CANNABIS LEGALIZATION & PUBLIC HEALTH OUTCOMES

Regulatory Determinants of Cannabis Outcomes Survey

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THE REGULATORY DETERMINANTS OF CANNABIS OUTCOMES SURVEY (RDCOS) IS AN INTERNAL INITIATIVE OF CANNABIS PUBLIC POLICY CONSULTING (CPPC) AND IS SELF-FUNDED.

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Better Data.

Better Policy.

Better Outcomes.

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Executive Summary

The *Cannabis Legalization and Public Health Outcomes: Part I* study is one of the largest studies to date on cannabis legalization and cannabis use. The study analyzes and compares survey data from approximately 5,000 U.S. residents across 25 U.S. states with varying status of cannabis legalization including illicit, medical-only, and adult use. Populations of the 25 states surveyed represent over 75% of the U.S. population and the sample sizes of each state assessed closely correspond with population statistics.

Data collected in August 2022 from the quarterly Regulatory Determinants of Cannabis Outcomes Survey (RDCOS) demonstrated that *greater risks of cannabis-related harms were associated with states where cannabis remains illicit compared to states where cannabis is regulated.*

Specifically, when comparing cannabis-related harms across state legalization status, the current analyses revealed that states with regulated medical or adult use cannabis showed:

➤ **Older age at first cannabis use**

➤ **Fewer days of past-month cannabis use for those 16-20 years old**

➤ **Fewer days of driving under the influence of cannabis (DUIC) in the past month**

Notably, there were no differences observed among the three state legalization statuses in terms of overall cannabis prevalence, cannabis use disorder (CUD) prevalence, and overall health status. These consistencies provide additional support for our topline finding: *Cannabis legalization may encourage positive cannabis-related outcomes to public health.*
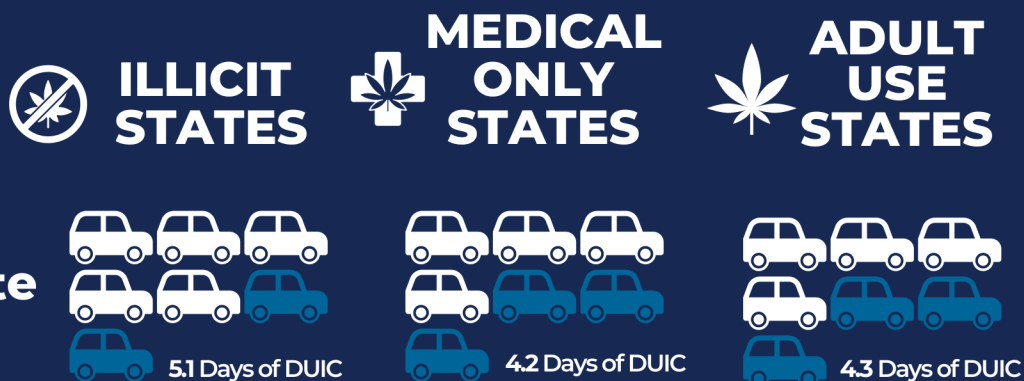
Several supplemental efforts were conducted including sophisticated participant recruitment and statistical modeling procedures to help control for alternative explanations and to increase confidence in the findings. Although this study was not designed to examine a causal role of legalization, the findings challenge common assumptions that cannabis legalization is associated with considerable public health harms and highlights the need for future research that helps understand the impacts of cannabis legalization on cannabis-related public health outcomes.

Cannabis Legalization and Public Health Outcomes is a series of studies that analyze the nuances of cannabis legalization with varying policies across the U.S. and relevant public health outcomes. In the coming months, we will release the results of a second study which will examine additional evidence of how legal cannabis markets might influence cannabis-related public health outcomes.

Important Facts & Figures
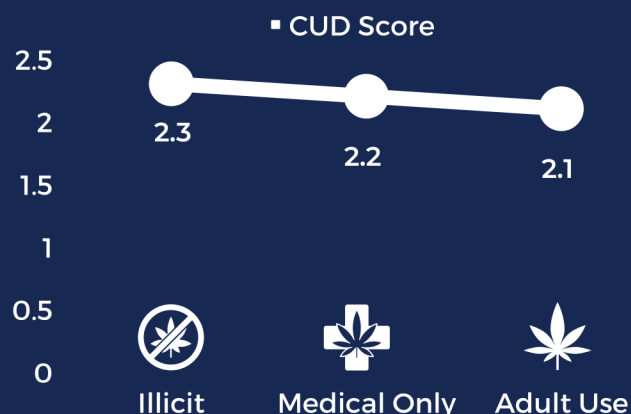
August 2022 RDCOS Findings

Days Driving Under the Influence of Cannabis by State Legalization Status

ILLICIT STATES	MEDICAL ONLY STATES	ADULT USE STATES
5.1 Days of DUIC	4.2 Days of DUIC	4.3 Days of DUIC

Age of Initiation by State Legalization Status

16.7 Years of age	17 Years of age	17 Years of age

Cannabis Use Disorder by State Legalization Status

■ CUD Score

2.5
2
1.5
1
0.5
0

Illicit	Medical Only	Adult Use
2.3	2.2	2.1

Frequency of Use for Ages 16-20 by State Legalization Status

■ Days Used In The Past Month

15
10
5
0

Illicit	Medical Only	Adult Use
13.6	7.9	9.5

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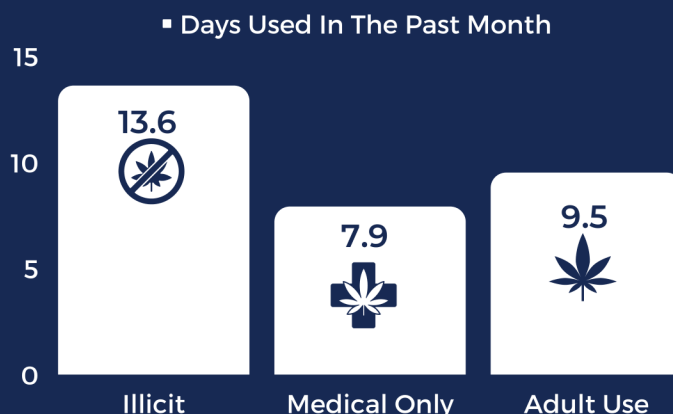
About the RDCOS

The Regulatory Determinants of Cannabis Outcomes Survey (RDCOS) is a quarterly, repeated-cross-sectional survey that assesses cannabis market, economic, public health, and equity outcomes in 25 U.S. states from approximately 5,000 participants who use cannabis at least annually. Total populations of the 25 states surveyed represent over 75% of the U.S. population. The RDCOS survey collects data on over 200 cannabis-related outcomes of interest. The frequency of RDCOS data collection and inclusion of states with varying cannabis policies makes it the most up-to-date inferential analysis of cannabis policies and outcomes.

Regulatory Determinants of Cannabis Outcomes Survey
August 2022 Surveyed States

Image 1. This map indicates the states that were included in the RDCOS August issuance and the current analysis, and their program status based on market accessibility.
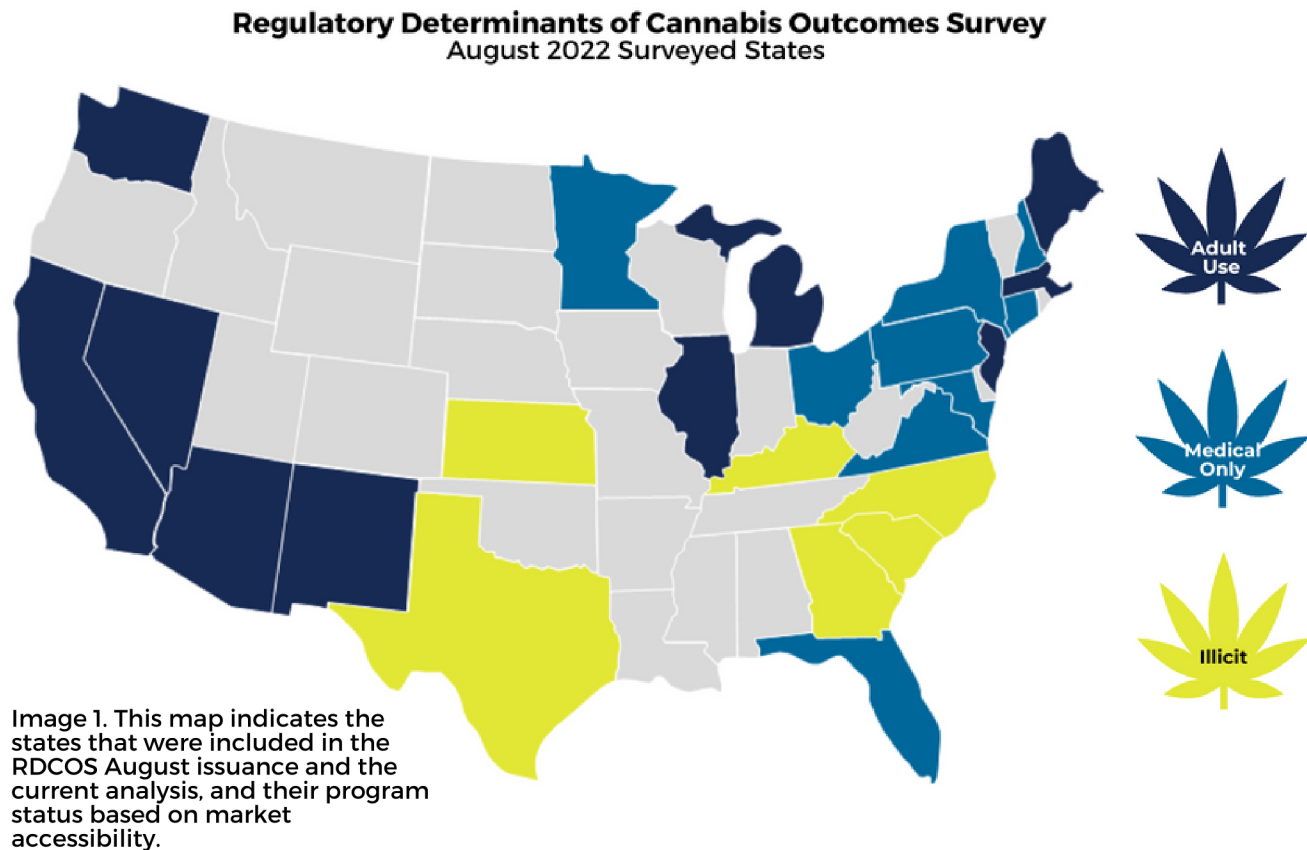
The first quarterly survey was conducted in April of 2022. Every quarter, 12,000 participants from the general population are recruited to provide general cannabis use prevalence data (daily, past-week, past-month, past-year, past five years, more than five years ago, and never). Those who have used in the past year and who complete data quality checks are administered the full RDCOS which includes over 200 outcomes.

In the second quarterly survey, conducted in August 2022, our data collection expanded to include five additional states where cannabis is illicit or contains a very low-THC medical-only cannabis program. Future rounds of the survey are planned for late November of 2022 and January of 2023.

Definition of state status. Cannabis legalization at large, such as passing policies that allow for a future regulated market, does not create an immediate point of consumer access. Because of this, we define states with an adult use cannabis program as states that have launched an adult use market where sales are occurring. For example, states like New York and Connecticut, both surveyed in August of 2022, have passed legislation for adult use but have yet to launch the regulated market. Therefore, we categorize them as medical cannabis states for this report. Additionally, some of the illicit states surveyed allow for low-THC medical cannabis. However, given the stringent nature of program eligibility and product accessibility, these states are considered "illicit" in our analysis.

Introduction

The proliferation of cannabis legalization across the United States has far outpaced available evidence on the potential risks of cannabis legalization.[1] This gap has created a pressing need to prioritize research that identifies how regulated access of cannabis may impact public health. To date, such research has been inconsistent and inconclusive on if, and how, cannabis legalization status may increase or decrease risks of cannabis-related public health outcomes.

The Regulatory Determinants of Cannabis Outcomes Survey (RDCOS) and the following report attempt to address this research gap by providing diverse, timely, and technical cannabis data to facilitate analysis of how public health outcomes differ between states with varied legalization status. The goal of this research is to identify if there are differences in cannabis-related public health outcomes when comparing state legalization status (illicit, medical use, adult use). To increase confidence that any observed relationships are truly associated with legalization status, this report includes statistical analyses that control for key sociodemographic variables, physical and mental health status, and patterns of cannabis use.

The Regulatory Determinants of Cannabis Outcomes Survey assesses over 200 outcomes in the areas of public health, behavioral economics, market interactions, equity, and more. The Cannabis Legalization and Public Health Outcomes series looks specifically at public health outcomes captured and analyzed from this survey. Future reports will expand the scope of public health outcomes as we evaluate policy sucess from a number of lenses.

Comparing Outcomes Between State Legalization Statuses

The legalization of cannabis among U.S. states has followed a natural progression of policies. While many states decriminalize cannabis prior to, or at the point of, legalizing for medical or adult use, many states move from illicit to medical to the launch of a fully commercial regulated market for all adult consumers. In this cross-sectional study, a series of key cannabis-related public health harms are compared between each of these legalization statuses: illicit, medical use, adult use. It is unlikely that the findings are due to fundamental differences in the samples recruited given that we have controlled for several confounding variables.

The main goal of this study was to compare cannabis-related public health outcomes between illicit, medical, and adult use states.

Public Health Outcomes - The Snowball Effect

As with other substances, efforts to prevent and reduce negative outcomes associated with cannabis use are best targeted to youth and young adults before increasingly risky behaviors have escalated to the point where they are causing long-term harm and are difficult to change. [2,3]

A large and growing body of scientific evidence strongly suggests there is a "snowball effect" of risk related to four patterns of behavior that account for much of the harm associated with cannabis use.[1,2] As each cannabis use pattern emerges, there are greater short and long-term risks of negative outcomes and a compounding effect on risk. These behaviors are:

1. Early initiation of cannabis use
2. Frequency of cannabis use, particularly in youth and young adults
3. Cannabis Use Disorder (CUD)
4. Driving Under the Influence of Cannabis (DUIC)

Early initiation of cannabis use **(1)** is associated with increased risks of youth & young adults using cannabis more frequently **(2)**, which likely increase risks of CUD **(3)** and DUIC **(4)**.

Specific cannabis use patterns may increase the risks of other negative cannabis-related outcomes, which in turn can heighten overall societal costs, but the four outcomes listed here are supported by sufficient evidence to narrow our research focus as we seek to understand the extent to which cannabis legalization status may product positive or negative public health impacts. These four cannabis-related public health outcomes focus on unique parts of the life span and carry considerable individual quality of life and society costs.

Note: The snowball effect is a generalized view of potential harms and should not be misconstrued as a predestined pathway for cannabis consumers who exhibit one or more of these behaviors. As with other substances, engaging in cannabis-use behaviors which pose risk is related to pre-existing vulnerability factors.

Early Age of Initiation (1)

Increased Frequency of Use (2)

Cannabis Use Disorder (3)

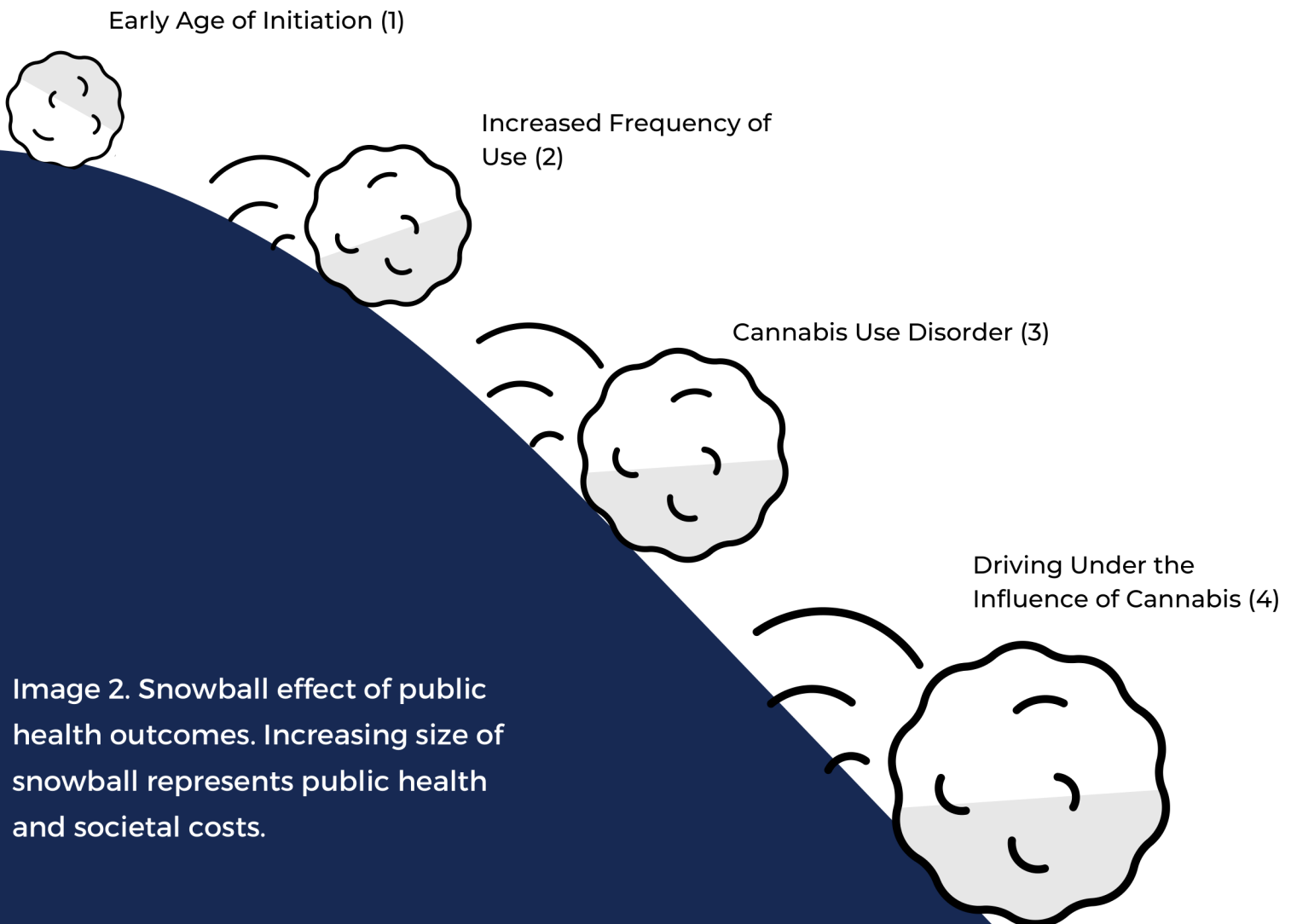Driving Under the Influence of Cannabis (4)

Image 2. Snowball effect of public health outcomes. Increasing size of snowball represents public health and societal costs.

#1. Age of Initiation

RDCOS FINDINGS:

16.7 Years of age

ILLICIT STATES

17 Years of age

MEDICAL ONLY STATES

17 Years of age

ADULT USE STATES

Age of first cannabis use, commonly referred to as age of initiation, is the age when someone first consumes cannabis. It has been found that younger age of initial use for any substance is associated with higher risk of negative short-term and long-term health outcomes, and societal consequence.[4–6]

Early initiation of cannabis use is recognized as a critical risk period associated with future risk of problematic cannabis use and driving under the influence of cannabis. Additionally, research shows that cannabis initiation between the ages of 12-14 years of age shows poorer education and occupational outcomes, indicating limitations for social mobility.[7–10] It is because of these findings that it is vital to delay initiation of cannabis use for as long as possible.

Most relevant datasets do not show the same age of initial cannabis use in the United States, although common estimates hover between 17 and 18 years old on average.[11] The RDCOS results are consistent with this finding. However, when analyzing this outcome across states where cannabis is illicit, legalized for medical purposes, or legalized for adult use, the average age of first cannabis use differs.

Illicit states surveyed showed younger age of cannabis use initiation by about four months, regardless of whether frequency of cannabis use and family income were controlled for in the analyses. Most individuals who consume cannabis initially try consumption between 15 and 18 years old.[11] Given this, and the general consensus among researchers that initiating cannabis use at 16 or younger is very risky, the difference of approximately four months earlier initiation of cannabis use in illicit states could very well represent a critical part of that key developmental period.[12]

The finding that those in adult use states show a higher average age of initiation is important as it indicates that regulated access of cannabis is not expediting cannabis use among youth. Given that this analysis only incorporates one data point, research comparing this outcome across multiple timepoints is necessary to further understand the role legalization may play.

#2. Frequency of Use for Ages 16-20

RDCOS FINDINGS:

13.6 **Days in Past Month**

ILLICIT STATES

7.9 **Days in Past Month**

MEDICAL ONLY STATES

9.5 **Days in Past Month**

ADULT USE STATES

Like other substances, early initiation of cannabis is associated with initiating or increasing use of other substances such as alcohol, which can escalate into more frequent and problematic cannabis use.[13,14] At present there is limited research available that pinpoints exactly what constitutes "regular" or "frequent" cannabis use among youth and young adults. However, the evidence that is available suggests that youth use of cannabis on most days (e.g. four out of seven days per week) that continues into adulthood is sufficient to be predictive of mental health outcomes such as psychosis.[15]

Few studies have examined differences in youth frequency of cannabis use between those living in legal versus illicit states. Although many theorized that legalizing cannabis use would increase youth use, available studies have shown greater, less, and similar levels of youth frequency between legal and illicit cannabis states, which suggests limited differences in general.[16–18]

However, all studies currently available are either multiple years old or only recruit participants from one or a few states. The RDCOS addresses these gaps in research.

Illicit states surveyed averaged a greater number of days of cannabis use in the past month for youth (ages 16-20) cannabis use by about five days per month, regardless of whether family income was controlled for in analyses. Together, youth and young adults in both medical and adult use states averaged about five days less of cannabis use compared to those in illicit states. This difference equates to an estimated sixty days more cannabis use in illicit relative to legal states on average each year.

The age of cannabis use initiation for illicit states (≈16 years old) aligns well with this finding when contextualized within the snowball effect, where earlier age of initiation increases the risks of future cannabis use. As such, these two findings are unlikely to be coincidental, and their co-occurrence is to be expected along with negative public health consequences.

While the term "youth" typically refers to populations under the age of 18, adult use cannabis policies follow the same age restrictions of alcohol, prohibiting regulated use for those 21 and under. As such, monitoring use in youth populations including those between the ages of 18-20 is important in understanding how young adults respond to this arbitrary age limit, particularly as many individuals will have initiated use by this age. Provided that adult use states demonstrate less frequent use of cannabis for ages 16-20, conclusions could be drawn that age restriction policies may be working in favor of preventing frequent consumption at average age of initiation. A very recent study within a legal adult use state provides additional support for this idea, showing less-frequent youth cannabis use in areas where legal dispensaries are located.[19]

#3. Cannabis Use Disorder

RDCOS FINDINGS:

2.3 CUD Score

ILLICIT STATES

2.2 CUD Score

MEDICAL ONLY STATES

2.1 CUD Score

ADULT USE STATES

Diagnostic Cannabis Use Disorder (CUD) is by definition a disorder in which individuals experience two or more symptoms including trouble controlling or reducing their cannabis use, experiencing withdrawal symptoms when stopping use, thinking about cannabis constantly, experiencing problems at work, school, or having issues with key relationships, and continuing use despite negative social consequences. [31,32] Unfortunately, three in ten people who use cannabis monthly are estimated to meet criteria for CUD. [33] As rates of cannabis use frequency and potency continue to rise in the U.S. and globally—markedly not as a direct result of legalization—it is likely that rates of CUD will continue to rise regardless of the rate and nature of cannabis legalization in the U.S..

CUD is not simply an issue for individuals. Those with CUD are more likely to experience cognitive deficits, experience occupational issues, and have co-occurring mood disorders and other substance use disorders (SUDs). Because developing CUD increases risks of experiencing other negative health outcomes that affect the economy, work environments, and local, state, and federal healthcare costs, CUD is a remarkably important issue for society.

Fortunately, research has begun to prioritize CUD globally as legalization becomes more widespread. Existing studies have shown mixed findings regarding whether legalization is associated with greater rates of CUD.[34] The RDCOS findings are consistent when analyzing this outcome for the general population across states with varying legalization status.

No differences were found in CUD prevalence or severity of problematic use between state legalization statuses. This strongly suggests that there were not fundamental differences in the number of individuals with CUD between the samples for each state.

This finding is interesting as it does not follow the same pattern of the past outcomes—illicit states do not exhibit a worse outcome. However, this is the first long-term outcome of interest. Provided that the development and onset of CUD occurs over a longer period of time than other outcomes, it could be that this outcome cannot be inferred so closely to legalization changes in the U.S.. Therefore, this data point is likely to change drastically for all state legalization statuses over the next decade.

However, the finding that there is no statistical difference across all three legalization statuses at present is a promising finding for legalization broadly, as it contradicts arguments that legalization at large would expedite an increase in CUD prevalence if an increase were to be observed.

#4. Days Driving Under the Influence of Cannabis

RDCOS FINDINGS:

5.1 Days of DUIC

ILLICIT STATES

4.2 Days of DUIC

MEDICAL ONLY STATES

4.3 Days of DUIC

ADULT USE STATES

Consuming cannabis shortly before or during driving significantly increases the odds of motor vehicle accidents and deaths.[35,36] Unfortunately, many who consume cannabis regularly are at high risk for driving under the influence of cannabis (DUIC) as research shows that this population may not believe that it is dangerous to drive while intoxicated from THC consumption.[37] Those who engage in at least monthly DUIC often meet criteria for CUD, and other polysubstance use problems.[38] Crucially, each year DUIC costs local, state, and federal governments billions of dollars and takes the lives of thousands of individuals.

The literature examining the relationship between state legalization and DUIC is mixed. Some studies have shown associations between legalization and DUIC, and others have not.[39] However, recent studies indicate that on average, states with legal cannabis laws show lower prevalence of DUIC.[40,41]

Those living in illicit states reported a significantly greater number of days driving under the influence of cannabis (DUIC) than those living in medical states and those living in adult use states. Importantly, the level of difference is approximately an average of about .85 (5.1-4.25) days per month of DUIC across medical and adult use states when compared to illicit states. When multiplied by twelve months and scaled to population levels at ages 16 and older, the difference of .85 fewer days of DUIC per month represents tens of millions of instances of DUIC each year across the United States.

It is unknown why the current study found greater DUIC prevalence in illicit relative to legal states, although one potential explanation is that the tens of millions of dollars spent on public health messaging and education campaigns in legal states has led to better outcomes. Moreover, individuals in legal states have been shown to have more protective attitudes towards DUIC than those in illicit states, which may underlie safer patterns of use despite similar overall levels of frequency of amount of use, a very promising finding for future research to build upon.[40]

Conclusion

The findings of this report provide one of the largest and most comprehensive studies to date examining potential differences in cannabis-related public health outcome as a function of state-level legal cannabis status. Given that this is not a causal analysis, the current findings will need to be replicated and extended using both cross-sectional and longitudinal studies that identify and compare the impacts of legalization across time.

However, the Cannabis Legalization and Public Health Outcomes: Part I study strongly suggests that it is not prudent to automatically assume that cannabis legalization leads to negative public health outcomes.

The cannabis-related public health outcomes analyzed in this report are not exhaustive, but they represent widely recognized public health harms that span individual lifespans and diverse societal costs. Fortunately, legal cannabis states have spent millions of dollars derived from cannabis tax revenue and licensing fees on cannabis-related public health messaging, prevention, and treatment funding. In illicit states without this unique revenue stream, significantly less funding has been prioritized for these public health projects.

Given the data deficit pervasive to the cannabis policy field, legalization efforts have often forced the implementation of policies that are not data-informed, but rather grounded in the principles of harm reduction. This fact, coupled with the findings presented here, show considerable promise for future data-driven legal cannabis policies to provide net wins to cannabis public health outcomes in addition to existing gains in social equity, criminal expungement, and economic conditions.

Appendix A. RDCOS Methodological Summary

Recruitment and Participant Procedures. Survey recruitment was designed and led by Dr. Michael Sofis, Principal Investigator, and Ms. Lydia Mudd, Lead Researcher of the RDCOS project. All study procedures were approved by a certified Institutional Review Board (IRB) prior to data collection. Additionally, given the sensitive nature of the data collected, Dr. Sofis and Ms. Mudd have both completed human subjects' and data privacy trainings prior to survey administration.

Participants were recruited using an online platform wherein the Principal Investigator leverages at least a dozen online research panels to source participants from the general population of each state. Importantly, recruitment materials did not reference cannabis, helping to ensure that the sample collected was not biased towards those who use cannabis, or those who may feel more inclined to respond to a survey about cannabis. The pre-screening questions include age (population 16 and older), demographic data and state of residency prior to providing the IRB approved introduction language where cannabis is mentioned. This process increases confidence that participants are accurately reporting both their age and the state in which they reside.

Participants who met age and state residency requirements during the pre-screening process were then given the opportunity to click a hyperlink that brought them to our survey landing page on the survey platform, Qualtrics. To begin, participants complete a series of substance use and demographic questions. Those who indicated using cannabis daily, weekly, monthly, or in the past year were given the opportunity to continue with the main portion of the survey that provided questions predominantly focused on cannabis use patterns, experiences, and outcomes.

Participants were compensated using the online recruitment platform and received approximately $1 to $2 on average. The average survey duration was 10 to 15 minutes long, remaining consistent with best practices for response completion, accuracy, and validity.

Ensuring Accuracy in Self-Reporting. Common criticism of surveys being inaccurate given the reliance on self-reporting is unfounded when using validated methods to ensure validity, accuracy, and completion. The RDCOS employs at least five different methods to screen participants' data including multiple attention checks, exclusions of computer bots, exclusions of duplicate responses, and fraud scores using reCAPTCHA methods. Additionally, digital recruitment and surveillance has been noted as more reliable in self-reporting given its minimally invasive nature. The drop-out rate for this survey was between 15% and 20%, further supporting that the results were not impacted by selection biases. All self-reported survey questions used for the current study were validated or supported based on previous empirical research studies, including but not limited to questions initially validated by the National Survey on Drug Use and Health and previous, peer-reviewed studies published by the Principal Investigator. Moreover, several consistent findings from previous scientific studies that were not the primary focus of this study were replicated here, providing additional support for the validity of the self-reported survey questions used.

Ensuring A Representative Sample Across All States. Participants were invited from a variety of online sources such as frequent flier mile programs and video game apps on smartphones, ensuring that invitations were provided to a diverse general population. Additionally, we oversampled for youth and racial/ethnic diversities that are historically underrepresented. A moderate correspondence was found between those participating in the survey relative to the population on demographic distributions.

Controlling for Relevant State Variables and Increased Confidence in Findings. When comparing levels of each outcome between illicit, medical, and adult use states, all findings held regardless of whether average family income, cannabis use frequency, severity of problematic cannabis use, and sum of health conditions were controlled for, which strongly reduces the odds that these findings can be explained by sociodemographic or cannabis-related differences between state jurisdictions.

We also found in separate analyses that there were no differences between state legalization status in average number of days of cannabis use in the past month, total grams of cannabis used in the past month, and number of physical and psychiatric health conditions, despite each of these variables demonstrating significant correlations with each other, which suggests that overall differences in cannabis use patterns and health status are unlikely to explain the current effect of lower harms for legal states. Moreover, no differences in average total monthly dollars spent on cannabis were found between any jurisdictions, suggesting comparable levels of behavioral demand for cannabis in samples across jurisdictions.

Appendix B. Statistical Methods

Survey recruitment for this study involved participation of over 4,000 U.S. residents who used cannabis in the past year and who were recruited from an original, general population sample of 4,841 U.S. residents across 25 U.S. states (6 illicit, 9 medical, 10 adult use). About 24%, 36%, and 40% of participants included in analyses were from illicit, medical-only, and adult use states, respectively. We assessed participants from over 3,400 U.S. zip codes. Variables included in the current analyses were age, family income, age of first cannabis use, cannabis grams by source in the past month (e.g., AU, medical dispensary, dealers, etc.), total grams used in the past month, frequency of cannabis use days in the past month, number of days of driving under the influence of cannabis in the past month, and typical THC potency used during the past month.

Main Analysis. Generalized linear models were used to examine differences in all outcomes. Each statistical model was run with and without including family income, frequency of cannabis use, severity of cannabis use, and sum of health conditions as covariates, which did not change the findings when entered into models. All findings demonstrated consistent results regardless of whether covariates were controlled for in the models. Rejection of null hypotheses was only concluded when significance (p) values were <.05, although most p values were <.01 for this study. Therefore, differences were not reported for trend-level effects (e.g., p>.05 but <.10). The above findings were replicated using multiple regression models with dummy coded state statuses for adult use and medical use jurisdictions (illicit states used as referent). The statistical approach for this analysis was checked and verified by a statistician with specific expertise in the current epidemiological context with cannabis.
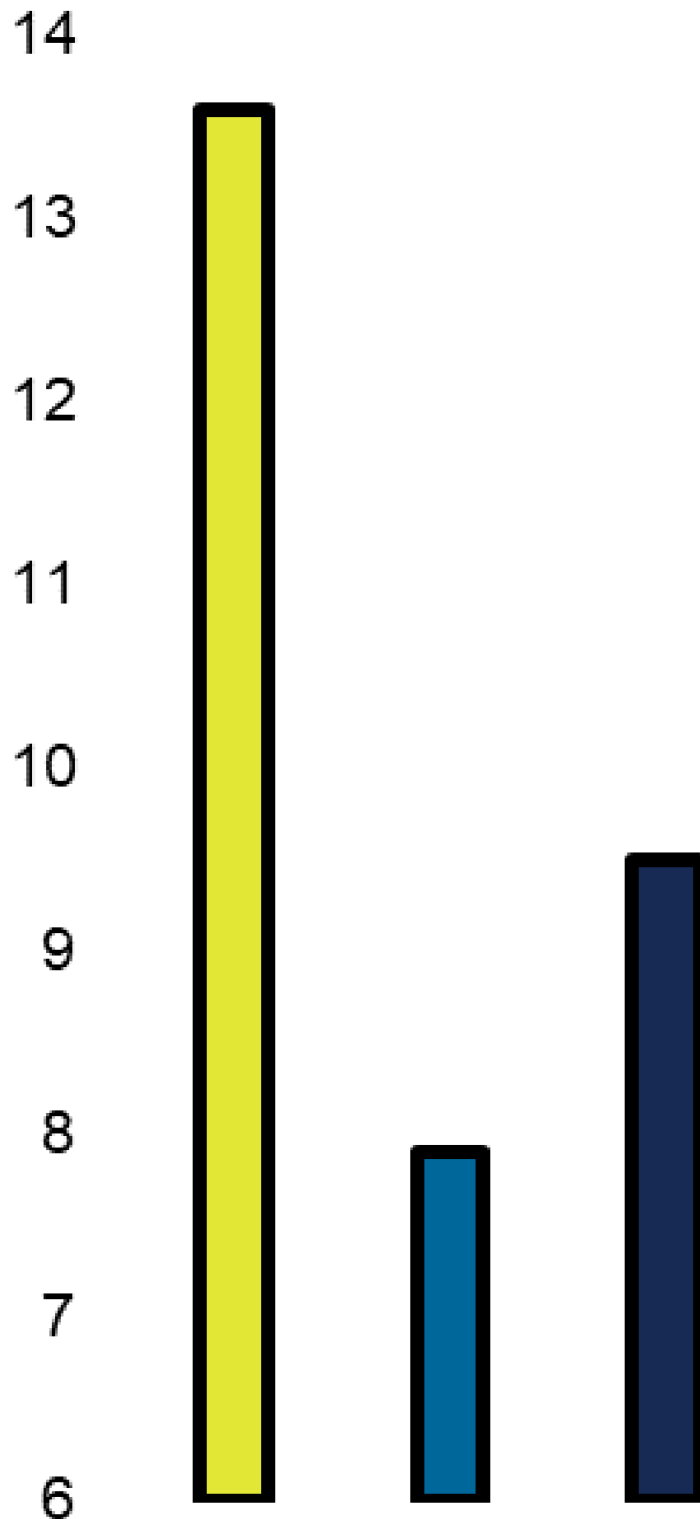
Age of First Cannabis Use

Youth # Cannabis Use Days in Past Month

Illicit States
Medical States
Adult Use States

CUD Score

2.4

2.3

2.2

2.1

2

DUIC Days in Past Month
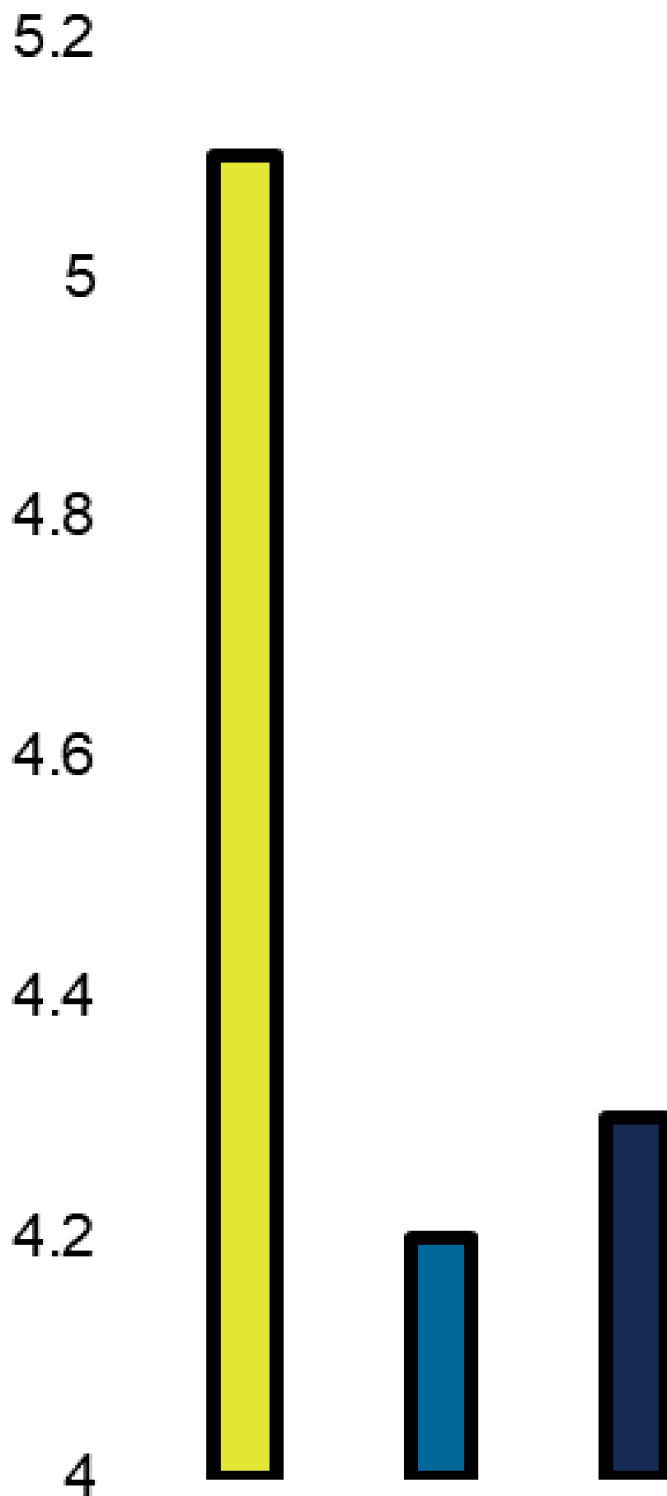
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