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Assessing the Impact of Recreational Cannabis Legalization on Cannabis Use Disorder and Admissions to Treatment in the United States

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Abstract

Purpose of Review Policy implications from changes in recreational cannabis laws (RCLs) have raised public health concerns. While numerous studies have examined the impact of RCLs on cannabis use, there is less research on the risk of developing cannabis use disorder (CUD). This review summarizes the latest research on the effects of RCLs on CUD prevalence and cannabis treatment admissions.

Recent Findings Nine studies were published between 2016 – 2022 that examined RCLs and CUD or treatment. Findings generally indicate an increase in CUD prevalence associated with legalization, but effects differ by age group. There was no significant association between legalization and CUD treatment admissions, and CUD admissions decreased overall during the study periods.

Summary To improve policy, prevention, and treatment services, policymakers should monitor RCLs' effects on adverse public health outcomes and researchers should consider the effects on individual and community-level characteristics. We discuss methodological challenges in conducting state-level research and provide suggestions for future studies.

Keywords Cannabis · Cannabis use disorder · Marijuana · Treatment · Recreational cannabis laws · State cannabis legalization

Introduction

It has been a decade since Colorado and Washington became the first states in the United States (U.S.) to legalize cannabis for recreational use. As of August 2022, 19 states and the District of Columbia have legalized the recreational use of cannabis for adults over the age of 21, while 37 states have passed medical legalization measures. Public perceptions of cannabis use have greatly changed over the years, which has continued to spur publicly-supported efforts towards recreational legalization across states [1, 2]. For example, in 2020, the National Survey on Drug Use and Health (NSDUH) found that 27.4% of people 12 or older perceive great risk from using cannabis once or twice a week [3], down from 43.6% in 2012 [4], while a recent Gallup poll found that 68% of Americans support cannabis legalization [5].

Cannabis is the most commonly used federally-illicit drug [3, 6], with almost 18% of individuals aged 12 and older (49.6 million people) reporting past year use of cannabis, and 2.8 million initiating use in the past year, including 1 million new adolescent initiates [3]. Among young adults, past-year, past-month, and daily cannabis use have reached historic highs [7]. Additionally, data from the 2020 NSDUH found that over 14 million people aged 12 and older met criteria for cannabis use disorder (CUD), with the highest proportions among young adults aged 18 to 25 [3]. Age-graded differences have also been observed in treatment admissions, with adolescents having higher rates of treatment for cannabis as the primary substance of abuse, and individuals under age 20 making up nearly 40% of treatment admissions with cannabis as the primary substance [8].

The rapid shift in recreational cannabis laws (RCLs) over the past several years has raised public health concerns about the potential impact of these policies on cannabis-related

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outcomes. Despite a decrease in the perceived harm of cannabis use, there is increasing evidence on several negative physical, social, and mental health outcomes associated with cannabis use. These include the risk of developing hyperemesis syndrome [9, 10] and cardiovascular disease [11, 12]; an increased risk for psychiatric comorbidity [13–16], including an earlier onset of schizophrenia [17]; impaired cognitive functioning [18]; lower levels of relationship satisfaction and life satisfaction [19]; and higher unemployment [19]. These adverse outcomes are particularly worrisome when it comes to adolescents and young adults, as the risk of developing a substance use disorder (SUD) is greatest with earlier age of onset [20•]. For these reasons, it is important to monitor cannabis use and related outcomes, particularly the most problematic in developing a disorder, as well as differences among age groups.

There have been several published articles and reviews finding a mixed picture on the impact of RCLs on cannabis use, including past-month, past-year, and lifetime use [20•]. However, fewer studies have focused on the effect of RCL on the smaller proportion of cannabis users who develop CUD [21•], or who end up in treatment due to their cannabis use. The smaller, but significant, proportion of cannabis users with CUD raises concern in an era of recreational legalization. As support for legalization is shared by the majority of Americans and more states consider adopting RCLs, understanding the effect of policies not just on use but on problematic use and CUD should be of great interest to researchers, policy makers, prevention and treatment professionals alike, and is key to developing appropriate public health responses. Thus, it is important to take stock of the available literature on the effects of legalization on more serious outcomes, namely CUD and cannabis-related treatment. The present review focuses on the association of RCLs and CUD, as well as CUD treatment among adolescents and adults in the U.S.

Cannabis Use Disorder (CUD)

The 5th edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) defines CUD as a *"problematic pattern of cannabis use leading to clinically significant impairment or distress"* in at least two of 11 realms of functioning within a 12-month period [22]. Distinct realms include: tolerance, withdrawal, unsuccessful efforts to cut down or control use, failure to fulfill obligations at work, school, or home, continued use despite recurrent physical or psychological consequences of use, and continued cannabis use despite having recurrent social or interpersonal problems caused or exacerbated by the effects of cannabis.

According to data from the National Epidemiologic Survey on Alcohol and Related Conditions (NESARC) and the National Comorbidity Survey (NCS), the transition from cannabis use to CUD is about 9% for people who have used cannabis at least once in their lifetime [23, 24]. Additionally, data from NSDUH indicated that the transition to CUD was roughly 12% for past-year users and 15% for past-30-day users, respectively [25]. A study in 2017 using data from NSDUH indicated that the rate for adolescents was more than twice greater than the rate for adults [25]. Further, data from NSDUH indicate that 5.1% (14.2 million people) of people 12 or older met criteria for cannabis use disorder in 2020 [3], including 4.1% of adolescents, 13.5% of young adults aged 18 to 25, and 4% of adults 26 or older [3]. It should be noted that prevalence rates may differ slightly between NESARC, NCS, and NSDUH, primarily due to methodological inconsistencies [25]. Specifically, estimates from NSDUH are typically more conservative due to data collection strategies and the exclusion of institutionalized populations, which often demonstrate higher rates of SUDs [25, 26]. Nevertheless, data from all three national studies have suggested that CUD impacts a significant portion of cannabis users, particularly among adolescents and younger adults.

CUD Treatment

Cannabis is the most common substance reported by adolescents presenting for SUD treatment [27]. In 2020, the ratio for CUD treatment admissions was 51 per 100,000 population aged 12 and older, while the proportion of CUD admissions represented 9.8% (139,481) of all SUD treatment admissions, indicating a steady decline each year from 18.6% (358,034) in 2010 [28]. Among adolescents aged 15—17, cannabis represented the majority (70.8%) of admissions in 2020. It is well-known among SUD researchers that the majority of individuals who meet criteria for SUD, including cannabis, do not receive treatment. For example, the NSDUH reports that, of individuals 12 or older with a past year SUD, just 6.5% (2.6 million people) received any SUD treatment in 2020 [3]. While this percentage typically hovers around 10% for those with SUD receiving past year treatment (e.g., the rate was 12.2% in 2019 [6]), it is possible that the COVID-19 pandemic reduced treatment seeking and increased barriers to treatment access in 2020. Nevertheless, 97.5% of those with a past year SUD reported they did not feel that they needed treatment [3]. The high rates of cannabis use combined with decreasing rates for CUD admissions suggests that many with CUD do not receive treatment, lack of access and resources, and discrimination or stigma associated with treatment could be reasons for these low treatment rates [29–31]. There are few reviews on treatment for cannabis as the primary substance and how the changing recreational policy landscape could impact treatment receipt. The present review examines evidence on whether

this treatment gap is widening or getting smaller in states with RCLs compared to other states.

Research on the Impact of Recreational Cannabis Laws (RCLs) and Cannabis Use

So far, the research on RCLs has tended to focus on cannabis use rather than CUD, and shows mixed results for adolescent use and a significant effect of RCLs on adult use, particularly young adults. For example, one study found a decrease in the likelihood of any past-30-day use and frequent past-30-day use among adolescents post-legalization [32], while others found no evidence of a significant association between RCLs and adolescent cannabis use [33, 34•, 35]. A study examining cannabis use in Colorado and Washington versus states without RCLs found an increase in past month cannabis use post-legalization in Washington among 8th and 10th graders, and a decrease among the same age group in states without RCLs; however, the study did not find significant differences for 12th graders in Washington or for youth in Colorado compared to states without RCLs [36]. Finally, an increase was found in adolescent past 30-day use after RCL was passed in Oregon [37] and after it was passed in California [38].

Despite the mixed results for adolescents, studies on the relationship between RCLs and cannabis use among young adults generally indicate an increase in cannabis use in states that enacted RCLs [39, 40–42]. Nevertheless, a few studies have found no relationship between legalization and young adult use [34•, 43]. Similarly, the research on older adult cannabis use is mixed, with some studies finding increases associated with legalization [34•] and others deeming the findings to be inconclusive [20•]. These findings suggest that the research on CUD should also differentiate effects by different age groups, including adolescents, young adults, and older adults.

By summarizing the available data on the effects of RCLs on the prevalence of CUD and CUD treatment, this review will add to our understanding of the potential cannabis-related public health implications of RCLs and provide information for other states that are considering implementation of RCLs. We conclude with a discussion of research challenges and recommendations for future studies on the impact of RCLs on cannabis-related outcomes.

Methods

Using three databases (PubMed, PsycINFO and Web of Science), we conducted searches for peer-reviewed journal articles published between January 2016 and September 2022. Terms such as "cannabis abuse," "cannabis dependence," and "cannabis use disorder" were searched in text words, as well as legalization terms, including "cannabis policy," cannabis law," "cannabis legalization," and "cannabis legislation." Given that many authors use the word "marijuana" rather than "cannabis," we also included the same outcome-related and policy-related terms mentioned above using the word "marijuana."

Our search yielded a total of 388 articles, although 144 of those were duplicates. Four articles were added through a manual search of cited references and relevant reviews identified in the database searches. Of the remaining 248 articles, we used the following criteria for inclusion in the review: a) published in a peer-reviewed journal between January 2016 – September 2022; b) full-text (in English) was available; c) used data from the U.S.; d) examined RCLs (i.e., studies that only examined medical cannabis laws (MCLs) were excluded, although they were included if they examined both RCLs and MCLs); e) focused on CUD or a related outcome (i.e., CUD treatment) as a central topic; and f) presented original data (i.e., reviews, opinion pieces, etc., were excluded). Two reviewers independently screened all titles and abstracts to determine potential eligibility based on the inclusion criteria. Full texts of these studies were then independently assessed for inclusion in the final set of studies.

We found that, of the 248 articles, 86 were outside of the review time frame. Further assessment of these 86 excluded articles indicated that 37 of these were published prior to 2012 (when the first RCLs were passed), 10 were published after 2012 but focused on MCLs, 32 did not specifically examine RCLs and CUD or CUD treatment, five did not present original data, and two did not use U.S. data. Of the remaining 162 that were within the review time frame (2016—2012), two were not in English, two were dissertation abstracts and not peer-reviewed articles, 20 did not use U.S. data, 12 focused on MCLs rather than RCLs, 82 did not specifically examine the effect of RCLs on CUD or cannabis/CUD treatment (e.g., they examined outcomes such as past-30-day cannabis use, lifetime cannabis use, and perceived risk of using cannabis), and 35 did not present original data (see Fig. 1). After screening, full-text assessment, and review, just nine studies met our inclusion criteria. We extracted the following information from each study: study authors, publication year, data source, study year(s), sample size, study location, study population, research design, statistical method, outcome measures, and key findings (see Tables 1 and 2).

Results

Of the nine studies, five examined CUD symptoms and four examined cannabis-related treatment. While our review focuses on the findings related to CUD and CUD treatment,

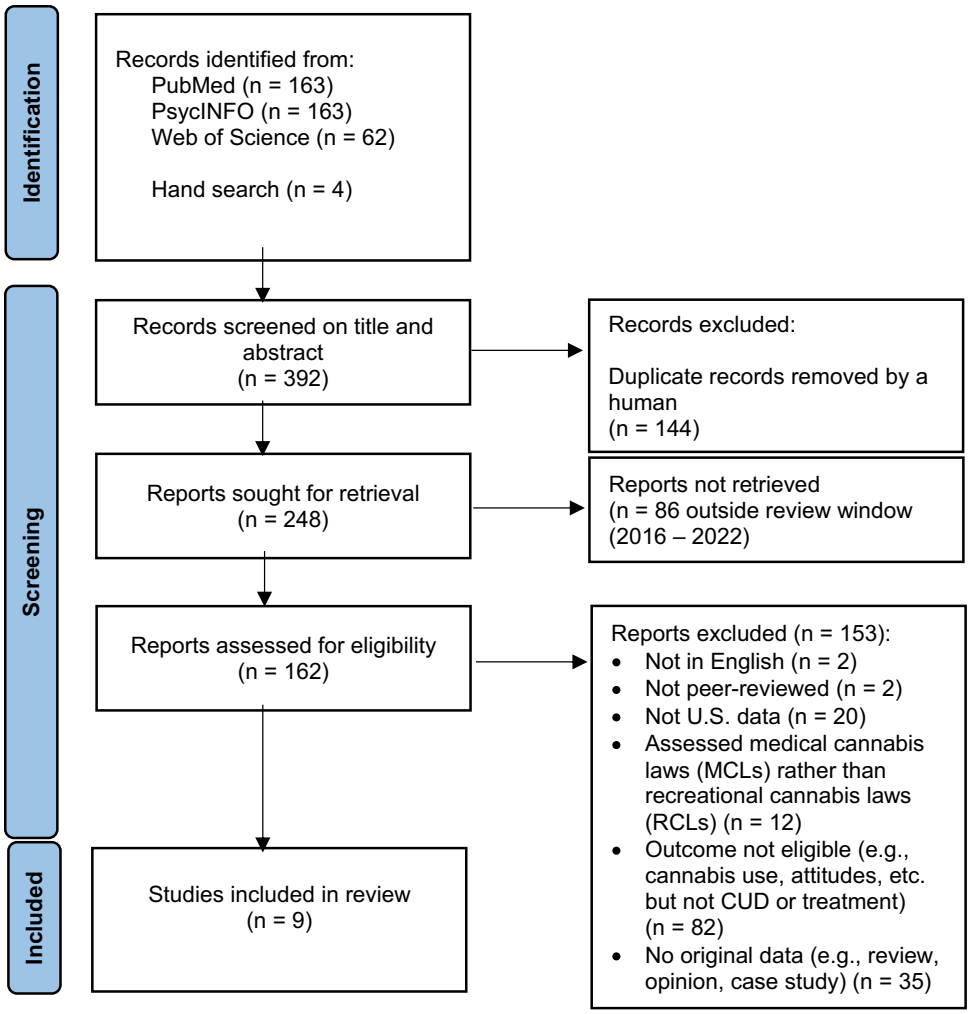

Fig. 1 Flow diagram of the included studies

we also report on the included studies' additional outcome measures, such as past-30-day use and past-year use.

RCLs and CUD

The five articles examining cannabis policy and CUD that were published within our review window used data ranging from 1985 to 2019, and had sample sizes ranging from 252 to 505,796 [34•, 44–47]. Three studies used samples from Washington State [41–43], and compared CUD rates pre- and post-legalization within the state. The other two used a national sample and a comparison group (e.g., states without RCLs) [34•, 47]. Of the five studies, two used a repeat cross-sectional design [34•, 46], one used data from a randomized, controlled intervention trial [45], one used a cross-sectional design (comparing RCL/MCL states with non-legalization states) [47], and one used longitudinal data [44]. There was variation in the study population, with one study examining young adults aged 18 to 25 [46], while another separated the sample into three groups for adolescents aged 12 to 17, young adults aged 18 to 25, and adults 26 or older [34•]. One study used individuals who were initiated into the longitudinal Seattle Social Development Project at age 10 and were aged 39 (with children) in 2014 [44]. The remaining two used study populations based on cannabis use; one recruited *frequent* cannabis users (used cannabis once or more per week for the past 12 months) [47], and one used *heavy* cannabis-using *adolescents* [45]. There was also variation in how the studies measured CUD symptomatology. Three studies used CUD criteria based on the DSM-IV [34•, 44, 45], one used nine items adapted from the 12 questions associated with "cannabis dependence" from NSDUH [46], and one assessed "problematic cannabis use" based on the Cannabis Use Problems Identification Test (CUPIT) [47]. Other outcome measures included past-month cannabis use, frequency of past-month use, and past-year use.

Results are mixed but generally support an increase in CUD prevalence among adolescents and adults post-legalization. For example, using repeated cross-sectional data from the NSDUH, Cerdá et al. [34•] examined CUD trends between 2008 and 2016 (n = 505,796) before any RCL

Table 1 Included studies (2016—2022) on the effects of recreational cannabis legalization on cannabis use disorder in the United States

Study Authors & Publication Year	Data Source & Study Year(s)	Sample Size & Study Location	Study Population	Research Design	Statistical Method	Outcome measure(s)	Key Findings
Cerdá et al. (2020) [34•]	National Survey on Drug Use and Health (NSDUH); 2008 to 2016	n = 505,796 States with recreational cannabis laws (RCLs): Colorado, Washington, Alaska, and Oregon Comparison group: states without RCLs	Adolescents aged 12–17; Young adults aged 18–25; Adults 26 or older	Repeated cross-sectional	Logistic regression	• Self-reported past-month cannabis use; • Past-month frequent cannabis use; • Past-month frequent use among past-month users; • **Past-year cannabis use disorder (CUD) symptomatology** *based on DSM-IV criteria*; • **Past-year CUD among past-year users**	Among the 12- to 17-year-old respondents, past-year CUD prevalence increased slightly in RCL states, with a 25% higher increase than that for the same group in states without RCLs. Among past-year cannabis users in this age group, CUD increased. Past-month use and past-month frequent use post- legalization did not change in the overall adolescent sample or among adolescent cannabis users No significant changes were found among the respondents aged 18 to 25 years Among respondents 26 years or older, CUD prevalence increased after RCL enactment as did prevalence of past-month cannabis use, and past-month frequent use. Among past-year cannabis users in this age group, there was no increase in past-month frequent marijuana use and past-year CUD
Kosterman et al. (2016) [44]	Seattle Social Development Project 1985 to 2014	n = 395 Washington	Parents participating in the Seattle Social Development Project Participants were interviewed 15 times between 1985 (age 10) and 2014 (age 39)	Longitudinal (15 time points)	Does not specify significance test	• Understanding of the provisions of the RCL; • Approval and perceived harm of adult and adolescent use; • Cannabis use (assessed beginning when they were age 10); • **Past-year CUD symptomatology** *based on DSM- IV criteria*; • Cannabis-related communication and behavior with their children	There was a significant increase in CUD and in frequency of use among past-year cannabis users Cannabis use was graphed since childhood; it steadily increased through adolescence, and there was modest variation over the next 12 years, until a significant increase at age 39 and a nearly doubling in monthly use among current past- year users, which coincided with retail cannabis availability There was a significant increase in approval of adult cannabis use and a decrease in perceived harm of regular use; and wide opposition to teen use and use around one's children

Table 1 (continued)

Study Authors & Publication Year	Data Source & Study Year(s)	Sample Size & Study Location	Study Population	Research Design	Statistical Method	Outcome measure(s)	Key Findings
Blevins et al. (2018) [45]	The Teen Marijuana Check-up 2012 (pre-RCL) to 2013	n = 252 Washington	Heavy cannabis-using adolescents (had used cannabis on at least 9 of the past 30 days during recruitment in 2011, and were not involved in treatment during recruitment)	Randomized, controlled intervention trial	ANOVA	• Frequency of cannabis use in the past 60 days; • **CUD symptomatology** *based on DSM-IV criteria*; • Cannabis problems via the Marijuana Problems Index (MPI)**;** • Attitudes toward approval and risk perception; • Perceived norms; • Policy understanding	There were significant increases in cannabis-related problems and CUD symptoms in participants recruited post-legalization There were, however, no significant differences in frequency of use or in attitudes, perceived risks, or norms in participants recruited pre- and post-legalization
Kilmer et al. (2022) [46]	Washington Young Adult Health Survey 2014 (pre- recreational retail sales) to 2019	n = 12,963 Washington	Young adults aged 18–25	Repeated cross-sectional	Logistic regression	• Past-year cannabis use; • **Past-year CUD symptomatology** based on 9 items adapted from the 12 questions NSDUH used to assess 5 symptoms of "cannabis dependence"; (1 = 2 or more symptoms; 0 = none or 1 symptom)	There was a significant increase in young adults' prevalence of endorsing at least 2 of 5 CUD symptoms post- legalization Prevalence of past-year, at least monthly, at least weekly, and daily use of cannabis also increased, although increases were driven by changes among those aged 21 to 25 years
Destrée et al. (2018) [47]	Amazon Mechanical Turk 2015	n = 329 National (compared states without RCLs to states with RCLs and/or medical cannabis laws (MCLs))	Frequent cannabis users (used cannabis once or more per week for the past 12 months and did not use any other illicit substances)	Cross-sectional	ANOVA	• **Problematic cannabis use** b*ased on the Cannabis Use Problems Identification Test (CUPIT) (impaired control and problems subscales)*; • Impulsivity	There were no significant differences in problematic cannabis use and impulsivity based on residence in states with and without legalization There was a positive association between problematic cannabis use and impulsivity in frequent cannabis users

Table 2 Included studies (2016—2022) on the effects of recreational cannabis legalization on cannabis treatment admissions in the United States

Study Authors & Publication Year	Data Source & Study Year(s)	Sample Size & Study Location	Study Population	Research Design	Statistical Method	Outcome measure(s)	Key Findings
Rhee & Rosenheck (2022) [48]	Treatment Episode Data Set—Admissions (TEDS-A) 2000 to 2017	n = 35,457,854 admissions National	Adults aged 18 or older	Repeated cross-sectional (2000-2005; 2006-2011; 2012-2017)	Interaction analyses	• Cannabis as the primary reason for admission; • Cannabis as either the primary, secondary, or tertiary reason for admission	There was no significant association between RCLs and cannabis-related treatment admissions The sample as a whole showed a small increase in cannabis-related admissions from 2000–2005 to 2006–2011, and then a small decrease in 2012–2017 Among adults aged between 18 and 29, the proportion of cannabis-related treatment admissions was greater than that of the overall sample
Mennis & Stahler (2020) [49]	TEDS-A 2008 to 2017	n = 653,232 admissions States with RCLs: Colorado, Washington (other states with RCLS during the study period were excluded) Comparison group: states without RCLs	Adolescents aged 12–17	Repeated cross-sectional	Difference-in- difference analysis/ Ordinary least squares regression	• Cannabis as the primary reason for admission	The rate of adolescent cannabis treatment admissions declined significantly over the study period in both Colorado/Washington and non-RCL states The admissions rate was initially higher in Colorado/Washington at the beginning of the study period but declined more rapidly post-legalization compared to non-RCL states
Mennis et al. (2021) [50]	TEDS-A & NSDUH 2008 to 2017	n = 918,961 admissions National	Young adults aged 18–24 (TEDS-A); Young adults aged 18–25 (NSDUH)	Repeated cross-sectional	Fixed-effects regression	• Cannabis as the primary reason for admission (TEDS-A); • Past-month cannabis use (NSDUH)	RCL states had higher cannabis use but lower cannabis-related treatment admissions Cannabis use increase was associated with declining treatment admissions in 38 states, including 7 of the 8 with RCLs during the study period Nationally, past month young adult cannabis use increased during the study
Bourdon et al. (2021) [51]	TEDS-Discharge (TEDS-D) 1992 to 2016	n = 1,863,585 admissions National (RCL, MCL, decriminalization, prohibition)	Adults aged 18 or older who sought treatment in an *outpatient* facility (i.e., excludes inpatient and residential admissions)	Repeated cross-sectional	Difference-in- difference analysis/ Logistic regression	• Treatment completion for those with cannabis as the primary reason for admission; • Length of stay for those with cannabis as the primary reason for admission	There was no significant difference between cannabis policy (RCL, MCL, decriminalization) and treatment completion There was a significant negative relationship between decriminalization and treatment length of stay, with individuals in decriminalization states being less likely to stay in treatment for 91 days or more

enactment (i.e., 2008—2011) and after RCL enactment (i.e., 2013—2016 or 2015—2016, depending on the state). The authors found that the prevalence of CUD among adolescents increased from 2.18% to 2.72% (OR, 1.25; 95% CI, 1.01–1.55) after RCL enactment, reflecting a 25% higher increase compared to that for adolescents in non-RCL states [34•]. Among past-year adolescent cannabis users, CUD prevalence increased from 22.8% to 27.2% (OR, 1.27; 95% CI, 1.01–1.59) [34•]. Among respondents 26 years or older, CUD prevalence increased from 0.9% to 1.23%% (OR, 1.36; 95% CI, 1.08–1.71) post-legalization. However, no significant changes were found among young adults aged 18 to 25 years [34•].

The three studies examining pre- and post-legalization in Washington, which passed its RCL in late 2012 and began recreational retail sales in July 2014, also found increases in CUD [44–46]. A longitudinal study on adult parents aged 39 in 2014 (n = 395) found a significant increase in CUD, from a range of 13–18% from ages 27—35 (in 2002—2010) to 26% at age 39 after Washington's RCL and retail outlets were established [44]. Another study using a sample of heavy cannabis-using adolescents in a randomized, controlled intervention trial in Washington (n = 252) found that rates of CUD right after legalization (from 2012 to 2013) were significantly higher for the research participants recruited post-legalization [45]. Specifically, the mean for CUD was 3.08 (SD = 2.47) pre-policy and 4.42 (SD = 2.64) post-policy. The third Washington study (n = 12,963 young adults aged 18—25) used a repeated cross-sectional design and found a significant increase post-legalization from 5.7% in 2014 (before state recreational retail sales were established) to 8.6% in 2019 in young adults' prevalence of endorsing at least two of the five CUD symptoms [46].

The fifth study used a 2015 cross-sectional national sample (n = 329) and was the only one to not find significant differences in CUD based on RCL status [47].

It should be noted that the studies above examined additional outcomes besides CUD, including past-month cannabis use and frequency of use, and generally found an increase in adult use to accompany the increase in adult CUD prevalence, but no similar increase in adolescent use post-legalization. For example, Blevins et al. [45] found that, despite an increase in adolescent CUD symptoms, rates of use, perceived risks, and attitudes did not significantly vary pre- and post-legalization. Similarly, while Cerdá et al. [34•] found an increase in adolescent CUD prevalence, they did not find significant changes in adolescent past-month cannabis use and past-month frequent cannabis use in states post-legalization. On the other hand, they did find increases in the prevalence of adult past-month cannabis use and past-month frequent cannabis to accompany the significant increase in adult CUD prevalence [34•]. Kosterman et al. [44] also found that, in addition to a significant increase in CUD, there was an increase in the frequency of use among past-year adult cannabis users (aged 39). Finally, Kilmer et al. [46] found a similar pattern, with increases in young adults' prevalence of past-year, at least monthly, at least weekly, and daily cannabis use as well as an increase in CUD symptoms post-legalization.

RCLs and CUD Treatment

Four research articles examining cannabis policy and CUD treatment admissions were published within our review window [48–51]. The study years ranged from 1992 to 2017. All four studies utilized the national Treatment Episode Data Set (TEDS). One study focused on adolescents [49], one used a sample of young adults aged 18—24 [50], and two examined treatment admissions for adults aged 18 or older [48, 51]. The outcome measure was treatment admission with cannabis listed as the primary reason for admission, although one study [48] also considered a second measure for cannabis as either the primary, secondary, or tertiary substance. One study looked at discharge rather than admission data and measured treatment completion and length of stay for those with cannabis as the primary reason for admission [51].

No studies found a significant relationship between RCL status and cannabis-related treatment admissions. Using the TEDS from 2000 to 2017 on *adult* treatment admissions, Rhee & Rosenheck [48] found no significant association between RCLs and cannabis-related treatment admissions. Throughout the 2000—2017 study period though, individuals in states that eventually legalized were less likely to be admitted to treatment. Further analysis limited to RCL states found that the number of years since legalization was also not associated with increased treatment admissions. Adult cannabis admissions nationwide showed a small increase from 2000–2005 to 2006–2011, followed by a small decrease in 2012–2017 [48].

Mennis & Stahler [49] compared 2008—2017 TEDS data from two RCL states (Colorado and Washington) and states without RCLs on *adolescent* cannabis treatment admissions, and found no increase in admissions in Colorado and Washington. Instead, admissions decreased significantly over the study period, with the mean admissions rate falling by nearly half in both the RCL states as well as in the non-RCL states ($\beta = -3.375$, 95% CI = -4.842, -1.907).

In another paper, Mennis, Stahler, & McKeon [50] found similar declines in cannabis treatment admissions for *young adults* aged 18—24 in 38 states, including seven of eight states with RCLs between 2008 and 2017. Specifically, the mean state cannabis treatment admissions rate declined from 40 admissions per 10,000 young adults to 28. Further, states with RCLs had lower admissions rates throughout the study period, including pre-legalization, compared to non-RCL states.

Finally, Bourdon et al. [51] examined TEDS discharge data from 1992 to 2016 for adults strictly in outpatient facilities (i.e., the study excluded treatment in inpatient and residential facilities), and also found no significant difference between RCLs and cannabis treatment completion.

Discussion

In this review, we examined the effects of RCLs on CUD and cannabis treatment admissions, which have received less attention than outcomes related to cannabis use. There were very few studies examining RCLs and CUD or treatment so it is not possible to draw firm conclusions on these effects. The five studies we reviewed on CUD generally found an increase in CUD prevalence associated with legalization among adults. This finding on RCLs is similar to that of research on MCLs, which finds that medical legalization is positively associated with adult CUD prevalence [52–54]. The data on RCLs and adolescent CUD is less clear but also points to an increase in CUD prevalence associated with legalization, even when prevalence of adolescent cannabis use did not experience a similar increase. Only one study that we reviewed did not find significant differences in CUD symptoms based on RCL status, but that study was cross-sectional and had a small sample size [47].

A potential reason for the increase in adolescent CUD, even when it was not accompanied by an increase in use, could be the increasing tetrahydrocannabinol (THC) potency of cannabis products sold in states with RCLs, including vaping products and edibles [55]. Another reason could be that one of the studies that found an increase in adolescent CUD but not in frequency of use used a sample of adolescents who were already heavy cannabis users [45]. Nevertheless, these results point to the need to continue to monitor both cannabis use as well as more serious problematic use and CUD post-legalization.

The scant literature on RCLs and treatment for cannabis did not find a significant association between legalization and treatment admissions, and, in fact, cannabis-related admissions were found to decrease overall. Taken together with the finding on increased CUD, this could indicate that treatment seeking among those with CUD decreased, which would be a concern as it would signify a widening of the treatment gap and an increase in unmet treatment need. It should be noted that, while the current evidence points to cannabis-related admissions to treatment not increasing, there has been evidence that legalization is associated with an increase in cannabis-related emergency department hospitalizations [56, 57]. It is possible that shifts in perception of risk and social acceptability of cannabis use could lead to the belief that problematic cannabis use is not a serious problem for which one should seek help, particularly in a specialized treatment setting [30]. On the other hand, as more states legalize recreational use of cannabis, this could reduce any stigma associated with using cannabis, which could potentially serve as a facilitator to seeking treatment for those who do not feel like they need to hide their use or problems stemming from it.

As referrals from the criminal justice system make a significant proportion of treatment admissions [58], there is also a possibility that the decrease in CUD treatment is linked to a decrease in criminal justice referrals to treatment, particularly in RCL states. However, none of the studies in the review found evidence of this. For example, Rhee & Rosenheck [48] found that there were no fewer criminal justice referrals to treatment in states with RCLs compared to states without RCLs. Mennis & Stahler [49] intentionally excluded criminal justice referrals from their analysis so as to account for the potential effect of legalization on reduced referrals to treatment from the criminal justice system. They did, however, conduct a post-hoc analysis that showed that such referrals declined significantly overall and did not significantly differ between RCL and non-RCL states.

Addressing Research Challenges

Given the limited number of studies examining our outcomes of interest, more research is needed before we can draw firm conclusions about the impact of RCLs. There are important factors that should be taken into account as more research is being done on this topic. First, the lagged effect between the time a law is passed, when it becomes effective, to when it is fully implemented (e.g., when retail sales are opened) needs to be taken into account in research designs. Similarly, it is important to consider secular trends in cannabis use and CUD as it is possible that these were already increasing in RCL states before RCL enactment. Third, while pre- and post-policy designs have advantages over cross-sectional studies, it is also important to include *individual-level* longitudinal studies to make it easier to draw causal associations. Fourth, future studies examining effects on CUD should use the new DSM-5 criteria, which merged cannabis abuse and cannabis dependence into a single CUD category, added a new diagnostic category for Cannabis Withdrawal Syndrome, and replaced the criterion of legal problems with one for cravings.

The studies we reviewed used a binary classification of whether a state had a RCL or not, yet there is a great deal of heterogeneity in policy provisions among states with RCLs. This variability applies to factors such as allowing retail sales, product packaging, potency, taxation, etc. [59]. Even within states with RCLs, many localities can make their own decisions on issues such as whether to allow retail outlets or not [60, 61•]. States could therefore be classified into different categories that reflect the combination of specific policy provisions, and these combinations could have varying effects on cannabis use and CUD.

A final challenge in conducting research on RCLs is that it can be difficult to identify the most appropriate control group. Just as there is heterogeneity among states with RCLs, states without RCLs (or MCLs) are not homogeneous in their cannabis policies (e.g., in terms of decriminalization, low-THC use, etc.) or other related policies. States with RCLs may differ from non-RCL states in many other ways, which can make it difficult to disentangle the effects of RCLs from these other state-level factors.

Conclusion

Nineteen states and Washington D.C. have passed RCLs, and around half of them passed legislation within the past two years. This means that very little time has elapsed to examine changes. As more time elapses, additional research is needed on the effect of RCLs on CUD, as well as related outcomes, such as co-occurring disorders, and treatment utilization so that appropriate prevention and treatment options are implemented. It will be important to consider the different effects particular policy provisions could have on different populations. The studies we reviewed already point to differences between adolescents, young adults, and older adults. It will be important to consider other individual-level characteristics, such as race and gender, as well as community-level characteristics that can provide insight into who to target for prevention or treatment services.

Declarations

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Ethical Considerations This article does not contain any studies with human or animal subjects performed by any of the authors.

References

Papers of particular interest, published recently, have been highlighted as: • Of importance

1. Compton WM, Han B. "The Epidemiology of Cannabis Use in the United States." In *The Complex Connection Between Cannabis and Schizophrenia*. 2018; 9–36.
2. Johnston LD, Miech RA, O'Malley PM, Bachman JG, Schulenberg JE, Patrick ME. Monitoring the Future national survey results on drug use 1975–2021: Overview, key findings on adolescent drug use. Ann Arbor: Institute for Social Research, University of Michigan; 2022.
3. Substance Abuse and Mental Health Services Administration. *Key substance use and mental health indicators in the United States: Results from the 2020 National Survey on Drug Use and Health* (HHS Publication No. PEP21–07–01–003, NSDUH Series H-56). Rockville, MD: Center for Behavioral Health Statistics and Quality, Substance Abuse and Mental Health Services Administration. 2021.
4. Substance Abuse and Mental Health Services Administration. *Results from the 2012 National Survey on Drug Use and Health: Summary of National Findings* (NSDUH Series H-46, HHS Publication No. (SMA) 13–4795). Rockville, MD: Center for Behavioral Health Statistics and Quality, Substance Abuse and Mental Health Services Administration. 2013.
5. Gallup. *Support for legal marijuana holds at record high of 68%*. 2021 Nov. https://news.gallup.com/poll/356939/support-legal-marijuana-holds-record-high.aspx
6. Substance Abuse and Mental Health Services Administration. *Key substance use and mental health indicators in the United States: Results from the 2019 National Survey on Drug Use and Health* (HHS Publication No. PEP20–07–01–001, NSDUH Series H-55). Rockville, MD: Center for Behavioral Health Statistics and Quality, Substance Abuse and Mental Health Services Administration. 2020.
7. Patrick ME, Schulenberg JE, Miech RA, Johnston LD, O'Malley PM, Bachman JG. *Monitoring the Future Panel Study annual report: National data on substance use among adults ages 19 to 60, 1976–2021*. Monitoring the Future Monograph Series. University of Michigan Institute for Social Research: Ann Arbor, MI. 2022. doi:https://doi.org/10.7826/ISRUM.06.585140.002.07.0001.2022
8. Substance Abuse and Mental Health Services Administration, Center for Behavioral Health Statistics and Quality. Treatment Episode Data Set (TEDS): 2002–2012. *National admissions to substance abuse treatment services.* [BHSIS Series S-71, HHS Publication No. (SMA) 14–4850]. Rockville, MD: Substance Abuse and Mental Health Services Administration; 2014.
9. Allen JH, de Moore GM, Heddle R, Twartz JC. Cannabinoid hyperemesis: Cyclical hyperemesis in association with chronic cannabis abuse. Gut. 2004;53:1566–70.
10. Khattar N, Routsolias JC. Emergency department treatment of cannabinoid hyperemesis syndrome: A review. Am J Ther. 2018;25:e357–61.
11. Franz CA, Frishman WH. Marijuana use and cardiovascular disease. Cardiol Rev. 2016;24:158–62.
12. Jouanjus E, Lapeyre-Mestre M, Micallef J. Cannabis use: signal of increasing risk of serious cardiovascular disorders. J Am Heart Assoc. 2014;3: e000638.
13. Dutra LM, Parish WJ, Gourdet CK, Wylie SA, Wiley JL. Medical cannabis legalization and state-level prevalence of serious mental illness in the National Survey on Drug Use and Health (NSDUH) 2008–2015. Int Rev Psychiatry. 2018;30(3):203–15.
14. Hasin DS, Kerridge BT, Saha TD, Huang B, Pickering R, Smith SM, Jung J, Zhang H, Grant BF. Prevalence and correlates of DSM-5 cannabis use disorder, 2012–2013: Findings from the National Epidemiologic Survey on Alcohol and Related Conditions-III. Am J Psychiatr. 2016;173:588–99.
15. Marconi A, Di Forti M, Lewis CM, Murray RM, Vassos E. Meta-analysis of the association between the level of cannabis use and risk of psychosis. Schizophr Bull. 2016;42:1262–9.
16. Radhakrishnan R, Wilkinson ST, D'Souza DC. Gone to pot—A review of the association between cannabis and psychosis. Front Psychiatry. 2014;22(5):54.
17. Di Forti M, Sallis H, Allegri F, Trotta A, Ferraro L, Stilo SA, Marconi A, La Cascia C, Reis Marques T, Pariante C, Dazzan P, Mondelli V, Paparelli A, Kolliakou A, Prata D, Gaughran F, David AS, Morgan C, Stahl D, Khondoker M, MacCabe JH, Murray RM. Daily use, especially of high-potency cannabis, drives the earlier onset of psychosis in cannabis users. Schizophr Bull. 2014;40:1509–17.

18. Meier MH, Caspi A, Ambler A, Harrington H, Houts R, Keefe RS, McDonald K, Ward A, Poulton R, Moffit TE. Persistent cannabis users show neuropsychological decline from childhood to midlife. Proc Natl Acad Sci USA. 2012;109:E2657–64.
19. Fergusson DM, Boden JM. Cannabis use and later life outcomes. Addiction. 2008;6:969–76.
20.• Hall W, Lynskey M. Assessing the public health impacts of legalizing recreational cannabis use: the US experience. *World Psychiatry*. 2020;19(2):179–186. **A review on the effects of legalization on cannabis use on cannabis-related harms; cannabis price, availability, potency and use; and regulatory policies that may increase or limit adverse effects of legalization**
21.• Smart R, Pacula RL. Early evidence of the impact of cannabis legalization on cannabis use, cannabis use disorder, and the use of other substances: Findings from state policy evaluations. Am J Drug Alcohol Abuse. 2019;45(6):644–663. **A review of the early evidence on how state MCLs and RCLs impact use of or harms from cannabis, alcohol, opioids, and tobacco, emphasizing studies using methods for causal inference markets**
22. American Psychiatric Association. *Diagnostic and statistical manual of mental disorders* (5th ed.). 2013.
23. Lopez-Quintero C, Pérez de los Cobos J, Hasin DS, Okuda M, Wang S, Grant BF, Blanco C. Probability and predictors of transition from first use to dependence on nicotine, alcohol, cannabis, and cocaine: results of the national epidemiologic survey on alcohol and related conditions (NESARC). *Drug Alcohol Depend*. 2011; 115(1–2):120–130.
24. Wagner FA, Anthony JC. From first drug use to drug dependence; developmental periods of risk for dependence upon marijuana, cocaine, and alcohol. Neuropsychopharmacology. 2002;26(4):479–88.
25. Richter L, Pugh BS, Ball SA. Assessing the risk of marijuana use disorder among adolescents and adults who use marijuana. Am J Drug Alcohol Abuse. 2017;43(3):247–60.
26. Fendrich M, Johnson TP (2001) Examining prevalence differences in three national surveys of youth: Impact of consent procedures, mode, and editing rules. *J Drug Issues*. 2001;31(3):615–642.
27. Standeven LR, Scialli A, Chisolm MS, Terplan M. Trends in Cannabis Treatment Admissions in Adolescents/Young Adults: Analysis of TEDS-A 1992 to 2016. J Addict Med. 2020;14(4):e29–36.
28. Substance Abuse and Mental Health Services Administration, Center for Behavioral Health Statistics and Quality. Treatment Episode Data Set (TEDS): 2020. *Admissions to and Discharges from Publicly Funded Substance Use Treatment Facilities*. Rockville, MD: Substance Abuse and Mental Health Services Administration, 2022.
29. Barry CL, McGinty EE, Pescosolido BA, Goldman HH. Stigma, discrimination, treatment effectiveness, and policy: public views about drug addiction and mental illness. Psychiatr Serv. 2014;65(10):1269–72.
30. Gates P, Copeland J, Swift W, Martin G. Barriers and facilitators to cannabis treatment. Drug Alcohol Rev. 2012;31(3):311–9.
31. van der Pol P, Liebregts N, de Graaf R, Korf DJ, van den Brink W, van Laar M. Facilitators and barriers in treatment seeking for cannabis dependence. Drug Alcohol Depend. 2013;133(2):776–80.
32. Anderson DM, Hansen B, Rees DI, Sabia JJ. Association of marijuana laws with teen marijuana use: New estimates from the Youth Risk Behavior Surveys. JAMA Pediatr. 2019;173(9):879–81.
33. Anderson DM, Rees DI, Sabia JJ, Safford S. Association of marijuana legalization with marijuana use among US high school students, 1993–2019. JAMA Netw Open. 2021;4(9): e2124638.
34.• Cerdá M, Mauro C, Hamilton A, Levy NS, Santaella-Tenorio J, Hasin D, Wall MM, Keyes KM, Martins SS. Association between recreational marijuana legalization in the United States and changes in marijuana use and cannabis use disorder from 2008 to 2016. JAMA Psychiat. 2020;77(2):165–171. **Using repeated cross-sectional survey data from the National Survey on Drug Use and Health (2008 – 2016), this study found a slight increase in the risk for CUD among adolescent users and a significant increase in frequent use and CUD among adults after legalization of recreational cannabis.**
35. Coley RL, Kruzik C, Ghiani M, Carey N, Hawkins SS, Baum CF. Recreational marijuana legalization and adolescent use of marijuana, tobacco, and alcohol. J Adolesc Health. 2021;69(1):41–9.
36. Cerdá M, Wall M, Feng T, Keyes KM, Sarvet A, Schulenberg J, Hasin DS. Association of state recreational marijuana laws with adolescent marijuana use. JAMA Pediatr. 2017;171:142–9.
37. Paschall MJ, Grube JW. Recreational marijuana availability in Oregon and use among adolescents. Am J Prev Med. 2020;58:e63–9.
38. Paschall MJ, García-Ramírez G, Grube JW. Recreational marijuana legalization and use among California adolescents: Findings from a statewide survey. J Stud Alcohol Drugs. 2021;82(1):103–11.
39. Bae H, Kerr DCR. Marijuana use trends among college students in states with and without legalization of recreational use: initial and longer-term changes from 2008 to 2018. Addiction. 2020;115:1115–24.
40. Miller AM, Rosenman R, Cowan BW. Recreational marijuana legalization and college student use: Early evidence. SSM Popul Health. 2017;3:649–57.
41. Wallace GT, Parnes JE, Prince MA, Conner BT, Riggs NR, George MW, Shillington AM. Associations between marijuana use patterns and recreational legislation changes in a large Colorado college student sample. Addict Res Theory. 2020;28(3):211–21.
42. Weinberger AH, Wyka K, Kim JH, Smart R, Mangold M, Schanzer E, Wu M, Goodwin RD. A difference-in-difference approach to examining the impact of cannabis legalization on disparities in the use of cigarettes and cannabis in the United States, 2004–17. Addiction. 2022;117(6):1768–77.
43. Doran N, Strong D, Myers MG, Correa JB, Tully L. Post-legalization changes in marijuana use in a sample of young California adults. Addict Behav. 2021;115: 106782.
44. Kosterman R, Bailey JA, Guttmannova K, Jones TM, Eisenberg N, Hill KG, Hawkins JD. Marijuana legalization and parents' attitudes, use, and parenting in Washington State. J Adolesc Health. 2016;59(4):450–6.
45. Blevins CE, Marsh E, Banes KE, Stephens RS, Walker DD, Roffman RA. The implications of cannabis policy changes in Washington on adolescent perception of risk, norms, attitudes, and substance use. Subst Abuse. 2018;12:1178221818815491. https://doi.org/10.1177/1178221818815491.
46. Kilmer JR, Rhew IC, Guttmannova K, Fleming CB, Hultgren BA, Gilson MS, Cooper RL, Dilley J, Larimer ME. Cannabis use among young adults in Washington state after legalization of nonmedical cannabis. Am J Public Health. 2022;112(4):638–45.
47. Destrée L, Amiet D, Carter A, Lee R, Lorenzetti V, Segrave R, Youssef G, Solowij N, & Yücel M. Exploring the association of legalisation status of cannabis with problematic cannabis use and impulsivity in the USA. Drugs Context, 2018;7:212541. https://doi.org/10.7573/dic.212541.
48. Rhee TG, Rosenheck RA. Admissions to substance use treatment facilities for cannabis use disorder, 2000–2017: Does legalization matter? Am J Addict. 2022;31(5):423–32.
49. Mennis J, Stahler GJ. Adolescent treatment admissions for marijuana following recreational legalization in Colorado and Washington. Drug Alcohol Depend. 2020;210: 107960.
50. Mennis J, Stahler GJ, McKeon TP. Young adult cannabis use disorder treatment admissions declined as past month cannabis use

increased in the U.S.: An analysis of states by year, 2008–2017. Addictive Behav. 2021;123:107049
51. Bourdon JL, Francis MW, Jia L, Liang C, Robinson HI, Grucza RA. The effect of cannabis policies on treatment outcomes for cannabis use among U.S. adults. J Subst Abuse Treat. 2021;131:108535. https://doi.org/10.1016/j.jsat.2021.108535.
52. Hasin DS, Sarvet AL, Cerdá M, Keyes KM, Stohl M, Galea S, Wall MM. US adult illicit cannabis use, cannabis use disorder, and medical marijuana laws: 1991–1992 to 2012–2013. JAMA Psychiat. 2017;74:579–88.
53. Wen H, Hockenberry JM, Cummings JR. The effect of medical marijuana laws on adolescent and adult use of marijuana, alcohol, and other substances. J Health Econ. 2015;42:64–80.
54. Cerdá M, Wall M, Keyes KM, Galea S, Hasin D. Medical marijuana laws in 50 states: investigating the relationship between state legalization of medical marijuana and marijuana use, abuse and dependence. Drug Alcohol Depend. 2012;120:22–7.
55. Smart R, Caulkins JP, Kilmer B, Davenport S, Midgette G. Variation in cannabis potency and prices in a newly legal market: evidence from 30 million cannabis sales in Washington State. Addiction. 2017;112(12):2167–77.
56. Heard K, Monte AA, Hoyte CO. Brief commentary: consequences of marijuana – Observations from the emergency department. Ann Intern Med. 2019;170:124.
57. Wang GS, Hall K, Vigil D, et al. Marijuana and acute health care contacts in Colorado. Prev Med. 2017;104:24–30.
58. Substance Abuse and Mental Health Services Administration. *Key substance use and mental health indicators in the United States: Results from the 2018 National Survey on Drug Use and Health* (HHS Publication No. PEP19–5068, NSDUH Series H-54). Center for Behavioral Health Statistics and Quality, Substance Abuse and Mental Health Services Administration, 2019.
59. Pacula RL, Kilmer B, Wagenaar AC, Chaloupka FJ, Caulkins JP. Developing public health regulations for marijuana: lessons from alcohol and tobacco. Am J Public Health. 2014;104(6):1021–8.
60. Dilley JA, Hitchcock L, McGroder N, Greto LA, Richardson SM. Community-level policy responses to state marijuana legalization in Washington State. Int J Drug Policy. 2017;42:102–8.
61.• Kilmer B. How will cannabis legalization affect health, safety, and social equity outcomes? It largely depends on the 14 Ps. Am J Drug Alcohol Abuse. 2019;45(6):664–672. **This essay highlights 14 factors that jurisdictions considering or implementing alternatives to cannabis supply prohibition will confront that will influence health, safety, and social equity outcomes: 1) Production, 2) Profit motive, 3) Power to regulate, 4) Promotion, 5) Prevention and treatment, 6) Policing and enforcement, 7) Penalties, 8) Prior criminal records, 9) Product types, 10) Potency, 11) Purity, 12) Price, 13) Preferences for licenses, and 14) Permanency.**