



# Recreational cannabis legalization alters associations among cannabis use, perception of risk, and cannabis use disorder treatment for adolescents and young adults

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## ABSTRACT

**Objective:** Understanding how recreational cannabis legalization may impact cannabis use disorder (CUD) among adolescents and young adults is key to developing an appropriate public health response. This research investigates whether associations among adolescent and young adult perception of risk of harm from cannabis use, prevalence of past-month cannabis use, and rate of CUD treatment admissions changed following recreational cannabis legalization in the US, 2008–2019.

**Methods:** Data from the NSDUH and TEDS-A datasets are employed in difference-in-differences models of the effect of recreational legalization on perception of risk, cannabis use prevalence, and CUD treatment admissions. Moderated models test whether associations among variables changed following recreational legalization.

**Results:** Following recreational legalization: 1) adolescent and young adult past-month cannabis use prevalence increased; 2) among both adolescents and young adults, the association of lower perception of risk of harm with higher cannabis use prevalence was strengthened; 3) among adolescents, the association of higher cannabis use prevalence with higher CUD treatment admissions was suppressed; and 4) among young adults, an association of higher cannabis use prevalence with lower CUD treatment admissions emerged.

**Conclusions:** Recreational legalization is likely to increase cannabis use among adolescents and young adults who perceive cannabis as less harmful, while at the same time reduce rates of CUD treatment utilization. These trends portend an increase in unmet need for CUD treatment for age groups particularly vulnerable to the development and negative consequences of CUD.

## 1. Introduction

Expanding legalization of recreational cannabis in the US represents a growing public health challenge (Leung et al., 2019). There are legitimate reasons for recreational cannabis legalization, such as potential therapeutic uses (Hill, 2019) and social justice concerns about the criminalization of cannabis use, including the racial and ethnic discrimination associated with legal sanctions (Adinoff & Reiman, 2019). However, long term and frequent cannabis use is associated with numerous negative health outcomes, including psychosis, mood disorders, and impaired cognitive function (Hasin & Walsh, 2021; Lovell et al., 2020; Onaemo et al., 2021), although direct causal evidence of such outcomes is unclear (Ganesh & D'Souza, 2022). Frequent cannabis use is also associated with cannabis use disorder (CUD) (Robinson et al., 2022), a condition marked by an inability to reduce or stop cannabis use

even when causing harm (Connor et al., 2021), with a recent meta-analysis reporting the prevalence of CUD among those using cannabis at 22 % (Leung et al., 2020), putting millions of cannabis users at risk.

The legalization and commercialization of cannabis is associated with risk factors for CUD, including easier access to cannabis, stronger cannabis potency, greater variety of cannabis products, and exposure to cannabis advertising and sales (Chiu et al., 2021; D'Amico et al., 2018; Smart & Pacula, 2019). Of particular concern is the impact of recreational cannabis legalization on CUD prevalence for adolescents (age 12–17) and young adults (age 18–25), age groups particularly vulnerable to the negative health effects of sustained, frequent cannabis use (Chadi et al., 2018; Hines et al., 2020). Young adults in the US have the highest rate of CUD as compared to all age groups (Substance Abuse and Mental Health Services Administration, 2021), and developing CUD is more likely when cannabis use is initiated earlier in adolescence

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(Richter et al., 2017), with more than 20 % of adolescents developing CUD within four years of beginning cannabis use (Han et al., 2019). Young adult cannabis use and CUD prevalence have risen since the early 2000s (Hasin et al., 2019), and the perception of cannabis use as harmful has declined substantially among both adolescents and young adults (Sarvet et al., 2018; Wen et al., 2019), trends which evidence suggests have increased following cannabis legalization (Cerdá et al., 2020; Leung et al., 2019; Smart & Pacula, 2019).

Given these increasing risk factors for CUD, one might expect that CUD treatment utilization for adolescents and young adults would also be increasing. However, evidence indicates that since the middle 2000s, adolescent and young adult CUD treatment admissions in the US have fallen (Mennis, 2020; Mennis & Stahler, 2020; Standeven et al., 2020; Rhee & Rosenheck, 2022). Indeed, our prior research showed that from 2008 to 2017 states with greater increases in young adult cannabis use prevalence actually had greater declines in CUD treatment admissions (Mennis et al., 2021), a counterintuitive pattern that descriptive statistics suggested was stronger in states legalizing recreational cannabis.

We theorize that recreational cannabis legalization may induce changes in the conventional directionality of associations between lower perception of risk of harm from cannabis use and higher cannabis use prevalence (Hasin et al., 2019; Parker & Anthony, 2018; Taylor et al., 2019), as well as between higher cannabis use prevalence and higher CUD prevalence (Han et al., 2019; Leung et al., 2020), which may explain the observed decline in CUD treatment admissions during a period of increasing risk factors for CUD in the US. To our knowledge, no prior research has investigated how recreational cannabis legalization may affect such associations among CUD risk factors and treatment. In the present research we address this gap by investigating the following research questions regarding the effects of recreational cannabis legalization in the US from 2008 to 2019, for both adolescents and young adults:

1. Did the prevalence of past-month cannabis use, perception of risk of harm from cannabis use, and rate of CUD treatment admissions change following recreational cannabis legalization?
2. Did the associations between a) perception of risk of harm from cannabis use and prevalence of past-month cannabis use and b) prevalence of past-month cannabis use and rate of CUD treatment admissions change following recreational cannabis legalization?

We expect to find that the positive association between perception of risk and prevalence of cannabis use was strengthened following recreational cannabis legalization, as greater accessibility to cannabis and other characteristics of legalization enable greater cannabis use among those who perceive a lower risk (Levy et al., 2021). We also expect that the positive association between prevalence of cannabis use and CUD treatment admissions was weakened following recreational legalization, as increasing social acceptance of cannabis use and decreasing perception of risk may suppress both the prevalence of CUD among cannabis users as well as perception of treatment need among those with CUD (Askari et al., 2021; Compton et al., 2019). Such findings can enhance understanding of how recreational legalization may impact CUD prevalence and inform public health strategies for CUD prevention and treatment.

## 2. Materials and methods

### 2.1. Data

The present study integrates state-level data for 2008–2019 from the National Survey of Drug Use and Health (NSDUH), a nationally representative survey of health behaviors and outcomes, and the Treatment Episode Dataset – Admissions (TEDS-A), an administrative dataset comprising annual substance use disorder treatment admissions to public and private treatment centers throughout the US receiving public

funds. Both are publicly available datasets from the US Substance Abuse and Mental Health Services Administration (SAMHSA). Estimates at the state level for NSDUH data are made available as pooled two-year samples which we joined to the TEDS-A data based on the latter pooled NSDUH year.

During the study period nine US states had a combined 22 annual observations missing from the TEDS-A dataset: Georgia (2015–2018), Kansas (2015), Mississippi (2009–2012), New Mexico (2018), Oregon (2015–2019), Pennsylvania (2012, 2013, 2015), South Carolina (2014–2015), Washington (2019), and West Virginia (2012). Delaware was missing data for adolescents for 2008. The remaining annual observations for states with missing data were kept. The resulting analytical dataset contained 578 state-year observations for young adults and 577 observations for adolescents, both covering 50 states over twelve years.

### 2.2. Measures

Each measure is calculated separately for adolescents (age 12–17) and young adults, for whom data are available within the age ranges of 18–25 in the NSDUH dataset and 18–24 in the TEDS-A dataset.

‘Perception of Risk’ represents the perception of risk of harm from cannabis use, calculated as the percentage of the population that responded by answering “Great Risk” to the NSDUH survey question “How much do people risk harming themselves physically and in other ways when they smoke marijuana once a month?,” expressed as a decimal value between 0 and 1. The state level variable is not available for 2014–2015 due to changes in estimation calculation methods following 2014, and analyses of perception of risk therefore exclude these observations.

‘Cannabis Use’ represents the prevalence of past-month cannabis use, calculated as the percentage of the population who indicated in the NSDUH they used cannabis (marijuana) in the past month, expressed as a decimal value between 0 and 1.

‘Treatment Admissions’ represents the rate of CUD treatment admissions (per 10,000 adolescents or young adults). From the TEDS-A dataset, we extracted admissions for which cannabis (marijuana, hash, or other THC preparation) was the primary substance used. We further restricted the sample to non-criminal justice system referrals, so that our results are largely independent of the changes to cannabis-related arrests and consequent criminal justice referrals to CUD treatment brought about by legalization (Mennis & Stahler, 2020; Plunk et al., 2019).

‘RCL\_Ever’ encodes whether a state enacted recreational cannabis legalization at any time during the study period (1 = yes, 0 = no).

‘RCL\_Status’ encodes whether recreational cannabis legalization was in effect for that year for each state (1 = yes, 0 = no), beginning the year following legalization in that state. For example, because Colorado enacted recreational legalization in 2012, RCL\_Status = 0 for annual observations from 2008 to 2012 and RCL\_Status = 1 for annual observations from 2013 to 2019.

### 2.3. Analytic plan

We conduct the following analyses for adolescents and young adults in separate models.

2.3.1 Did cannabis use, perception of risk, and treatment admissions change following recreational cannabis legalization? We begin by investigating whether states that ultimately legalized recreational cannabis differed from states that did not in perception of risk, cannabis use, and treatment admissions, prior to legalization. We select only state-year observations prior to, or without, recreational legalization and visualize the trajectory of each outcome over time, grouped by whether a state legalized recreational cannabis. We then test whether there is a significant difference in each outcome between states which ultimately enacted recreational cannabis legalization and those that did not, prior to legalization, by regressing each outcome on RCL\_Ever,

while fixing year effects and controlling for whether a state had medical cannabis legalization in effect that year (1 = yes, 0 = no).

Following previous research (Dilley et al., 2019; Mennis & Stahler, 2020; Wen et al., 2019), we employ difference-in-differences analysis to test whether cannabis use, perception of risk, and treatment admissions changed following recreational cannabis legalization. Using the data for all available states and years, we regress each outcome on RCL\_Status in separate models, while fixing the effects of state and year to control for the secular trend and differences among states, and while also

controlling for medical cannabis legalization.

2.3.2 Did the associations between a) perception of risk and cannabis use and b) cannabis use and treatment admissions change following recreational cannabis legalization? We first investigate the association of perception of risk with cannabis use independent of the moderating effect of recreational legalization by regressing cannabis use on perception of risk while fixing state and year effects and controlling for medical cannabis legalization. Following established methods (Lindo et al., 2020; Macdonald et al., 2022), we then investigate the moderating

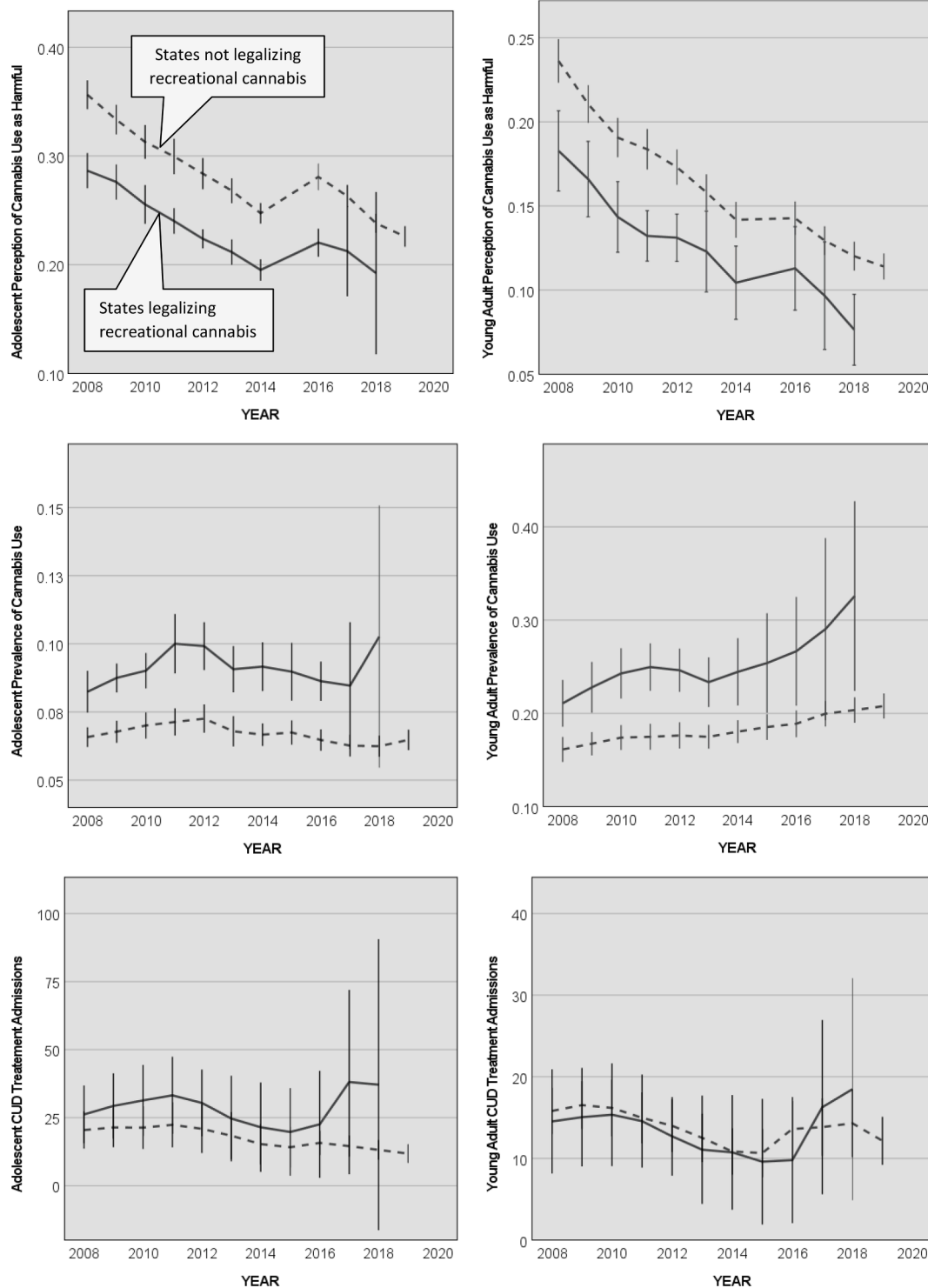


Fig. 1. Crude annual trajectories of perception of risk, cannabis use, and treatment admissions, grouped by states legalizing (solid line) or not legalizing (dashed line) recreational cannabis, but restricted to state-year observations prior to, or without, enactment of recreational legalization for each state.

effect of recreational legalization by adding RCL\_Status and the interaction term perception of risk X RCL\_Status to each model, the coefficient for which represents the difference in the effect of perception of risk on cannabis use before versus after recreational legalization. We fit analogous sets of models to test the association of cannabis use with treatment admissions, and moderation by recreational legalization.

2.3.3 Sensitivity tests. We conduct additional analyses to investigate the sensitivity of the difference-in-differences and moderation modeling results, including shifting the first year encoded for recreational legalization ahead one year to account for potential delays in the effects, bootstrapping confidence intervals using 1000 samples to account for potential non-normality in model residuals, and adding annual, state-level measures of percent without health insurance and number of substance use disorder treatment centers as covariates to address changes in access to treatment within states over time. All models are estimated using SPSS Version 27 (IBM, Inc.) using OLS regression and two-tailed significance tests at  $p < 0.05$ . Statistical moderation is estimated using the PROCESS 3.4.1 macro for SPSS (Hayes, 2017), which also generates conditional effects pre- versus post-recreational legalization and bootstrapped confidence intervals using 1000 samples. We report unstandardized coefficients, 95 % confidence intervals, and p values.

### 3. Results

#### 3.1. Did cannabis use, perception of risk, and treatment admissions change following recreational cannabis legalization?

Fig. 1 shows that, prior to legalization, states eventually enacting recreational legalization had higher cannabis use and lower perception of harm as compared to states that did not, for both adolescents and young adults; Although, perception of risk declined, and cannabis use increased, during the study period for both groups of states (Table 1, Model 1). We did not find a significant difference in treatment admissions prior to legalization, for adolescents or young adults (Table 1,

**Table 1**

Results of regressions modeling whether perception of risk, cannabis use, and treatment admissions differ 1) between states which enacted recreational cannabis legalization and those that did not, prior to legalization (Model 1), and 2) before versus after recreational legalization (Model 2), for adolescents and young adults. Unstandardized coefficients are reported with significance in parentheses and 95% confidence intervals in brackets.

Outcome	Age Group	Model 1 RCL_Ever <sup>ab</sup>	Model 2 RCL_Status <sup>cd</sup>
Perception of risk	Adolescents	-0.030 (p < 0.0005) [-0.040, -0.019]	0.001 (p = 0.790) [-0.008, 0.010]
	Young adults	-0.025 (p < 0.0005) [-0.034, -0.015]	0.010 (p = 0.002) [0.004, 0.017]
Cannabis use	Adolescents	0.010 (p < 0.0005) [0.006, 0.013]	0.009 (p < 0.0005) [0.006, 0.012]
	Young adults	0.030 (p < 0.0005) [0.019, 0.041]	0.034 (p < 0.0005) [0.026, 0.041]
Treatment admissions	Adolescents	-1.430 (p = 0.633) [-7.315, 4.455]	-1.216 (p = 0.617) [-5.991, 3.559]
	Young adults	-2.337 (p = 0.109) [-5.194, 0.519]	-0.624 (p = 0.562) [-2.738, 1.490]

Note: <sup>a</sup> Observations restricted to states and years without, or prior to, recreational cannabis legalization; <sup>b</sup> Models adjusted for year fixed effects and medical cannabis legalization; <sup>c</sup> Observations include all available state-year observations; <sup>d</sup> Models adjusted for state and year fixed effects and medical cannabis legalization. RCL\_Ever encodes whether each state enacted recreational cannabis legalization at any time during the study period (1 = yes, 0 = no). RCL\_Status encodes whether recreational cannabis legalization was in effect for that year for each state (1 = yes, 0 = no).

Model 1, and Fig. 1). Confidence intervals widen over time for the recreational legalization group due to the shrinking sample size of pre-legalization observations.

Fig. 1 indicates that the difference-in-differences assumption of parallel trends prior to recreational legalization is met for each outcome, confirmed by statistical tests (see Supplementary Materials). Results of the difference-in-differences models indicate that 1) among adolescents, the legalization of recreational cannabis did not significantly alter the trajectory of perception of risk, 2) among young adults, perception of risk declined at a significantly lesser rate after recreational legalization, and 3) among both adolescents and young adults, cannabis use increased following recreational legalization (Table 1, Model 2). We did not find evidence that the trajectory of adolescents or young adult treatment admissions changed significantly following recreational legalization.

#### 3.2 Did the associations between a) perception of risk and cannabis use and b) cannabis use and treatment admissions change following recreational cannabis legalization?

State and year fixed effects regression models of cannabis use on perception of risk, without considering the moderating effect of recreational legalization, indicate that, not surprisingly, lower perception of risk is associated with higher cannabis use among both adolescents ( $\beta = -0.085$ ; 95 % CI  $-0.117, -0.054$ ;  $p < 0.0005$ ) and young adults ( $\beta = -0.156$ ; 95 % CI  $-0.117, -0.039$ ;  $p = 0.009$ ). Regressions of treatment admissions on cannabis use indicate that, among adolescents, increasing cannabis use is associated with increasing treatment admissions ( $\beta = 209.152$ ; 95 % CI  $81.092, 337.213$ ;  $p = 0.001$ ). The analogous model for young adults, however, yielded non-significant results ( $\beta = -1.218$ ; 95 % CI  $-23.782, 21.345$ ;  $p = 0.916$ ).

Results of the moderated models indicate that the effect of perception of risk on cannabis use is significantly stronger following recreational legalization among young adults, with analogous effects observed for adolescents (though  $p = 0.054$ ) (Table 2, Model 1). This is illustrated in Fig. 2, top, which shows the mean estimated cannabis use for values of perception of risk for groups of states pre-, and post-, recreational legalization for adolescents (top, left) and young adults (top,

**Table 2**

Results of regressions modeling the moderating effect of recreational cannabis legalization on the association between perception of risk and cannabis use (Model 1), and between cannabis use and treatment admissions (Model 2), for adolescents and young adults. Unstandardized coefficients are reported with significance in parentheses and 95% confidence intervals in brackets.

Age Group	Variables	Model 1 Cannabis use on Perception of risk <sup>a</sup>	Model 2 Treatment admissions on Cannabis use <sup>a</sup>
Adolescents	Perception of risk	-0.085 (p < 0.0005) [-0.116, -0.054]	
	Cannabis use		277.462 (p < 0.0005) [141.250, 413.674]
	RCL_Status	-0.036 (p = 0.011) [-0.008, -0.063]	32.832 (p = 0.029) [3.470, 62.194]
	Perception of risk X RCL_Status	-0.146 (p = 0.054) [-0.295, 0.003]	
Young adults	Cannabis use X RCL_Status		-381.812 (p = 0.014) [-687.389, -76.235]
	Perception of risk	-0.238 (p < 0.0005) [-0.346, -0.130]	
	Cannabis use		10.569 (p = 0.401) [-14.106, 35.244]
	RCL_Status	0.088 (p < 0.0005) 0.054, 0.122]	20.784 (p = 0.002) [7.432, 34.135]
	Perception of risk X RCL_Status	-0.544 (p = 0.003) [-0.901, -0.187]	
	Cannabis use X RCL_Status		-74.252 (p = 0.001) [-119.793, -28.711]
	RCL_Status		

Note: <sup>a</sup> Models adjusted for state and year fixed effects and medical cannabis legalization. RCL\_Status encodes whether recreational cannabis legalization was in effect for that year for each state (1 = yes, 0 = no).

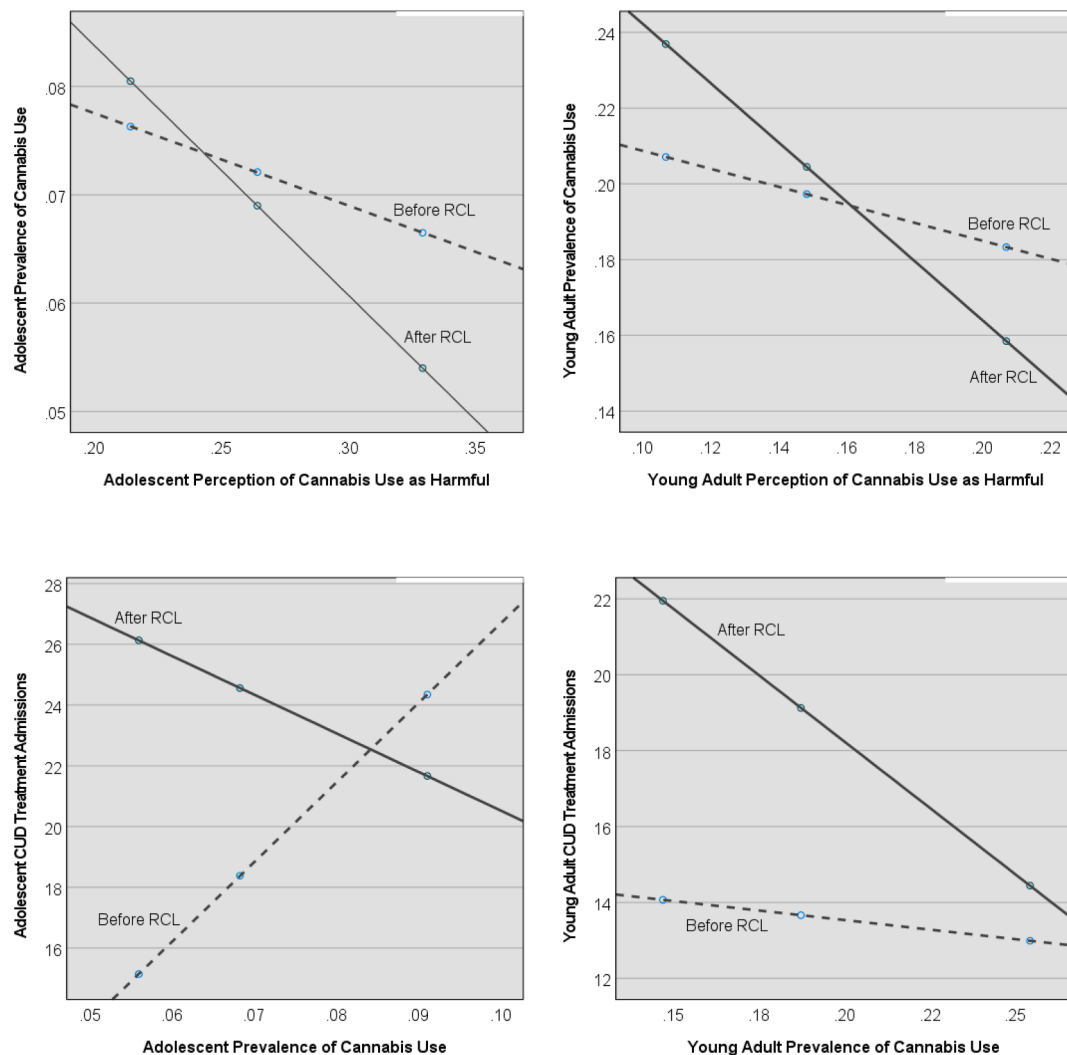


Fig. 2. Graphs illustrating moderation by recreational cannabis legalization (RCL) on the effect of 1) perception of risk on cannabis use among adolescents (top left) and young adults (top right), and 2) cannabis use on treatment admissions among adolescents (lower left) and young adults (lower right). Lines represent associations between variables for states before RCL (dashed lines) and after RCL (solid lines), adjusted for state and year fixed effects and medical cannabis legalization.

right). Tests of conditional effects of perception of risk on cannabis use for the pre- versus post-legalization periods (Table 3, Model 1) indicate the effect size more than doubles for adolescents and more than triples for young adults following legalization of recreational cannabis.

Table 3

Conditional effects of 1) perception of risk on cannabis use, and 2) cannabis use on treatment admissions, before and after recreational cannabis legalization (RCL). Unstandardized coefficients are reported with significance in parentheses and 95% confidence intervals in brackets.

Age Group	Variables	Model 1 Cannabis use on Perception of risk <sup>a</sup>	Model 2 Treatment admissions on Cannabis use <sup>a</sup>
Adolescents	Before RCL	-0.085 (p < 0.0005) [-0.116, -0.054]	261.920 (p < 0.0005) [124.539, 399.301]
	After RCL	-0.231 (p = 0.003) [-0.380, -0.082]	-127.102 (p = 0.409) [-429.390, 175.186]
Young adults	Before RCL	-0.238 (p < 0.0005) [-0.346, -0.130]	-10.074 (p = 0.411) [-34.153, 14.005]
	After RCL	-0.782 (p < 0.0005) [-1.158, -0.406]	-70.026 (p = 0.004) [-117.817, -22.236]

Note: <sup>a</sup> Models adjusted for state and year fixed effects and medical cannabis legalization.

We also found evidence that among adolescents the positive association between cannabis use and treatment admissions is observed only prior to recreational legalization (Table 2, Model 2). Fig. 2, bottom left, shows the steep positive slope of the association before recreational legalization, whereas the slope becomes negative following recreational legalization, though notably the post-legalization association is not significant (Table 3, Model 2). Conversely, among young adults, a significant association between cannabis use and treatment admissions is observed following, but not prior to, recreational legalization (Tables 2 and 3, Model 2), where after recreational legalization higher cannabis use is, perhaps surprisingly, associated with lower treatment admissions (Fig. 2, bottom right).

### 3.2. Sensitivity analyses

Results of the sensitivity analyses were consistent with our main results (see Supplementary Materials) and do not cause us to change our conclusions.

## 4. Discussion

To our knowledge, this is the first study to examine the effect of recreational cannabis legalization on associations among the perception



of risk of harm from cannabis use, prevalence of past-month cannabis use, and rate of CUD treatment admissions through the novel integration of NSDUH and TEDS-A datasets. Our results offer several insights. First, we found that cannabis use increased among both adolescents and young adults following recreational cannabis legalization. These findings are consistent with previous research regarding adults (Bae & Kerr, 2020; Cerdá et al., 2020; O'Grady et al., 2022), but to our knowledge differ from previous research regarding adolescents, for whom cannabis use prevalence trends have been relatively stable (Han et al., 2017; Sarvet et al., 2018). This may be because our study offers a larger sample of recreational legalization states and a longer period following legalization as compared to prior studies. Differences in sampling and data collection strategies between NSDUH and other national datasets used in adolescent substance use research may also play a role.

Second, we found that the association between perception of risk from cannabis use and cannabis use prevalence was strengthened following recreational cannabis legalization, likely due to the increase in access to cannabis, particularly for young adults. We speculate that the changes in accessibility and social acceptance brought about by recreational legalization are likely to most strongly influence those for whom perception of risk is low (Levy et al., 2021). Recreational legalization thus appears to have a polarizing effect, where cannabis use behavior differs by perception of risk to a greater extent following recreational legalization.

Third, our findings suggest that recreational cannabis legalization may suppress the proportion of cannabis users entering CUD treatment. This is particularly concerning given that, even prior to recreational legalization, only 13 % of those with CUD in the U.S. received substance use disorder treatment (Wu et al., 2017), and that recent research suggests that approximately a third of people who ever use cannabis ultimately develop CUD (Marel et al., 2019). The increase in the social acceptance of cannabis use associated with recreational legalization may contribute to declines in both the rate of CUD among frequent cannabis users (Compton et al., 2019; Davenport, 2018; Santaella-Tenorio et al., 2019) and the perceived need for treatment among those with CUD (Askari et al., 2021) by suppressing the recognition of frequent use as problematic and, consequently, mitigating the desire to reduce use among those with CUD.

Recent research also indicates that recreational cannabis legalization is associated with increased cannabis use among adults with children in the home (Goodwin et al., 2021), with the potential for reduced pressure by cannabis using parents and guardians to address problematic cannabis use among adolescents. Cannabis legalization also increases exposure to cannabis sales and advertising (Rup et al., 2020), which can serve as environmental cues to craving among those with CUD (Rheuw et al., 2022), thus inhibiting efforts at cessation, as has been found with alcohol and tobacco (Kohen et al., 2022; Mennis & Mason, 2016; Pearce et al., 2016).

While our analytical strategy of excluding criminal justice referrals to treatment allows for the estimation of the main and moderating effects of recreational cannabis legalization on treatment admissions independent of changes to cannabis-related arrests, we note that substance use disorder is highly prevalent among criminal justice-involved adolescents and young adults (Dennis et al., 2019; Funk et al., 2020; Siringil Perker & Chester, 2021), and the criminal justice system is the most common source of referral to CUD treatment for adolescents and young adults (Standeven et al., 2020). In our dataset, criminal justice referrals comprise 48 % of adolescent, and 57 % of young adult, treatment admissions, figures likely to contain a disproportionate number of racial and ethnic minoritized groups, such as African Americans, who are overrepresented in the criminal justice system (Jeffers, 2019; Spinney et al., 2018). To investigate the potential impact of excluding criminal justice referred admissions from our analyses, we conducted additional sensitivity analyses using all admissions. Results are consistent with the main results (see [Supplementary Materials](#)), though the significance for the moderating effect of recreational legalization is slightly attenuated.

We also acknowledge other limitations of this study. State- and annual-level data may mask variations over smaller spatial and temporal scales. For the TEDS data, a handful of states did not report CUD treatment admissions data for certain years, and the degree to which reporting varied within states, or from state to state or year to year, is unknown. The NSDUH is a representative sample of the US and thus is subject to measurement error. The young adult age group in the NSDUH dataset includes age 25 whereas the TEDS dataset does not, and neither distinguishes the age threshold (age 21) to purchase cannabis where it is legal.

Further, state-level NSDUH data on other measures of cannabis consumption, the prevalence of frequent cannabis use, CUD prevalence, and CUD treatment utilization among those with CUD are not publicly available, limiting our ability to analyze these important characteristics. This may be particularly limiting regarding interpreting associations between cannabis use and treatment admissions, where CUD prevalence likely plays a key mediating role. Research suggests that medical cannabis legalization impacts cannabis attitudes and use (Smart & Pacula, 2019; Wen et al., 2019), and while we controlled for the main effects of medical legalization, moderating effects prior to recreational legalization may also occur. Finally, although we controlled for secular trends and variation among states via fixed effects, as well as access to treatment in sensitivity tests, unaccounted for explanation offered by cultural shifts or other characteristics unique to a particular state over time may persist in our models.

## 5. Conclusions

The evidence presented here indicates that recreational cannabis legalization is likely to increase the prevalence of cannabis use among adolescents and young adults, particularly among those who perceive low risk of harm from use, while at the same time potentially mitigating concomitant increases in CUD treatment utilization among cannabis users. These trends suggest the potential for an increase in unmet need for CUD treatment among age groups particularly vulnerable to the development and negative consequences of CUD.

McLellan and colleagues have recently advocated for a greater focus on intervention during the “preaddiction” stage to prevent adolescents and young adults from transitioning from substance use to early-stage harmful misuse (McLellan et al., 2022). This concept may be particularly important for cannabis use given that it is likely that reduced recognition of need for CUD treatment will accompany expanding recreational legalization, with public health strategies such as informational messaging campaigns which leverage social media and other communication sources popular with adolescents and young adults, and early detection, screening, mobile health, and other early treatment interventions for CUD, serving an important role.

Future research is needed on how recreational legalization can alter the associations among attitudes towards cannabis use, initiation into use, frequency of use, the development of CUD, CUD treatment seeking behavior, and treatment completion and other treatment outcomes. Questions also remain on how stronger cannabis potency, increasing numbers of cannabis products, and greater exposure to cannabis sales and advertising may impact the prevalence of CUD. Understanding how main and moderating effects of cannabis legalization may vary among different population groups (e.g. by age, sex, gender and sexual identity, race and ethnicity) (Han et al., 2018; Hasin et al., 2019; Mauro et al., 2022) is also key to tailoring CUD prevention and intervention strategies appropriately.

## CRedit authorship contribution statement

**Jeremy Mennis:** Conceptualization, Methodology, Formal analysis, Writing – original draft, Visualization. **Thomas P. McKeon:** Conceptualization, Data curation, Formal analysis, Writing – review & editing. **Gerald J. Stahler:** Conceptualization, 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.

## Data availability

Data will be made available on request.

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## Appendix A. Supplementary material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.addbeh.2022.107552>.

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