



# Perceived risk of harm from monthly cannabis use among US adolescents: National Survey on drug Use and Health, 2017

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## ABSTRACT

There has been a steady increase in cannabis use among US adolescents over the past decade. Perceptions of risk, specifically the belief that cannabis use is not harmful, may contribute to this increased use. The purpose of this study was to evaluate parental, school, and peer influence as protective factors in perceiving there is risk of harm from monthly cannabis use. Using the 2017 National Survey on Drug Use and Health (NSDUH), the study outcome was self-reported perceived risk of harm from monthly cannabis use amongst adolescents between ages 12 and 17. The exposures were parental monitoring and support, perception of school importance, extracurricular activity participation, peer attitudes towards cannabis use, and perception of peer cannabis use. Of 12,024 eligible adolescents, about 80% reported perceived risk of harm from monthly cannabis use. Multiple logistic regression models suggest the perception of risk of harm from monthly cannabis use was significantly associated with perception of peers using cannabis, perception of peers' disapproval of cannabis use, perception of school importance, and participation in extracurricular activities. Adolescents who perceived that monthly cannabis use was risky had high parental monitoring, low perception of peer use, high perception of peers' disapproval of cannabis use, high perception of school importance, and participated more in extracurricular activities. These findings suggest substance use prevention programs targeting adolescent attitudes and beliefs would benefit from leveraging peer influence, promoting extracurricular activities, and enhancing schoolwork to be more meaningful.

## 1. Introduction

Cannabis ("marijuana") users younger than 18 years of age have a 1 in 6 chance of developing cannabis dependence. (SAMHSA, 2019) Frequent cannabis use in adolescence has been shown to increase the risk for mental health conditions such as depression, anxiety, and psychotic symptoms, and has potential consequences on brain development, especially in cognition, memory, and problem-solving. (Bechtold et al., 2016; NIDA, 2010; Volkow et al., 2014; Lubman et al., 2015) While some studies have suggested these impairments may be reversible after abstaining from use, (Macleod et al., 2004; Jacobus et al., 2009) others found heavy use (at least 5 times per week) may worsen attention and memory if initiated during adolescence. (Schweinsburg et al., 2008) Additionally, adolescent cannabis use is related to poor educational outcomes, lower career achievement, and lower relationship and life satisfaction. (Volkow et al., 2014; Fergusson and Boden, 2008; Green and Ensminger, 2006; Hall and Degenhardt, 2009)

Despite these risks, adolescents' cannabis use has risen and their overall perception that cannabis use is harmful has declined over the past two decades. (Johnston et al., 2009) These shifts could be attributed to the rapidly changing policies regarding cannabis legalization. While results have been inconsistent in the role legalization plays in adolescent cannabis use, (Estoup et al., 2016; Cerdá et al., 2017; Rusby et al., 2018) there is an increased need for public health campaigns and interventions designed to address misperceptions of cannabis use. Due to emerging pro-cannabis messaging on social media, adolescents are exposed to less information about the health-related risks of using cannabis while there is an increasing amount of data promoting its potential benefits, such as pain reduction. (Roditis et al., 2016) Increased information about cannabis use risks alone has not been found to help change adolescent behaviors. (Rosendahl et al., 2005; Melchert and Burnett, 1990; Rohde et al., 2018) Additionally, pro-substance use media messages have been recognized as having a strong association with adolescents' substance use, (Strasburger and Donnerstein, 1999) further emphasizing the

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importance of identifying potential protective factors (e.g., social influences) that may offset the effects of media exposures on adolescents. Given the significant inverse relationship between perception of risk and substance use, (Grevenstein et al., 2015; Lopez-Quintero and Neumark, 2010) it is essential to further investigate modifiable factors that contribute to the perception of risk. Previous studies have indicated there may be protective effects on an adolescent's decision to use cannabis from parental, (Simantov et al., 2000; Barrera et al., 2001; Van Ryzin et al., 2012) peer, (Hill et al., 2007; Larson et al., 1996; Loeber et al., 2000; Mason et al., 2014; D'Amico and McCarthy, 2006; Brook et al., 2001; Urberg et al., 2003) and school-related (Simantov et al., 2000; Mayberry et al., 2009; Shears et al., 2006; Hemphill et al., 2011; Schepis et al., 2011) factors.

### 1.1. Parental monitoring and support

Parental roles have been shown to be protective factors in reducing adolescent substance use. (Simantov et al., 2000; Barrera et al., 2001; Van Ryzin et al., 2012) Using a nationally representative sample, Simantov, Schoen, and Klein (Simantov et al., 2000) found that strong parental support reduces the risk of adolescents smoking and drinking. (Simantov et al., 2000) Barrera and colleagues (2001) obtained similar results in a sample of seventh-grade students in Oregon; those with greater parental monitoring had stronger family relationships and less involvement with peers who used substances. (Barrera et al., 2001) Following adolescents from age 12 to age 23, Van Ryzin and colleagues (2012) identified different influential roles for family and friends; with family playing a stronger role among younger adolescents (ages 12 to 17) and friends being more influential in early adulthood (aged 23). (Van Ryzin et al., 2012) Moreover, parental monitoring and family relations may play a role in how adolescents choose their friends. (Van Ryzin et al., 2012)

### 1.2. Peer attitude and perception of peer use

As adolescents decrease their time with parents and family, their relationships with their peers increase, and these relationships could play a critical role in their decision to use substances. (Hill et al., 2007; Larson et al., 1996; Loeber et al., 2000) When their peers disapprove of using substances, adolescents have lower odds of substance use themselves. (Mason et al., 2014) Conversely, the perception of peers engaging in use (D'Amico and McCarthy, 2006) and deviant peer association (Van Ryzin et al., 2012) predict the onset of substance use. An examination of peer influences on adolescent substance use using the 2010 National Survey on Drug Use and Health (NSDUH) found that adolescents with close friends who disapprove of cannabis were 87% less likely to use, which was a stronger influence than when friends disapproved of cigarette and alcohol use. (Mason et al., 2014) Adolescents' perceptions of their peers engaging in substance use also appears important. Brook and colleagues (2001) conducted an integrated analysis from three longitudinal studies to examine predictors of cannabis use among adolescents and consistently found that adolescents were more likely to use cannabis if they believed their peers used it as well. (Brook et al., 2001) Urberg and others (2003) found similar results where adolescents with close friendships with peers who drink alcohol and/or smoke cigarettes were more likely to use those respective substances. (Urberg et al., 2003)

### 1.3. School perception and extracurricular activities

To have a holistic understanding of an adolescent's life, it is necessary to account for school-related factors, since adolescents spend most of their time in school. Positive school perception (Mayberry et al., 2009; Shears et al., 2006; Hemphill et al., 2011) and participating in extracurricular activities (Simantov et al., 2000; Schepis et al., 2011) have been identified as protective factors in preventing adolescent substance use. A longitudinal school-based survey of students in 7th and

9th grade conducted in Washington State, USA, and Victoria, Australia found that those who were more likely to report low school commitment (i.e., do not find school meaningful) had higher odds of using cannabis. (Hemphill et al., 2011) Furthermore, results from a cross-sectional study conducted in Connecticut found adolescents who participated in extracurricular activities had lower odds for both lifetime and 30-day cannabis use. (Schepis et al., 2011)

The impetus for the present study was a Healthy People 2020 objective, "to increase the proportion of adolescents aged 12 to 17 years perceiving great risk associated with smoking cannabis once a month." (Office of Disease Prevention and Health Promotion. Substance Abuse | Healthy People, 2020) Since parental support and monitoring, peer attitude and perception, and school perception and involvement are known to influence substance use, these modifiable factors could protect adolescents against the perception-altering effects of the influx of pro-cannabis messages. The objective of this study was to test the hypothesis that adolescents' perceived risk of harm from monthly cannabis use is significantly associated with stronger parental monitoring and support, higher peer disapproval of and lower perception of peer engagement in cannabis use, positive school perception, and higher involvement in extracurricular activities.

## 2. Methods

**Sample.** Data from the 2017 NSDUH (SAMHSA, 2019) was used. This is an annual, nationwide survey administered to approximately 70,000 individuals aged 12 years and older in the U.S. through a multistage probability sampling design. The purpose of NSDUH is to provide national and state-level estimates for the use of tobacco products, alcohol, illicit drugs, and mental health. Individuals excluded from the survey are those with no fixed household address, active-duty military personnel, and residents of institutional group quarters, such as correctional facilities, nursing homes, mental institutions, and long-term care hospitals. (SAMHSA, 2019) Of adolescents between ages 12 and 17 who participated in the 2017 NSDUH survey (N = 13,722), 1,698 had missing responses to survey questions relevant to the current study. A total of 12,024 adolescents are included in the final analytic sample for this study.

**Outcome.** The primary outcome for this analysis was perceived risk of harm from monthly cannabis use stemming from the question, "how much do people risk harming themselves physically and in other ways when they smoke marijuana once a month?" Response options were on a 4-point Likert scale from no risk to great risk, dichotomized to either any risk of harm from cannabis use (great risk, moderate risk, slight risk) or no perceived risk of harm from monthly cannabis use (no risk).

**Parental factors.** Parental support and parental monitoring were assessed using responses to the questions, "During the past 12 months, how often did your parents let you know when you'd done a good job?" and "How often did your parents or guardians limit the amount of time you went out with friends on school nights in the past 12 months?", respectively. Both questions had responses on a 4-point Likert scale and were recoded into three categories based on the distribution of responses (never/seldom, sometimes, always).

**School factors.** School perception was measured by the question, "During the past 12 months, how often did you feel that the schoolwork you were assigned to do was meaningful and important?" Responses used a 4-point Likert scale and were recoded into three categories due to the distribution of responses (never/seldom, sometimes, always). Extracurricular involvement was dichotomized to whether they participated in at least one school-based, community-based, church or faith-based, and/or other activity in the past 12 months (yes/no).

**Peer factors.** Perception of peer cannabis use was measured by the question, "How many of the students in your grade at school would you say use marijuana or hashish?" Responses were on a 4-point Likert scale, which was recoded into three categories (none, a few, most/all). Peer disapproval was assessed with the question, "How do you think your

close friends would feel about you using marijuana or hashish once a month or more?" Responses were dichotomized to whether their close friends disapprove of using cannabis (yes [somewhat/strongly disapprove], no [neither approve nor disapprove]). Peer disapproval and peer attitudes are used interchangeably throughout this paper.

**Covariates.** Demographic covariates included race categories (Non-Hispanic White, Non-Hispanic Black, Hispanic, and Other: combining Non-Hispanic Asian, Native Americans, Pacific Islander, and reported multiple races), sex (male/female), age, and household income (<\$20,000, \$20,000-\$49,999, \$50,000-\$74,999, >\$75,000). Lifetime substance use included using alcohol, tobacco, prescription drug misuse, and other illicit drugs (e.g., cocaine, hallucinogens, heroin, inhalants, methamphetamine, sedatives, tranquilizers, and stimulants) at least once or twice in their life (yes/no). Lifetime cannabis use was separated from combined lifetime substance use as literature suggests that lifetime cannabis users hold lower perceived risk of harm from cannabis use compared with non-users (yes/no). (Salloum et al., 2018; Pacek et al., 2015)

**Analysis.** Frequency and proportions were used to describe demographic characteristics, substance use history, and reported parental, peer, and school factors for the analytic sample. Chi-square tests were conducted to examine for differences in demographics, substance use history, reported parental, peer, and school factors, and perceived risk of harm from monthly cannabis use between the analytic sample and survey participants with missing responses. Chi-square tests also examined differences in demographic, substance use history, and reported parental, peer, and school factors between adolescents in the analytic sample who perceived risk of harm from monthly cannabis use and those who did not. The association between the outcome of perceived risk of harm from using cannabis and the predictors of parental factors, peer factors, and school factors were analyzed using bivariate and adjusted logistic regression models. The adjusted logistic regression model included parental factors, peer factors, and school factors, and adjusted for demographic characteristics and history of substance use. Unadjusted and adjusted odds ratios (OR/aOR), 95% confidence intervals (95% CI), and two-sided *p*-values (significant *p* < 0.05) were reported. Analyses were conducted with survey procedures to account for complex sampling using SAS 9.4.

### 3. Results

**Sample Characteristics.** Table 1 displays demographic characteristics for the analytic sample (*n* = 12,024). Compared to adolescents with missing responses, respondents in the analytic sample were significantly older ( $\chi^2(5) = 159.66$ ; *p* < 0.001), more were female ( $\chi^2(1) = 17.51$ ; *p* < 0.001) and Non-Hispanic White ( $\chi^2(3) = 25.73$ ; *p* < 0.001), and more reported having higher household income ( $\chi^2(3) = 75.58$ ; *p* < 0.001). More respondents in the analytic sample reported lower perceived risk of harm from monthly cannabis use ( $\chi^2(1) = 10.93$ ; *p* < 0.001), a history of cannabis use ( $\chi^2(1) = 43.30$ ; *p* < 0.001) and other substance use ( $\chi^2(1) = 29.00$ ; *p* < 0.001). Adolescents in the subsample had lower perception of the importance of schoolwork ( $\chi^2(2) = 23.69$ ; *p* < 0.001) and higher odds of participating in extracurricular activities ( $\chi^2(1) = 70.58$ ; *p* < 0.001). Additionally, more of the analytic sample perceived students in their grade use cannabis ( $\chi^2(1) = 43.30$ ; *p* < 0.001) and their friends were less likely to disapprove of cannabis use ( $\chi^2(1) = 54.4$ ; *p* < 0.001). There were no significant differences detected for parental factors between those with missing responses and the analytic sample.

Approximately half of the adolescents in the analytic sample were male (50%), Non-Hispanic White (53%), and had a household income of more than \$75,000 (45%). The mean age was 15 years old (SE = 0.02). Almost a fifth of the adolescents reported no perceived risk of harm from using cannabis monthly (19%), 29% reported perceiving a slight risk, 28% moderate risk, and 24% reported great risk, suggesting that most adolescents perceived there is risk of harm from monthly cannabis use (81%). A little more than half (53%) reported always having parental

**Table 1**

Characteristics of adolescent sample and differences in perceived risk of harm from monthly cannabis use.

	Total (n = 12024)	No risk (n = 2430; 19.4%)	Any risk (n = 9591; 80.6%)
<b>Male<sup>a</sup></b>	6079 (50.2%)	1388 (56.4%)	4692 (48.7%)
<b>Age<sup>a</sup></b>			
12	1618 (13.5%)	113 (4.4%)	1503 (15.7%)
13	1882 (15.4%)	210 (8.9%)	1672 (17.0%)
14	2022 (17.4%)	334 (14.5%)	1689 (18.1%)
15	2167 (17.6%)	453 (18.0%)	1714 (17.5%)
16	2180 (18.3%)	595 (24.2%)	1585 (16.9%)
17	2155 (17.7%)	725 (30.0%)	1428 (14.7%)
<b>Race/Ethnicity<sup>a</sup></b>			
Non-Hispanic White	6457 (53.3%)	1304 (53.4%)	5154 (53.3%)
Non-Hispanic Black	1512 (12.9%)	326 (14.2%)	1184 (12.6%)
Hispanic	2630 (23.9%)	542 (25.1%)	2086 (23.6%)
Non-Hispanic Other/ Multi-racial	1425 (9.8%)	258 (7.2%)	1167 (10.4%)
<b>Household income<sup>a</sup></b>			
<\$20 k	1817 (14.8%)	410 (18.2%)	1406 (13.9%)
\$20–49 k	3376 (26.8%)	782 (31.2%)	2591 (25.8%)
\$50–74 k	1794 (13.6%)	379 (14.2%)	1415 (13.5%)
>\$75 k	5037 (44.8%)	859 (36.4%)	4179 (46.8%)
<b>Parental support<sup>a</sup></b>			
Never/Seldom	1691 (14.0%)	507 (19.5%)	1184 (12.7%)
Sometimes	3893 (33.3%)	836 (34.9%)	3055 (32.9%)
Always	6440 (52.7%)	1087 (45.6%)	5352 (54.5%)
<b>Parental monitoring<sup>a</sup></b>			
Never/Seldom	4068 (33.6%)	492 (18.9%)	1679 (17.6%)
Sometimes	3307 (27.6%)	680 (28.0%)	2626 (27.5%)
Always	4649 (38.8%)	782 (33.3%)	3865 (40.1%)
<b>Extracurricular activity participation<sup>a</sup></b>	10,430 (87.0%)	1909 (78.6%)	8520 (89.1%)
<b>Perception of school importance<sup>a</sup></b>			
Never/Seldom	3012 (25.3%)	940 (39.7%)	2073 (21.9%)
Sometimes	6015 (49.9%)	1053 (41.4%)	4960 (52.0%)
Always	2997 (24.7%)	437 (18.9%)	2558 (26.1%)
<b>Perception of peer disapproval<sup>a</sup></b>	9354 (78.8%)	1017 (44.3%)	8146 (84.9%)
<b>Perception of peer use<sup>a</sup></b>			
None	3613 (30.7%)	280 (11.9%)	3331 (35.2%)
A few	5121 (42.6%)	912 (37.3%)	4208 (43.9%)
Most/All	3290 (26.7%)	1238 (50.8%)	2052 (21.0%)
<b>Lifetime cannabis use<sup>a</sup></b>	2099 (16.3%)	1154 (45.7%)	945 (9.2%)
<b>Lifetime other substance use<sup>a</sup></b>	6053 (48.8%)	1798 (71.9%)	4255 (43.2%)

<sup>a</sup> Statistically significant difference in perceived risk of harm from monthly cannabis use using chi-square test (*p* < 0.05).

support and 39% reported always having parental monitoring. Most adolescents participated in at least one extracurricular activity (87%). A quarter (25%) always perceived schoolwork as meaningful and important. Thirty-one percent perceived that none of the students in their grade have used cannabis, and 77% perceived their close friends would disapprove of them trying cannabis. Sixteen percent of the adolescents reported lifetime cannabis use and almost half (49%) had used alcohol or other illicit drugs at least once in their life.

**Table 1** also presents differences between adolescents in the analytic sample who perceived risk of harm from monthly cannabis use and those who did not. Significantly more females reported perceived risk of harm from using cannabis than males ( $\chi^2(1) = 22.14$ ;  $p < 0.001$ ). Most of those who reported household income greater than \$75,000 perceived risk of harm from monthly cannabis use ( $\chi^2(3) = 62.67$ ;  $p < 0.001$ ). Higher proportions of Non-Hispanic Black and Other races (Asian, Native Americans, Pacific Islander and multiracial) perceived risk of harm from monthly cannabis use than Non-Hispanic White respondents ( $\chi^2(3) = 18.19$ ;  $p < 0.001$ ). Younger adolescents ( $\chi^2(5) = 415.15$ ;  $p < 0.001$ ) were more likely to report perceived risk of harm from monthly cannabis use. More of those who reported no history of cannabis use ( $\chi^2(5) = 1781.42$ ;  $p < 0.001$ ) and other substance use ( $\chi^2(5) = 370.67$ ;  $p < 0.001$ ) perceived risk of harm from monthly cannabis use. Adolescents who received more frequent parental support ( $\chi^2(2) = 63.58$ ;  $p < 0.001$ ) and more parental monitoring ( $\chi^2(2) = 30.79$ ;  $p < 0.001$ ) were more likely to report perceived risk from using cannabis monthly. Adolescents who had positive school perception ( $\chi^2(2) = 187.33$ ;  $p < 0.001$ ) and participated in at least one extracurricular activity ( $\chi^2(1) = 120.43$ ;  $p < 0.001$ ) were more likely to report perceived risk of harm from monthly cannabis use. And those adolescents who perceived risk of harm from monthly cannabis use were less likely to feel that their peers use cannabis ( $\chi^2(2) = 543.36$ ;  $p < 0.001$ ) and more likely their peers disapprove of cannabis use ( $\chi^2(1) = 1368.75$ ;  $p < 0.001$ ).

**Table 2** displays results of unadjusted and adjusted logistic regression models used to test for the associations between parental, school and peer-related factors and the risk perception of harm from monthly cannabis use.

**Parental Factors.** After adjusting for demographic characteristics, parental, school- and peer-related factors, only parental monitoring was statistically significant. Adolescents with parents who always limited time out with friends during school nights had higher odds of perceiving risk of harm from monthly cannabis use compared with adolescents whose time with friends was never or seldom limited during school nights.

**School-Related Factors.** Compared with adolescents who never or seldom found schoolwork meaningful or important, adolescents who sometimes or always perceived schoolwork important had twice the odds of perceiving risk of harm from monthly cannabis use. Adolescents who participated in at least one extracurricular activity had higher odds of perceiving risk of harm from monthly cannabis use compared with those who did not participate in any extracurricular activities.

**Peer Factors.** Results from the adjusted model suggest that adolescents with close friends who disapproved of trying cannabis in their lifetime had 4 times the odds of perceiving risk of harm from monthly cannabis use than their counterparts who reported friends did not disapprove of cannabis use. Compared with adolescents who perceived that most or all their classmates use cannabis, those who perceived that only a few or none of their classmates use cannabis had 2 and 3 times the odds of perceiving risk of harm from monthly cannabis use, respectively.

#### 4. Discussion

Using a nationally representative sample, this study evaluated the association between parental, school, and peer influences as protective factors for cannabis use and the perceived risk of harm from monthly cannabis use among US adolescents aged 12 to 17 years old. Findings from the current study indicate that adolescents who had parents always

**Table 2**

Results of logistic regression: Association between parental, peer and school related factors and perceived risk of harm from monthly cannabis use among US adolescents.

	Unadjusted <sup>a</sup>	Adjusted <sup>b</sup>
<b>Parental support (ref: Never/Seldom)</b>		
Sometimes	1.49 (1.24–1.79) *	0.93 (0.72–1.19)
Always	1.86 (1.56–2.22) *	0.93 (0.74–1.18)
<b>Parental monitoring (ref: Never/Seldom)</b>		
Sometimes	1.19 (1.04–1.36) *	1.13 (0.95–1.34)
Always	1.32 (1.14–1.53) *	1.22 (1.02–1.46) *
<b>Extracurricular activity participation</b>	2.14 (1.87–2.46) *	1.50 (1.23–1.82) *
<b>Perception of school importance (ref: Never/Seldom)</b>		
Sometimes	2.33 (2.03–2.67) *	1.60 (1.35–1.89) *
Always	2.60 (2.19–3.08) *	1.41 (1.14–1.75) *
<b>Perception of peer disapproval</b>	7.22 (6.44–8.09) *	3.30 (2.85–3.81) *
<b>Perception of peer use (ref: Most/All)</b>		
None	7.28 (6.14–8.63) *	2.16 (1.71–2.71) *
A few	2.86 (2.48–3.29) *	1.44 (1.21–1.71) *
<b>Demographic Characteristics</b>		
Female vs. Male	1.34 (1.19–1.51) *	1.58 (1.35–1.84) *
Age	0.70 (0.68–0.73) *	0.95 (0.91–0.99) *
<b>Race/Ethnicity (ref: NH White)</b>		
NH Black	0.89 (0.77–1.02)	0.94 (0.75–1.17)
Hispanic	0.97 (0.85–1.10)	1.08 (0.89–1.31)
NH Other/Multi-racial	1.44 (1.19–1.73) *	1.26 (0.97–1.59)
<b>Household income (ref: &gt;\$75 k)</b>		
<\$20 k	0.62 (0.54–0.71) *	0.58 (0.48–0.70) *
\$20–49 k	0.65 (0.56–0.75) *	0.64 (0.53–0.78) *
\$50–74 k	0.79 (0.68–0.91) *	0.75 (0.62–0.92) *
<b>Lifetime cannabis use</b>	0.12 (0.11–0.14) *	0.34 (0.29–0.40) *
<b>Lifetime substance use</b>	0.30 (0.27–0.34) *	0.74 (0.63–0.85) *

\*Statistically significant in Type 3 Analysis of Effects ( $p < 0.05$ ).

<sup>a</sup> ORs (95% CI) from crude logistic regression analyses for each variable with perceived risk of harm from monthly cannabis use as outcome.

<sup>b</sup> aORs (95% CI) from multivariate logistic regression model for parental support and monitoring, school perception and extracurricular activities, and peer attitudes and perception of peer use accounting for demographic characteristics.

limiting their time out during school nights, did not perceive peers using cannabis, perceived their peers disapprove of cannabis use, considered schoolwork as important, and participated in extracurricular activities have higher odds of perceiving monthly cannabis use as risky. This is the first known study to examine parental, school, and peer factors as potential influences on adolescents' perception of risk of harm from cannabis use. These findings are timely as they may be capitalized in developing targeted approaches in educational interventions aimed at helping reduce harmful substance use among at-risk youth.

Results from the current study align with others' findings related to the role of peer and school perceptions as protective factors in adolescents' attitudes and beliefs about substance use. (van Hoorn et al., 2016; Choukas-Bradley et al., 2015; Li et al., 2011) Compared with parental



and school-related protective factors, adolescents' perceptions of their peers' attitudes towards and use of cannabis had a larger magnitude association with perceiving risk of harm from using cannabis. Public health campaigns and interventions should involve images, messaging, and opportunities that leverage adolescents' capacity as peer role models to promote healthy behaviors. Boosting positive attitudes towards school and encouraging extracurricular activities should be considered in the development of substance use prevention programs. Previous studies have found peer education interventions to be a cost-effective and valuable method for promoting HIV/STD prevention and nutrition in developing countries. (Abdi and Simbar, 2020; Shankar et al., 2020) However, few studies have examined interventions to prevent substance use among youth in developed countries. Studies that analyzed the effectiveness of peer education interventions in adolescent substance use were limited to the country of Turkey. (Yasli et al., 2012; Ayaz and Açil, 2015; Bilgiç and Günay, 2018; Demirezen et al., 2020) An earlier study found that peer education did not have significant effect adolescents' smoking behaviors (Yasli et al., 2012) but later research identified increased knowledge and positive behavior changes in smoking cigarettes. (Ayaz and Açil, 2015; Bilgiç and Günay, 2018) The only study that examined adolescent use of substances besides cigarette smoking and that included cannabis use found that a peer education intervention was effective in significantly decreasing use of cannabis and other substances among 10th graders (Demirezen et al., 2020).

More adolescents who perceived risk of harm from using cannabis monthly reported stronger parental support and parental monitoring. Interestingly, multivariate modeling identified that parental monitoring remained significantly associated with perception of risk of harm from cannabis use, but parental support did not after adjusting for other protective factors. These findings are in line with previous research which also found that parental involvement did not have as strong an association with adolescent substance use compared with other socio-environmental factors, such as peer relations. (Webster et al., 1994; Bahr et al., 2005; CONRAD et al., 1992) However, findings from the literature related to the strength of parental influence in substance use has been mixed. Some studies indicate strong parenting methods have direct protective influence on adolescent substance use (Piko and Kovács, 2010) or have indirect influence by affecting adolescent's choice of peers. (Van Ryzin et al., 2012) The present study's results, which indicate that protective factors other than parental influence play a stronger role in the perception of risk of harm from cannabis use, may be due to the focus on adolescent perception of risk of harm instead of actual cannabis use.

Adolescents who have a history of using cannabis and other substances had lower odds for perceiving risk of harm from using cannabis. These results align with other studies found in the literature that investigated the reciprocal effects of substance use and perception of risk of harm from their use. (Salloum et al., 2018; Pacek et al., 2015) Multivariate modeling indicated that adolescents with a history of cannabis use had lower perceived risk of harm compared with those who had a history of using other substances. This is an important finding as studies have found that cannabis consumption decreases perceived risk of harm from using cannabis (Grevenstein et al., 2015; Apostolidis et al., 2006).

Limitations to consider when interpreting results of this study include the inability to conclude causal relation, limited generalizability, and response biases. Although complex sampling was used to have the most generalizable adolescent population to the US, some differences in perceived risk of harm from cannabis use and history of substance use were detected between the full sample of US adolescents from the NSDUH dataset and the analytic subsample that had complete responses to the pertinent survey questions, thereby limiting generalizability. Furthermore, there is potential for response biases with retrospective, self-report questions that may result in underreporting or recall bias. For example, reported perception of peer use has been linked to a respondent's own substance use (Henry et al., 2011).

Recommendations for future research are to conduct prospective studies to confirm the findings of the current study. Furthermore, research analyzing longitudinal data to monitor trends in risk perceptions and consumption, differentiating by state is essential as cannabis laws differ by state. Additionally, research examining the effects of interactions between age or sex and peer influence on cannabis risk perception will be useful for adapting prevention services tailored for age and sex. Understanding the effects of legalization of cannabis on adolescent use can better inform state officials on ways to implement programs to educate adolescents about the risk of harms associated with its use. Adolescent cannabis use prevention programs might include age-appropriate messaging about the risk of harm from using cannabis and elements that bolster the protective influences of peers and schools.

The current study adds further evidence to justify capitalizing on the potency of peer and social influences in substance use prevention interventions. Adolescents in this study who perceived risk of harm from monthly cannabis use had lower odds of believing their peers used cannabis, higher odds of perceiving their peers disapproved of using cannabis, higher odds of their parents limiting their time out with friends during school nights, higher odds of regarding school as important, and higher odds of reporting participation in extracurricular activities. This study further emphasizes the need for effective, multi-dimensional programs that target adolescent attitudes and beliefs about cannabis use through peer education, enhancing school engagement, and promoting youth clubs, athletics and other school-based or community social events.

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## CRediT authorship contribution statement

**Abigail Cadua Mariani:** Conceptualization, Methodology, Writing - original draft. **April R. Williams:** Writing - review & editing.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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