adolescent marijuana, alcohol, and cigarette use have been positively associated with one another [e.g., 26, 27]. The mechanisms underlying these associations may involve gateway processes [28] or complementary effects wherein one type of substance is used to enhance the effects of another [29]. The associations may also be rooted in a trait-like common liability or vulnerability to substance use [30, 31]. In an analysis that includes multiple changing factors, population decreases in alcohol and cigarette use may account for the stability in marijuana use in the presence of increases in marijuana-specific risk.

The current study used biennial statewide survey data from 10th-grade students in Washington State and examined these two hypotheses regarding the seemingly paradoxical stability in marijuana use during a time of increased marijuana-specific risk. First, we examined the stability of associations between marijuana-specific risk factors and marijuana use over the past 15 years, testing whether these associations have weakened. Second, we examined whether decreases in alcohol and cigarette use accounted for divergence in trends for marijuana-specific risk factors and marijuana use, testing the second hypothesis that countervailing changes in other factors offset increases in marijuana-specific risk.

Methods

Data source and sample

Data were from the Washington State Healthy Youth Survey [32] that is administered biennially to representative cross-sectional samples of 6th-, 8th-, 10th-, and 12th-grade students in Washington State schools. Participation in the surveys was voluntary and anonymous. Our study was exempt from human subjects review by the Washington State Institutional Review Board. We present results based on 10th-grade survey data from 2000 to 2014. (Results of analyses conducted on 12th-grade data are available in the online supplement.) Public schools were randomly selected to administer surveys, with 60% to 90% of selected high schools participating across years. Participation for students in those schools ranged from 46% to 67% across years. A range of 33 to 59 schools were represented in any given year, or a total of 269 total school-year units.

Pencil-and-paper surveys were administered in classrooms in multiple forms. The analysis sample consisted of 30,365 students who completed forms that included questions on the marijuana-specific risk factors and who responded to the item on perceived harm of regular marijuana use. Year-specific samples ranged from 2,507 to 4,660. Overall, 48% of the analytic sample was male, with little variation across years. In 2000, the sample was 71% non-Hispanic White, 5% African American, 10% Asian (including Pacific Islander), 3% Native American, 11% Hispanic, and 1% other (i.e., students choosing “other” ethnic category or endorsing multiple categories); in 2014, the composition was 57% non-Hispanic

White, 5% African American, 12% Asian, 2% Native American, 11% Hispanic, and 13% other. The racial/ethnic composition was representative of the 10th-grade public school population in Washington State [33].

Measures

We dichotomized measures of substance use and risk to match the way these variables are commonly used when mapping national and state-level trends [e.g., 1]. (Sensitivity analyses were conducted using the full range of response options on all of the substance use and risk items. Results are available in the online supplement.)

Marijuana use—Students were asked on how many days in the prior month they had used "marijuana or hashish (grass, hash, pot)" and were offered 5 response options ranging from "none" to "10 or more." We created 2 measures of marijuana use: 1) *any marijuana use* in the past month, and 2) *frequent marijuana use*, defined as using on 6 or more days in the past month and thus capturing more than weekly use.

Marijuana-specific risk factors—From 2000 through 2012, perceived harm of marijuana use was measured using the question, "How much do you think people risk harming themselves if they smoke marijuana regularly?" In 2014, "at least once or twice a week" was added in parentheses to define "regularly." We coded the variable as *low perceived harm of marijuana use* (1 = "no risk" or "slight risk"; 0 = "moderate risk" or "great risk"). *Attitudes favorable to marijuana use* was measured in 2000 through 2012 using the question, "How wrong do you think it is for someone your age to smoke marijuana?" In 2014, the word "smoke" was replaced with the word "use." (In all years, 1 = "a little bit wrong" or "not at all wrong"; 0 = "wrong" or "very wrong"). *Easy access to marijuana* was based on the question, "If you wanted to get some marijuana, how easy would it be for you to get some?" (1 = "sort of easy" or "very easy"; 0 = "sort of hard" or "very hard"). Perception of *community attitudes favorable to marijuana use* was based on the item, "How wrong would most adults in your neighborhood think it was for kids your age to use marijuana?" In 2010 and 2012 the words "or community" were added after "neighborhood." (In all years, 1 = "a little bit wrong" or "not at all wrong"; 0 = "wrong" or "very wrong").

Alcohol and cigarette use—Alcohol use was based on the question, "During the past 30 days, on how many days did you drink a glass, can or bottle of alcohol (beer, wine, wine coolers, hard liquor)?" (1 = any use; 0 = no use). Cigarette use was also based on whether the respondent reported any use in the past month (1 = any use; 0 = no use) and was based on the question, "During the past 30 days, on how many days did you smoke cigarettes?" In 2000 and 2002, some respondents (< 2%) skipped this item but answered the question, "During the past 30 days, on the days you smoked, about how many cigarettes did you smoke per day?" For these respondents, the coding of any cigarette use was based on the latter question.

Covariates—Gender (1 = male; 0 = female) and dummy codes for race/ethnicity (Asian, Black, Native American, Hispanic, and other, with non-Hispanic White as the reference

category) were included as covariates in our analyses to account for potential differences in substance use and risk associated with these variables [34, 35].

Analysis

Models that adjusted standard errors for clustering of students within sampled schools were estimated with Stata 12.1 [36]. We first examined trends in prevalence of marijuana use, marijuana-specific risk factors, and alcohol and cigarette use across time, using year-specific model-based estimates. We then estimated a series of logistic regression models to predict any and frequent marijuana use that tested our guiding hypotheses.

To test our first hypothesis, we estimated, for each survey year, the associations between both measures of marijuana use and each of the marijuana-specific risk factors, as well as associations with alcohol and cigarette use. We then tested variability in associations with time series models based on all years of data (2000 through 2014). These models included year dummy coded, with 2000 as the reference year, and interactions between the given predictor and the year dummies. Wald tests were calculated to assess the null hypothesis that the effects of interaction terms were zero (i.e., that the strength of the association was the same in all years).

To test our second hypothesis, we used 2 logistic regression time series models for each marijuana use outcome. Model 1 included the marijuana-specific risk factors and year dummy coded, with 2000 as the reference. In this model, the parameter estimates for effects of the year dummies reflect changes in likelihood of marijuana use relative to the year 2000 above and beyond the effects of marijuana-specific risk factors. That is, the parameters for year effects capture the extent to which the likelihood of any or frequent marijuana use in a given year differed from what would be expected based on the prevalence of marijuana-specific risk factors in that year relative to the prevalence of those factors in 2000. In Model 2 we added alcohol and cigarette use as covariates and examined whether including these variables reduced the magnitude of the estimates of year effects. Changes in the year parameter estimates in Model 2 compared to Model 1 indicated whether decreases in other types of substance use account for the divergence in trends for prevalence of marijuana-specific risk factors and marijuana use.

Missingness was below 3% for most measures, although 4% for perceived harm of marijuana use due to some respondents answering “not sure” and 7% for attitudes favorable to marijuana use, likely due to survey noncompletion and the item being placed toward the end of the survey forms [33]. Listwise deletion was used for all models. The models used to test our second hypothesis required nonmissing data on all predictors, resulting in a sample size of 26,484.

Results

Trends in prevalence

Table 1 shows the prevalence for substance use and marijuana-specific risk factors across years. As shown in Figure 1, a divergence in trends for low perceived harm and marijuana use began in the early 2000s and increased in recent years. The prevalence of low perceived

harm of marijuana use rose between 2000 and 2002, plateaued through 2006, and then rose steadily through 2014. In contrast, both any and frequent marijuana use prevalence declined between 2000 and 2004. Any marijuana use rebounded to previous levels in 2010 but then declined slightly through 2014. Frequent use remained relatively stable since 2006.

Trends for youth and community attitudes favorable to marijuana use mirror trends for marijuana use through 2010 but, like low perceived harm, these risk factors increased in prevalence in recent years and diverged from the stable or downward trend in marijuana use. Changes in easy access to marijuana more closely matched trends in marijuana use, with a slight decline since 2010. Prevalence of any alcohol use declined from 2000 to 2002, increased slightly in 2006, and then declined steadily to 2014. Any cigarette use declined steadily throughout the study period.

Tests of first hypothesis

Adjusted odds ratios (AORs) for individual-level associations between marijuana use and risk factors are shown by year in Figure 2. All of the AORs were above 1, indicating positive associations, and statistically significant at $p < .01$. Although the figure suggests some variability across time in the size of the AORs, particularly where AORs are larger and their confidence intervals wider, in only 2 cases did the statistical test of variability indicate the null hypothesis, that the strength of the association was the same in all years, should be rejected (Table 2). In the first case, the association between low perceived harm and frequent use varied but examination of the association for each year (and the upwardly sloping line in Figure 2) suggests that, rather than weakening, the association grew stronger over time. In 2000 and 2002 the AORs for the associations between low perceived harm and frequent marijuana use were 10.69 (95% confidence interval [CI]: 8.29, 13.79) and 13.97 (95% CI: 9.96, 19.60), respectively; in 2012 and 2014 the AORs were 22.99 (95% CI: 16.78, 31.50) and 18.13 (95% CI: 12.58, 26.12), respectively. The association between community attitudes favorable to marijuana and any marijuana use also showed evidence of variability, increasing from 2000 (AOR = 3.51, 95% CI: 2.77, 4.44) to 2012 (AOR = 5.05, 95% CI: 4.24, 6.03), followed by a decrease in 2014 (AOR = 3.35, 95% CI: 2.80, 4.00).

Tests of second hypothesis

Table 3 shows estimates for the models assessing whether the divergence in trends for marijuana-specific risk factors and marijuana use may be accounted for by decreases in alcohol and cigarette use. In Model 1, for both measures of marijuana use, the AORs for year shrank across years to less than .4 for 2014, indicating that prevalence of marijuana use was lower than what would be expected given the increases in the marijuana-specific risk factors. The expected prevalences for marijuana use based on the change in marijuana-specific risk factors, other things being equal, were 29% for any marijuana use and 16% for frequent marijuana use (computed using model-based estimates and entering the observed prevalence of the marijuana-specific factors in 2014, but omitting the 2014 year effect). Adding alcohol and cigarette use in Model 2 resulted in a reduction in the magnitude of the estimated year effects. For any use, none of the AORs for year in Model 2 were statistically significant. For frequent use, some year parameters were statistically significant, but the AORs were closer to 1. For example, the AOR for Year 14 changed from 0.30 (95% CI =

0.25, 0.38) in Model 1 to 0.68 (95% CI = 0.55, 0.85) in Model 2. The reduced magnitude of year effects suggest that, after taking into account alcohol and cigarette use, the prevalence of marijuana use in recent years was similar to what would be expected, even with the increases in marijuana-specific risk factors. In other words, the decreases in alcohol and cigarette use at least partially account for the lack of increases in marijuana use.

Model 2 estimates also point to multiple salient factors with respect to adolescent marijuana use. Although the unique effects for each of the marijuana-specific risk factors were smaller than associations illustrated in Figure 2, the adjusted associations in Model 2 were positive and statistically significant for both measures of marijuana use. (Additional sensitivity checks for these models are provided in the online supplement.)

Discussion

We examined two possible explanations for the lack of increase in prevalence of marijuana use during a period of time when marijuana-specific risk increased. Our findings do not support the hypothesis that low perceived harm of marijuana use or other marijuana-specific risk factors have become weaker risk factors for marijuana use among adolescents. In fact, the individual-level association between perceived harm and frequent use grew stronger. Although the association between perceived community attitudes favorable to marijuana use and adolescent use of marijuana varied in strength, this variability did not involve a clear pattern of attenuation over time. For the most part, associations between other marijuana risk factors and adolescent marijuana use in Washington State remained positive and stable since 2000.

As seen in national data [1, 5], the Washington State data showed marked increases in low perceived harm of marijuana use, particularly since 2006 during a period of time when medical marijuana became established in Washington and other states. The Washington data also displayed more recent increases in favorable attitudes to use, similar to trends in national data [11], and perception of community attitudes favorable to use. These recent changes might reflect the effects of rapid expansion of the medical marijuana market after 2009 and the legalization of recreational marijuana in 2012. Given that associations between marijuana-specific risk factors and marijuana use have not weakened and some marijuana-specific risk factors have increased, we would expect to observe increases in marijuana use. Our findings provide a plausible explanation for why these increases have not occurred. More than one third of 10th graders had used alcohol in the past month in 2000 compared to one fifth in 2014. Past-month cigarette use dropped by more than half during this time period. Through gateway [28] or complementary [29] processes, decreases in alcohol and cigarette use may have directly dampened a potential increase in adolescent marijuana use. The results are also consistent with trends in alcohol and cigarette use as indicators of changes in risk common across different types of substance use, and perhaps across problem behaviors more generally [37], that have been offset for marijuana use by the increase in marijuana-specific risk factors. Notably, another way of viewing these findings is that adolescent marijuana use has not *decreased* as much as would be expected given the decreases in other types of substance use. Adolescent marijuana use has increased *relative* to

other types of substance use, which could be due to increases in marijuana-specific risk factors that have occurred in the context of evolving marijuana policy.

The results point to increases in some types of risk being mitigated by decreases in other types of risk. Our study falls short, however, of testing causal influences between risk factors and marijuana use or across different types of substances. We examined concurrent associations likely based on reciprocal relationships as well as potentially influenced by method effects due to data coming from the same survey. Moreover, we lacked consistent measures of some potentially salient factors (e.g., socioeconomic status) that may be related to trends in marijuana use and marijuana risk factors. Limitations also included minor changes in wording to survey questions that occurred during the study period, missing data on some survey questions due to respondents not completing surveys or answering "unsure" to the perceived harm question, and school and student participation rates being low (e.g., < 50%) in some years. The survey procedures were consistent across years, however, and the sample is considered representative of 10th-grade public school students in Washington State [33]. Finally, we used data from Washington State. The relationships identified in our study may differ in other states and change in the context of further expansion of the recreational marijuana market [38].

An implication of our findings is that multiple factors affect adolescent marijuana use. Although associations between individual factors and marijuana use have remained relatively stable, population-level changes in these factors can move in different directions with respect to increasing or decreasing risk. Thus, our findings caution against interpreting the recent divergence in marijuana-specific risk factors and marijuana use as evidence that these risk factors are no longer relevant for preventing adolescent substance use. This divergence does not mean we should abandon educating youth about potential harms of marijuana use or end efforts to dampen increases in favorable attitudes towards adolescent use. Our results do suggest that successful efforts to reduce adolescent alcohol and cigarette use, or substance use in general, may lessen the potential impact of liberalization of marijuana laws on adolescent marijuana use.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Implications and Contribution

In Washington State, individual-level associations between marijuana-specific risk factors and adolescent marijuana use have remained stable since 2000, despite recent population-level increases in some risk factors that have not been matched by increases in adolescent marijuana use. Decreases in prevalence of alcohol and cigarette use may account for this divergence.

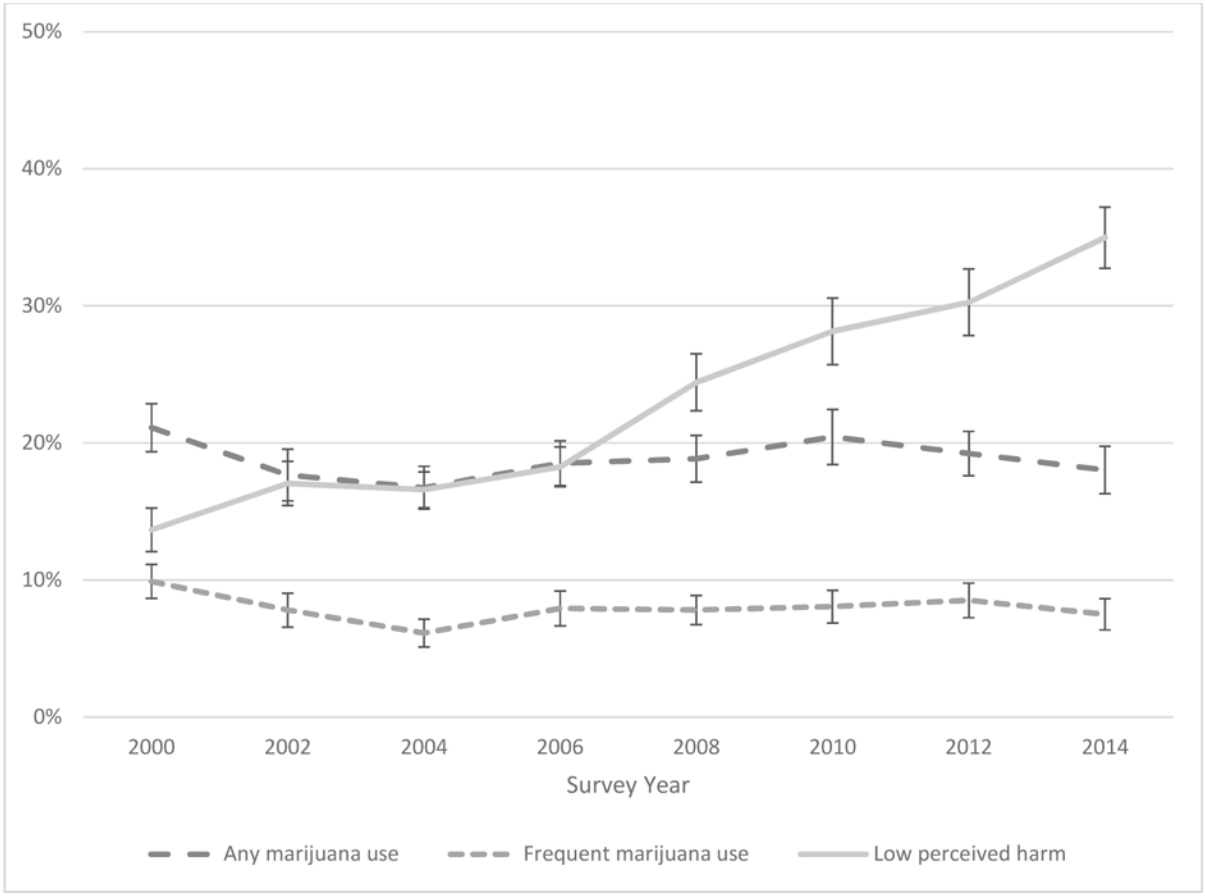

Figure 1.
Prevalence and 95% confidence intervals for marijuana use and low perceived harm by survey year.

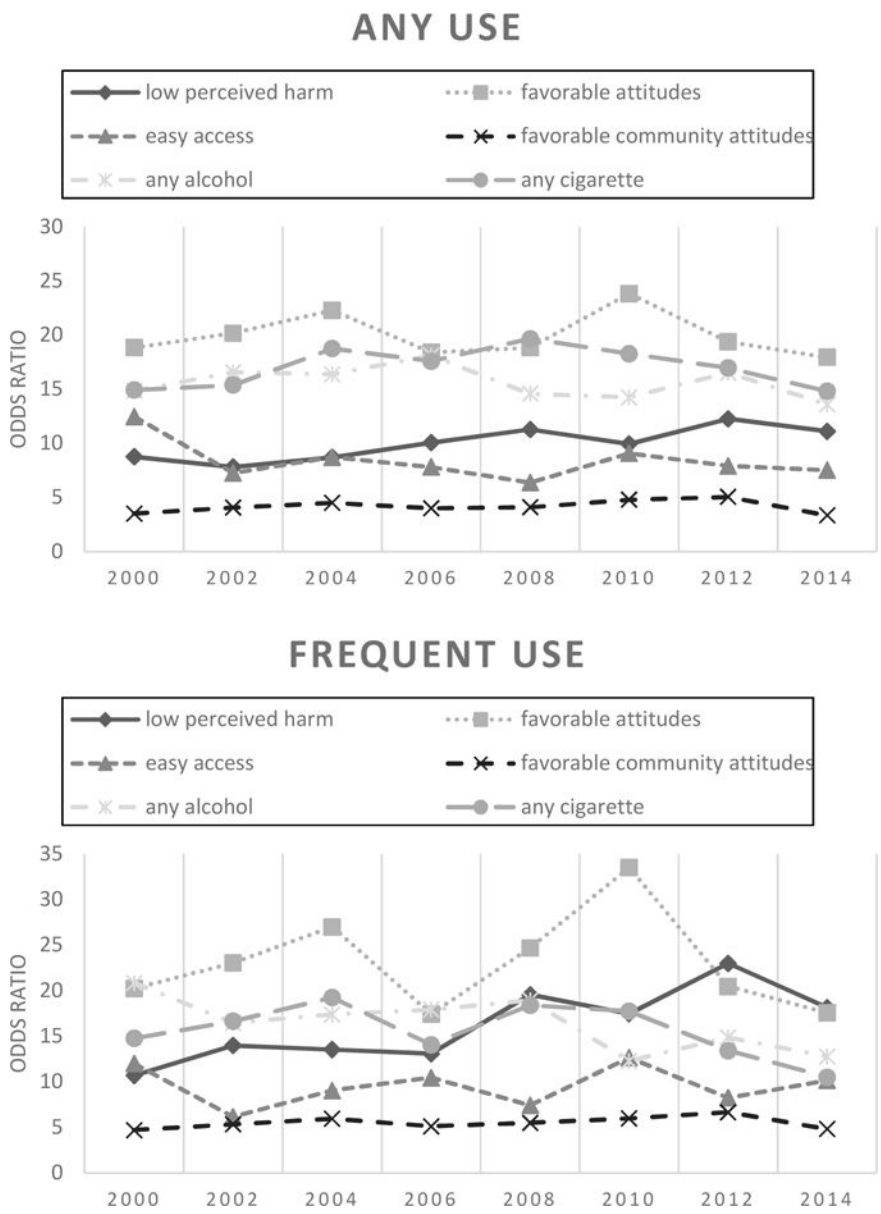

Figure 2.

Adjusted odds ratios for associations between marijuana use and marijuana-specific risk factors and alcohol and cigarette use by year.

Table 1

Prevalence of marijuana use, marijuana-specific risk factors, and alcohol and cigarette use by survey year

Survey year	Any past-month marijuana use % (95% CI)	Frequent past-month marijuana use % (95% CI)	Low perceived harm of marijuana use % (95% CI)	Favorable attitudes to marijuana use % (95% CI)	Easy access to marijuana % (95% CI)	Perceived community attitudes favorable to use % (95% CI)	Past-month alcohol use % (95% CI)	Past-month cigarette use % (95% CI)
2000	21 (19, 23)	10 (9, 11)	14 (12, 15)	31 (29, 33)	62 (59, 64)	13 (11, 15)	37 (35, 39)	21 (19, 22)
2002	18 (16, 20)	8 (7, 9)	17 (15, 19)	26 (24, 29)	51 (48, 54)	13 (11, 14)	28 (26, 30)	16 (14, 18)
2004	17 (15, 18)	6 (5, 7)	17 (15, 18)	23 (21, 25)	47 (45, 50)	12 (10, 13)	31 (29, 33)	13 (12, 15)
2006	19 (17, 20)	8 (7, 9)	18 (17, 20)	25 (24, 27)	47 (45, 49)	15 (13, 16)	32 (30, 33)	15 (13, 16)
2008	19 (17, 21)	8 (7, 9)	24 (22, 26)	28 (26, 30)	51 (48, 53)	16 (15, 18)	30 (28, 32)	14 (12, 15)
2010	20 (18, 22)	8 (7, 9)	28 (26, 31)	30 (28, 33)	54 (52, 57)	18 (15, 20)	28 (26, 29)	13 (11, 14)
2012	19 (18, 21)	9 (7, 10)	30 (28, 33)	32 (30, 34)	51 (49, 54)	17 (15, 19)	23 (21, 24)	10 (8, 11)
2014	18 (16, 20)	8 (6, 9)	35 (33, 37)	39 (37, 41)	53 (50, 56)	20 (18, 23)	20 (18, 21)	8 (7, 10)

CI = confidence interval.

Estimates are based on year-specific logistic regression models that include gender and race/ethnicity as covariates and adjusted for clustering of students within schools.

Table 2

Tests of variability in strength of relationships between predictors and two measures of marijuana use

Predictor	Any marijuana use F (7,262)	Frequent marijuana use F (7,262)
Low perceived harm	1.64	3.19**
Favorable attitudes to use	0.98	1.20
Easy access	1.94	1.20
Perceived community attitudes favorable to use	2.32*	0.97
Alcohol use	1.06	1.30
Cigarette use	1.18	1.22

* $p < .05$;

** $p < .01$.

Models included student gender and race/ethnicity as covariates and main effects for the given predictor and year dummy variables. Model estimates are adjusted for clustering of students within schools. The F statistic is for the Wald test of the null hypothesis that year-by-predictor interaction effects are zero.

Table 3

Logistic regression time series models predicting any and frequent past-month marijuana use

	Any past-month marijuana use		Frequent past-month marijuana use	
Predictor	**Model 1 AOR (95% CI)**	**Model 2 AOR (95% CI)**	**Model 1 AOR (95% CI)**	**Model 2 AOR (95% CI)**
Marijuana-specific risk factor				
Low perceived harm	3.31 (3.03, 3.62)	2.68 (2.42, 2.96)	4.67 (4.10, 5.31)	3.84 (3.36, 4.39)
Favorable attitudes to use	8.50 (7.81, 9.26)	5.46 (4.98, 5.99)	7.35 (6.24, 8.66)	4.31 (3.70, 5.00)
Easy access	3.34 (2.97, 3.76)	2.73 (2.41, 3.08)	2.89 (2.39, 3.50)	2.30 (1.90, 2.78)
Community attitudes favorable to use	1.69 (1.54, 1.86)	1.46 (1.31, 1.63)	2.25 (2.01, 2.51)	2.00 (1.77, 2.25)
Other substance use				
Alcohol use		5.11 (4.69, 5.58)		4.05 (3.52, 4.65)
Cigarette use		4.93 (4.42, 5.49)		3.95 (3.51, 4.45)
Year effects (reference = 2000)				
2002	0.84 (0.70, 1.02)	1.10 (0.90, 1.34)	0.76 (0.61, 0.95)	0.93 (0.73, 1.18)
2004	0.87 (0.75, 1.01)	1.09 (0.93, 1.28)	0.57 (0.46, 0.72)	0.66 (0.53, 0.83)
2006	0.89 (0.75, 1.06)	1.05 (0.85, 1.29)	0.72 (0.56, 0.93)	0.80 (0.59, 1.07)
2008	0.69 (0.59, 0.82)	0.96 (0.80, 1.15)	0.51 (0.41, 0.64)	0.64 (0.50, 0.80)
2010	0.68 (0.57, 0.80)	1.12 (0.92, 1.37)	0.44 (0.35, 0.54)	0.63 (0.49, 0.81)
2012	0.56 (0.48, 0.66)	1.14 (0.97, 1.34)	0.45 (0.36, 0.56)	0.81 (0.64, 1.03)
2014	0.38 (0.32, 0.45)	0.94 (0.79, 1.12)	0.30 (0.25, 0.38)	0.68 (0.55, 0.85)

AOR = adjusted odds ratio; CI = confidence interval.

Models include student gender and race/ethnicity as covariates and are adjusted for clustering of students within schools.