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Associations between cannabis policies and state-level specialty cannabis use disorder treatment in the United States, 2004-2019

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ABSTRACT

Background: Cannabis use disorder (CUD) treatment prevalence decreased in the US between 2002-2019, yet structural mechanisms for this decrease are poorly understood. We tested associations between cannabis laws becoming effective and self-reported CUD treatment.

Methods: Restricted-use 2004-2019 National Surveys on Drug Use and Health included people ages 12+ classified as needing CUD treatment (i.e., past-year DSM-5-proxy CUD or last/current specialty treatment for cannabis). Time-varying indicators of medical cannabis laws (MCL) with/without cannabis dispensary provisions differentiated state-years before/after laws using effective dates. Multi-level logistic regressions with random state intercepts estimated individual- and state-adjusted CUD treatment odds by MCLs and model-based changes in specialty CUD treatment state-level prevalence. Sensitivity analyses tested associations between CUD treatment and MCL or recreational cannabis laws (RCL).

Results: Using a broad treatment need sample definition in 2004-2014, specialty CUD treatment prevalence decreased by 1.35 (95% CI=-2.51, -0.18) points after MCL without dispensaries and by 2.15 points (95% CI=-3.29, -1.00) after MCL with dispensaries provisions became effective, compared to before MCL. Among people with CUD in 2004-2014, specialty treatment decreased only in MCL states with dispensary provisions (aPD=-0.91, 95% CI=-1.68, -0.13). MCLs were not associated with CUD treatment use in 2015-2019. In sensitivity analyses, RCL were not associated with CUD treatment among people with CUD.

Conclusions: Policy-related reductions in specialty CUD treatment were concentrated in states with cannabis dispensary provisions in 2004-2014, but not 2015-2019, and partly driven by reductions among people without past-year CUD. Other mechanisms (e.g., problem identification, criminal-legal referrals) could contribute to decreasing treatment trends.

KEY WORDS: cannabis policy; medical cannabis law; recreational cannabis law; cannabis; policy; treatment

1. INTRODUCTION

Cannabis use disorder (CUD) prevalence has increased among US adults (Hasin et al., 2015a; Hasin et al., 2022; Hasin et al., 2019), especially mild CUD (Compton et al., 2019). Cannabis use disorder has negative health and social consequences (Cerdá et al., 2016; Gutkind et al., 2021; Hasin et al., 2016; Meier et al., 2016) and yet is rarely treated (Askari et al., 2021; Budney et al., 2019; Kerridge et al., 2017). Lifetime and past-year CUD treatment prevalence among people with CUD is 13.7% and 6.1%, respectively (Askari et al., 2021; Kerridge et al., 2017; Wu et al., 2017). Treatment for CUD primarily involves psychosocial interventions to reduce cannabis use frequency and dependence severity (Gates et al., 2016). Intervention efficacy for CUD is moderate and heterogeneous (Lee et al., 2019) and there are currently no FDA-approved pharmacological treatments for CUD (Connor et al., 2021). Despite the harms associated with CUD, a recent study reported decreasing CUD treatment trends among people with CUD in the US between 2002-2019 (Askari et al., 2021). From a public health perspective, identifying structural factors that could affect CUD treatment uptake is a public health priority (Budney and Borodovsky, 2017; Budney et al., 2019).

Changing state cannabis policies are structural factors that could affect CUD-related trends. While cannabis use in the US remains illegal at the federal level, 38 states and the District of Columbia (DC) have medical cannabis laws (MCLs) and 23 states and DC have recreational cannabis laws (RCLs) for adult (≥21 years) cannabis use as of June 2023 (National Conference of State Legislatures, 2023). Legalization increased the range of cannabis products available and also the average potency of cannabis accessible through legal and illegal markets (Budney and Borodovsky, 2017; Carlini et al., 2017; Sevigny et al., 2014). Studies testing the associations between cannabis laws going into effect and cannabis use indicate increases among adults (Chu, 2014; Hasin et al., 2017; Kim et al., 2020; Martins et al., 2021; Mauro, C.M. et al., 2019), and mixed evidence among adolescents (Choo et al., 2014; Hasin et al., 2015b;

Lynne-Landsman et al., 2013; Mennis et al., 2023; Orsini et al., 2023; Sarvet et al., 2018). Localized studies suggest that cannabis dispensaries increase subsequent cannabis use frequency (Freisthler and Gruenewald, 2014) and harms from cannabis use, such as cannabis dependence and hospitalizations (Mair et al., 2015). RCLs are associated with increased cannabis accessibility (Hall and Lynskey, 2016) and co-use of cannabis and alcohol among adults (Gonçalves et al., 2022). RCLs have also been associated with CUD prevalence increases between 2008-2016 among adults 26 and older (e.g., 0.90% before RCL, 1.23% after RCL) (Cerdá et al., 2020), suggesting greater CUD treatment need in states with RCLs**.** Despite this greater burden, the downstream effects of MCLs with cannabis dispensaries and RCLs on CUD treatment remain understudied.

Given increases in CUD prevalence among adults, especially in states with earlier MCL passage (Hasin et al., 2017; Wen et al., 2015), one would expect changes in CUD treatment use after cannabis laws become effective. However, the evidence testing relationships between MCLs, RCLs, and CUD treatment is limited and mixed, and signals decreases in CUD treatment (Budney et al., 2019; Mennis et al., 2023; Smart and Pacula, 2019). National population-level associations between cannabis laws and CUD treatment have examined clinical samples using administrative records of publicly funded treatment admissions (Chu, 2014; Mennis et al., 2023; Pacula et al., 2015). In these data, cannabis laws were negatively associated with specialty CUD treatment admissions overall (Chu, 2014; Pacula et al., 2015; Smart and Pacula, 2019), which could be related to decreasing perceptions of cannabis-related harm following RCL (Mennis et al., 2023). However, associations varied by specific aspects of cannabis laws, such as operational dispensaries (Pacula et al., 2015; Smart and Pacula, 2019). This could be due to variation in policy operationalization (e.g., cannabis dispensary provisions), research methods, and sample differences (Smart and Pacula, 2019). A major limitation of these studies is their exclusion of individuals who may have received CUD treatment outside of publicly funded

specialty facilities, such as people who were mandated to treatment without a CUD diagnosis. Evidence on the relationship between MCLs, RCLs, and cannabis-specific treatment in the general population is lacking, especially among individuals meeting CUD criteria (Mennis et al., 2023).

The purpose of this study was to fill knowledge gaps in the association between MCL and RCL (using the laws' effective dates) and self-reported CUD treatment. We obtained restricted access to the 2004-2019 National Survey on Drug Use and Health (NSDUH), which sampled US community-based individuals. We used a broad sample definition of people classified as needing CUD treatment, including people with past-year CUD and people receiving specialty CUD treatment regardless of CUD criteria. We used a DSM-5-proxy CUD measure because it may be more sensitive to changes in prevalence than DSM-IV criteria (Compton et al., 2019). We hypothesized that CUD treatment use would be lower after MCLs became effective, especially MCLs with cannabis dispensaries, consistent with reports using clinical administrative records (Chu, 2014; Pacula et al., 2015; Smart and Pacula, 2019) and partly due to changes in legal status affecting mandated treatment. We then restricted our sample to people with past-year CUD to examine if reductions were observed among people meeting this clinical need indicator. Secondary analyses measured changes in treatment before and after RCLs became effective to examine effects of recreational laws above and beyond MCLs. Planned sensitivity analyses examined whether outcome and sample definitions affected findings. We tested associations with CUD treatment in any setting to determine whether changes were limited to specialty settings. Age-stratified models among people with CUD examined differences in associations among people ages 12-20, among whom cannabis use remained illegal even in states with RCL, and adults 21 and older, among whom cannabis became legal for recreational use following RCLs. Models using DSM-IV measures tested if associations were sensitive to the use of the DSM-5-proxy CUD measure. In post hoc analyses, we lagged the policy exposure

effective dates by one year to examine delayed policy effects. This comprehensive quantitative approach addressed limitations of past research and aimed to inform decisions related to CUD treatment provision and uptake in a changing policy landscape.

2. METHODS

2.1 Data Source

The NSDUH is a nationally- and state-representative annual survey of non-institutionalized civilian people ages ≥12 from the 50 states and DC. Approximately 68,000 people were sampled yearly. Weighted interview response rates ranged from 77.00% in 2004 to 64.92% in 2019 (Center for Behavioral Health Statistics and Quality [CBHSQ], 2018; CBHSQ, 2020b). Data were collected during face-to-face interviews using computer-assisted interviewing and audio computer assisted survey instruments. We accessed the 2004-2019 NSDUH data with restricted-use state-level indicators through the Research Data Center in New York.

2.2 Sample

We included people classified as needing CUD treatment, defined as meeting past-year DSM-5-proxy CUD criteria (Askari et al., 2021; Compton et al., 2019; Levy et al., 2021) or reporting treatment in a specialty facility for cannabis use in the last/current past-year treatment episode. This approach adopted the Substance Abuse and Mental Health Services Administration (SAMHSA) definition of people "classified as needing substance use treatment" (CBHSQ, 2020b) and refined it to be CUD-specific. The DSM-5-proxy CUD criteria included people endorsing 2 or more of 10 DSM-IV cannabis abuse or dependence criteria overlapping with DSM-5 criteria (Askari et al., 2021; Compton et al., 2019; Levy et al., 2021). Measures did not capture craving and withdrawal symptoms because these were not assessed in the NSDUH through 2019 (Levy et al., 2021). Treatment in a specialty facility included inpatient or outpatient treatment in a drug or alcohol rehabilitation facility, inpatient treatment in hospital, or treatment

in a mental health center (CBHSQ, 2020b). Individuals classified as needing CUD treatment without CUD at the time of data collection may have been coerced or court-mandated into treatment, had sub-threshold CUD symptoms due to past-year treatment, or received treatment without meeting self-reported CUD diagnostic thresholds. In sub-analyses, we restricted our sample to people meeting past-year DSM-5-proxy CUD criteria, which is a clear clinical indicator of cannabis-related problems. Our sample was stratified by year (2004-2014, 2015-2019) due to survey changes in the 2015 NSDUH redesign (CBHSQ, 2017).

2.3 Measures

Past-year specialty CUD treatment. CUD treatment was measured using separate questions regarding the last/current treatment episode among people who reported ever receiving treatment for alcohol or drugs. Measures specified if last/current treatment was for cannabis, whether it was in the past year, and the type of treatment setting, as done previously (Askari et al., 2021). Any past-year CUD treatment use was defined as last/current treatment for cannabis (i.e., "received treatment or counseling for your use of marijuana or hashish") in any location or facility type. Specialty CUD treatment indicated last/current treatment for cannabis was at a specialty facility (i.e., inpatient or outpatient drug or alcohol rehabilitation facility, inpatient hospital, or mental health center), which excluded primary care settings, self-help, and other non-specialty settings.

State medical and recreational cannabis laws: We obtained state MCL and RCL policy effective dates from multiple sources (Marijuana Policy Project, 2020; ProCon, 2023; RAND-USC Schaeffer Opioid Policy Tools and Information Center, 2020), supplemented as needed with our own original legal research. As the protections provided by laws often do not immediately go into effect after the passage of the law, we elected to use "effective dates" capturing when the legal protections provided by cannabis laws would have been available to individuals and

organizations in that state, in contrast to “passage dates” which represent when the law was adopted. Dispensary dates indicated the date when policies legalizing medical cannabis dispensaries (i.e., legally protected dispensaries) became effective, which occurred on average 3.6 years after the initial MCL became effective (range: 0-12.7 years). We linked policy effective dates with survey response dates using state-level identifiers and used survey interview dates to determine an individual’s policy exposure status. Two separate categorical policy measures distinguished interviews in (a) state-years before/after MCL and cannabis dispensaries, and (b) state-years before/after MCL and RCL. For MCL and medical cannabis dispensaries, we created a time-varying four-level variable using state-specific years of MCL and cannabis dispensary provision effective dates between 2004-2019: 1) never had MCL, 2) before MCL became effective, 3) after MCL became effective without cannabis dispensary provisions, and 4) after MCLs legally allowed cannabis dispensary provisions. For example, interview dates in Nevada before October 2001 were categorized as “before MCL became effective”; interviews from October 2001 to June 2013 were “after MCL without cannabis dispensary provisions;” interviews from July 2013 onwards were “after MCLs with cannabis dispensary provisions.” For MCL and RCL, we created a time-varying four-level exposure variable using state-specific years of MCL or RCL effective dates between 2004-2019: 1) never MCL/RCL, 2) before MCL/RCL 3) after MCL/before or no RCL, and 4) after MCL/after RCL (ProCon, 2019a, b). We operationalized MCL and RCL effective dates as one categorical variable because all states with RCL previously had an existing MCL in effect. See Table S1 for the number of states with before and after data for each period.

Multi-level control variables. Individual-level control variables included age group (12-17, 18-34, 35+); sex (male, female); race and ethnicity (Hispanic person of color, Hispanic white, non-Hispanic Asian, non-Hispanic Black, non-Hispanic white, other non-Hispanic multiracial or other than Asian/multiracial); household income (<$20,000, $20,000 to $49,999, $50,000 to $74,999,

greater than $75,000); urbanicity (living in a metropolitan area, micropolitan area, or not living in a core-based statistical area). Year was operationalized as a continuous variable with 2004=0 (2005=1, 2006=2, etc.) within the 2004-2014 data and 2015=0 (2016=1, 2017=2, etc.) in the 2015-2019 data. State-level characteristics from the 2010 US Census were standardized using the range method, including percentages of the population ages 10-24, white, or male, and unemployment rate (Census, 2010). Variables corresponded with measures used in the complex survey sampling protocols (CBHSQ, 2020a). Sampling units within states were first selected based on urbanicity, which were sorted by core-based statistical area/socioeconomic status indicators and by population percentages of white and non-Hispanic people. Younger people 12-25 years old were oversampled. Finally, we included sex because it is a key variable of interest associated with both CUD and treatment (Hasin et al., 2016; Wu et al., 2017).

2.4 Analytic strategy

First, we described characteristics of people meeting our inclusion criteria using survey weights to derive nationally representative estimates in public NSDUH data. Then, using restricted-use NSDUH with state-level indicators, we fit a series of unweighted models among people needing CUD treatment. Our main models used multi-level logistic regressions with state random intercepts to estimate associations between MCL with cannabis dispensary provision status and past-year specialty CUD treatment. As “never MCL” states may be substantially different than states where MCLs and RCLs were enacted, we used the “before MCL” reference category to compare likelihood of CUD treatment after MCL became effective (without cannabis dispensary provisions) and after cannabis provisions became effective. We used these multi-level models to calculate predicted marginal probabilities of specialty CUD treatment use by state cannabis legal status. We calculated adjusted prevalence differences to estimate the incremental change in state-level CUD treatment use prevalence associated with MCLs and cannabis dispensary provisions becoming effective. Models were not survey weighted and controlled for variables

used in the complex survey sampling protocols, consistent with prior state-level policy research (Martins et al., 2021; Mauro, C.M. et al., 2019). Doubly robust estimates controlled for survey year, individual-level covariates (age, sex, race and ethnicity, urbanicity, income), and state-level covariates (% ages 10 to 24, % male, % white, unemployment rate). We repeated procedures restricting our sample to people with past-year DSM-5-proxy CUD. Due to positivity violations, we could not run analyses among people who did not meet CUD criteria but got treatment. Secondary analyses examined differences by MCL after RCLs became effective, regardless of dispensary status, following the procedures above.

Post-hoc analyses lagged our policy exposure variable by 1 year to account for delayed policy effects. Planned sensitivity analyses (a) broadened our outcome to include CUD treatment in any setting, instead of specialty settings only; (b) stratified the sample by legal age restrictions for purchasing cannabis in MCL and RCL states (12-20 vs. ≥21); and (c) used DSM-IV instead of DSM-5-proxy CUD to identify people with past-year CUD.

Analyses were conducted in Stata Version 16 using the restricted NSDUH data with state identifiers in the Research Data Center. Models were stratified by year (2004-2014 and 2015-2019) per SAMHSA rules. The Research Data Center output including only percentages or aggregated model estimates was reviewed prior to public disclosure to ensure confidentiality was protected. This study was approved by the Columbia University Institutional Review Board.

3. RESULTS

Descriptive characteristics of people meeting inclusion criteria using survey-weighted nationally representative data in the 2004-2014 and 2015-2019 public-use NSDUH are presented in Table 1. Among the 2.4-2.5% of people ages 12 and older needing CUD treatment, 7.3-10.4%

reported any CUD treatment, 5.2-7.0% reported specialty CUD treatment, and 1.4-2.6% perceived a need for CUD treatment. Among people with CUD (i.e., 2.3-2.4%), 4.2-6.4% reported any CUD treatment, 2.1-2.9% reported specialty CUD treatment, and 1.4-2.6% perceived a need for CUD treatment.

Table 2 reports the predicted state-level prevalences by state MCL with and without cannabis dispensary provisions among people needing CUD treatment based on unweighted, fully adjusted multi-level models. In 2004-2014, average state prevalence of specialty CUD treatment was 6.91% before MCL became effective and 5.56% after MCL without dispensary provisions, resulting in an adjusted prevalence difference [aPD] of -1.35 (95% CI = -2.51, -0.18). After MCL with dispensary provisions became effective, specialty CUD treatment prevalence (4.76%) was 2.15 points lower (95% CI=-3.29, -1.00) compared to before MCL. Adjusted odds of specialty CUD treatment were 0.67-0.79 times after MCL (with or without dispensaries) than before MCL became effective. Patterns were similar In 2015-2019, but associations overlapped the null.

In the subsample of people with past-year DSM-5-proxy CUD, specialty CUD treatment prevalence was lower and associations with MCLs were attenuated (Table 3). In 2004-2014, adjusted state-level prevalence of specialty CUD treatment was 3.38% before MCL and did not change meaningfully after MCL without dispensary provisions (3.22%) but decreased to 2.47% after MCL with dispensary provisions (aPD=-0.91, 95% CI=-1.68, -0.13). Adjusted odds of specialty CUD treatment were 0.72 (95% CI=0.54, 0.97) times lower after MCL with cannabis dispensaries than before MCL. In 2015-2019, there were no associations between specialty CUD treatment and MCL with dispensary provisions among people with past-year CUD.

Findings examining differences in specialty CUD by MCL/RCL were generally consistent with the main analyses in 2004-2014 but also detected associations in 2015-2019 (Table 4).

Reductions in specialty CUD treatment among people needing CUD treatment were larger in states with both MCL/RCL than states with MCL only in both 2004-2014 (aPD=-2.41, 95% CI=-4.76, -0.06) and 2015-2019 (aPD=-1.41, 95% CI=-2.59, -0.23). Unlike main analyses, MCL/RCL status was not significantly associated with specialty CUD treatment among people with past-year CUD from 2004-2019 (Table 5). Treatment use prevalence was lowest in states with both MCL/RCL, with only 2.5% of people with CUD reporting specialty CUD treatment in 2004-2014 and 1.8% reporting CUD treatment in 2015-2019.

3.1 Post-hoc and sensitivity analyses

Post-hoc analyses with one-year lagged policy exposures are presented in Tables S2-S5. Lagged models were generally consistent with our main results in 2004-2014, though MCL without dispensaries were no longer associated with specialty treatment among people needing CUD treatment (Table S2). Unlike our main results, lagged models indicated a consistent reduction in specialty CUD treatment in 2015-2019 among people needing CUD treatment in MCL states with and without dispensaries (Table S2) and states with MCL and RCL (Table S3). Lagged associations between cannabis policy and specialty CUD treatment among people with CUD overlapped the null (Table S4-S5).

Sensitivity analyses using any CUD treatment use as an outcome (Tables S6-S9) were of similar magnitude and direction to findings in specialty settings when using cannabis policy effective dates (Model A) or one-year lags (Model B), respectively. In models stratified by legal age, confidence intervals comparing CUD treatment before and after cannabis policy changes overlapped the null and were particularly wide among ages 12-20 and in 2015-2019 (Table S10). Findings among people with past-year DSM-IV CUD were consistent with MCL-related reductions in specialty CUD treatment in 2004-2014 (Table S11).

4. DISCUSSION

To our knowledge, this is the first study to estimate relationships between medical and recreational cannabis laws and self-reported CUD treatment in a nationally representative US community-based sample of people ages 12 and older. We examined cannabis laws as structural contributors to the decreasing US CUD treatment prevalence trends (Askari et al., 2021). We estimated changes in treatment related to cannabis policy effective dates in two community-based study samples: one classifying people needing CUD treatment (including people with past-year CUD or in specialty treatment for cannabis problems without CUD), and another using a clinically focused definition of people with CUD. We found that only MCLs with cannabis dispensary provisions were associated with lower specialty CUD treatment among people with past-year CUD, but both MCLs and RCLs were associated with lower specialty CUD treatment when broadly defining needing CUD treatment. Together, findings indicate cannabis policy-related reductions in CUD treatment among people with CUD were concentrated in states with cannabis dispensary provisions; reductions were observed in both in MCL regardless of dispensaries and in RCL states when including people who did not meet past-year CUD criteria. Importantly, CUD treatment use remained very low across years and policy exposures, indicating unmet CUD treatment need throughout the US.

Our results clarify past studies reporting associations between cannabis policies and cannabis-related admissions in publicly funded specialty treatment facilities (Chu, 2014; Meinhofer et al., 2019; Mennis et al., 2023; Pacula et al., 2015). Our comprehensive analyses using individual-level data distinguished different policy levers, needing CUD treatment from past-year CUD, and any treatment location from specialty settings (regardless of public funding), which addressed limitations of past studies using public survey or administrative data (Mauro et al., 2022; Mennis et al., 2023). We found that specialty CUD treatment did not meaningfully change among people with past-year CUD in states with MCL/RCL but decreased in states with cannabis dispensary

provisions or when including people without past-year CUD who reported treatment. Reductions in CUD treatment in any location among people needing CUD treatment were similar in magnitude to findings in specialty treatment locations, indicating most of the reductions in treatment were in specialty settings.

The largest reductions in specialty CUD treatment were observed when broadly defining needing CUD treatment. People reporting specialty CUD treatment but not meeting past-year CUD criteria could include people who previously met CUD criteria but not in the year before survey administration, people who did not meet CUD thresholds but perceived a need for treatment, and people without CUD referred to treatment through the criminal legal system or other types of legally mandated or coerced treatment. Treatment reductions were observed in RCL states and MCL states with and without cannabis dispensaries, suggesting that reductions among people without CUD were due to the changing legal status of cannabis rather than dispensaries. Reductions in CUD treatment among people exposed to the criminal legal system are consistent with cannabis policy-related reductions in criminal legal referrals to treatment (Mennis et al., 2023) and cannabis arrests (Grucza et al., 2018; Plunk et al., 2019), particularly for cannabis possession (Gunadi and Shi, 2022a, b; Joshi et al., 2023). However, recent evidence from two cities shows public consumption arrests increased in certain cities following legalization (Joshi et al., 2023), suggesting ongoing criminal legal exposure in areas where cannabis is legal for adult use. While beyond the scope our study, changing cannabis policies could be associated with drug courts implementing best practices using validated eligibility assessment tools to avoid “subjective suitability determinations” (National Association of Drug Court Professionals, 2018), which could result in decreased mandated treatment among people without CUD. Studies should examine whether changing cannabis laws are associated with reductions in mandated treatment without CUD, either through reducing subjective drug court program eligibility determinations or other forms of criminal legal exposure.

Reductions in treatment among people with CUD were concentrated in MCL states with cannabis dispensary provisions, uncovering structural drivers of decreasing CUD treatment use among people with CUD (Askari et al., 2021). Our findings add to the evidence indicating cannabis dispensaries as a key policy lever affecting cannabis-related outcomes (Pacula et al., 2015; Smart and Pacula, 2019). Dispensaries could affect treatment if they affect the likelihood of identifying CUD symptoms and perceiving treatment need. Cannabis dispensaries have been associated with knowledge of cannabis legal status (Mauro, P.M. et al., 2019), perceptions of cannabis-related harm (Han and Shi, 2023), and cannabis use (Han and Shi, 2023; Rhew et al., 2022). Signage with messages supporting the health benefits of cannabis use outside cannabis dispensaries have been associated with higher cannabis use near one's home (Han and Shi, 2023). Medical cannabis laws have also been associated with higher self-medication with cannabis among people with mood or anxiety disorders (Sarvet et al., 2018), which could also hinder CUD symptom identification in vulnerable populations. Cannabis use coping have been associated with CUD and related problems (Bresin and Mekawi, 2019; Moitra et al., 2015), further contributing to community treatment needs. Together, these changes in cannabis-related perceptions of risk and behavior could decrease people's perceptions that problems are related to their cannabis use (i.e., lower CUD symptom identification), thereby decreasing treatment perceived need and use. In a recent study of people reporting drug use problems, individuals were less likely to report being aware of needing treatment for cannabis than for other drugs (Kim et al., 2022), which could add to existing challenges associated with CUD treatment engagement (Budney et al., 2007). Consistent with past work (Askari et al., 2021), few people needing CUD treatment in our study perceived a need for CUD treatment. Unfortunately, we were unable to estimate associations between cannabis policy and perceived treatment need due to model convergence problems, so this question remains of clinical interest.

Factors beyond changing cannabis policies could be contributing to decreases in treatment, including growing number of people with mild CUD (Compton et al., 2019), decreasing perceived risk (Carliner et al., 2017; Compton et al., 2016; Pacek et al., 2015; Schuermeyer et al., 2014), and low perceptions of CUD treatment need (Askari et al., 2021). While higher CUD severity is associated with higher likelihood of treatment use (Kerridge et al., 2017), CUD prevalence among people reporting daily cannabis use decreased (Compton et al., 2019; Santaella-Tenorio et al., 2019). Low treatment use among people with CUD could be related to difficulties identifying CUD-related problems, especially among people with mild CUD. Findings suggest the need for public education about the likelihood and symptoms of CUD, as well as need for treatment when clinically indicated, in the context of changing cannabis legal status.

While associations between MCL with cannabis dispensaries and lower CUD treatment were limited to the 2004-2014 period, we also detected reductions in specialty CUD treatment in 2015-2019 when comparing states with RCL vs MCL among people needing CUD treatment. When lagging the policy exposure by one year, policy-related reductions in specialty CUD treatment in 2015-2019 among people needing CUD treatment indicated potentially delayed associations between policy changes and specialty CUD treatment. However, SAMHSA requirements to stratify survey years due to NSDUH methodological changes may have disrupted our ability to detect associations in the later period, as 23 states and DC had MCL effective dates before 2015. In a recent study using public data, the 2015 NSDUH redesign did not appear to modify trends in CUD treatment (Askari et al., 2021), calling into question the need for stratification. Sensitivity analyses stratified by legal purchasing age appeared similar for adults compared to our main results, wide confidence intervals overlapping the null indicated low precision, especially in ages 12-20 and in 2015-2019. While increasing sample sizes with additional years of data would result in higher precision, methodological NSDUH changes in 2020 and 2021 hinder combining additional years of data (CBHSQ, 2022). Our study included

the most comprehensive years with comparable data for policy analysis, as 2021 will be a new baseline year.

4.1 Limitations

Because of data restrictions, we did not have pre-MCL data for states that enacted MCLs before 2004. Specialty CUD treatment use measures were defined by combining self-reported past-year substance-specific last/current treatment in specialty settings. This could lead to underreporting if participants with multiple past-year treatment episodes did not report that the last treatment encounter was CUD-related. Since CUD treatment was low, we do not expect this to substantially affect our estimates. DSM-5-proxy measures did not include craving or withdrawal, which were not collected in the NSDUH. However, craving has not been found to considerably change the likelihood of a CUD diagnosis (Peer et al., 2013). Our policy exposure distinguished MCL states with cannabis dispensary provisions and states with RML using policy effective dates. States could have various additional policies implemented simultaneously, producing heterogeneity in policy implementation, leading to measurement error. Future studies should build on our findings to examine different policy exposures and test whether the strength of the associations differ across states over time.

4.2 Policy and practice implications

Targeted efforts are needed to support people with CUD, particularly in states with cannabis dispensaries. From a structural perspective, this includes training and supporting providers to increase screening and discussions about cannabis use and CUD in primary care settings (US Preventive Services Task Force, 2020) and increasing access to evidence-based services. However, discussions with healthcare providers remain rare among people with CUD (Mauro et al., 2020). Interventions to overcome structural and stigma barriers, including harm reduction interventions (Meffert et al., 2019), are needed as states increasingly adopt more liberal

cannabis laws. Important questions remain about whether treatment reductions could reflect decreases in coercive treatment associated with policy change among people without CUD. Our findings suggest cannabis policies may reduce clinically unnecessary but legally mandated treatment episodes. Separately reforming court-mandated treatment policies could further reduce undue burden on the treatment system. Continued monitoring of changes in treatment in younger ages is warranted, as our age-stratified analyses lacked the precision to estimate treatment changes in people under the legal cannabis purchasing age.

5. CONCLUSIONS

While only MCL with cannabis dispensary provisions were associated with decreases in specialty CUD treatment among people with CUD, both MCL and RCL were associated with reductions in treatment among people needing CUD treatment, including people without CUD who reported past-year specialty treatment. Evidence of lagged cannabis policy effects could lead to further reductions in CUD treatment. Importantly, low CUD treatment prevalence across states indicates unmet treatment need in the US**.** Future studies should explore changing cannabis-related problem identification and patterns of criminal legal system treatment referrals to further explain national-level reductions in CUD treatment.

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CONTRIBUTORS

PMM conceptualized the study, supervised all analyses, and wrote the original draft. SG and MA contributed to the original draft and conducted data analyses at the Research Data Center at the Baruch Census location in New York City, supervised by PMM at Columbia University. EMA conducted descriptive analyses with public use data, assisted by SG and supervised by PMM. PMM and SG had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. All authors contributed to the interpretation of findings, reviewed and edited the writing, and approved the final materials.

CONFLICT OF INTEREST

Dr. H. Samples reports being a paid consultant for the American Society of Addiction Medicine; other authors report no potential conflicts of interest.

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Table 1: Nationally representative characteristics of people needing CUD treatment in the 2004-2014 and 2015-2019 public-use NSDUH.

	Needing CUD treatment		Past year CUD	
	2004-2014	**2015-2019**	**2004-2014**	**2015-2019**
(Row % of overall within year stratum)	(2.40)	(2.50)	(2.30)	(2.42)
Sociodemographics	Col %	Col %	Col %	Col %
Age				
12-17	17.01	11.36	17.33	11.58
18-34	65.32	67.85	65.87	68.56
35 and older	17.67	20.79	16.79	19.86
Sex				
Male	66.99	64.82	66.95	64.76
Female	33.01	35.18	33.05	35.24
Race and ethnicity				
Asian, non-Hispanic	1.63	2.67	1.67	2.72
Black, non-Hispanic	16.65	16.39	16.11	16.40
Hispanic, any race	14.96	17.38	15.13	17.30
White, non-Hispanic	63.05	58.23	63.41	58.22
Other, non-Hispanic	3.70	5.33	3.68	5.37
Urbanicity				
Large metro	55.18	58.03	55.35	58.45
Small metro	31.40	30.70	31.41	30.53
Non-metro	13.42	11.26	13.24	11.01
Household income				
<$20,000	30.99	26.33	30.17	25.79
$20,000-$49,999	34.71	31.43	34.72	31.32
$50,000-$74,999	13.69	14.04	13.92	14.12
$75,000+	20.61	28.20	21.18	28.77
Past-year cannabis-related measures				
CUD treatment use				
No treatment	89.62	92.73	93.57	95.84
Any treatment location	10.38	7.27	6.43	4.16
Specialty treatment	6.98	5.23	2.88	2.05
Perceived CUD treatment need				
No perceived need	97.40	98.57	97.39	98.63
Any perceived need	2.60	1.43	2.61	1.37

Notes: CUD= cannabis use disorder; treatment need sample included people with past-year CUD based on DSM-5 proxy CUD criteria or had a last/current treatment episode in a specialty facility in the past year for cannabis. Survey-weighted percentages estimated using public use National Survey on Drug Use and Health data.

Table 2: Model-based state prevalence and adjusted odds of past-year specialty CUD treatment use by state cannabis policy and dispensary provisions among individuals who needed CUD treatment, NSDUH 2004-2019

Medical cannabis laws and dispensary provisions	**Specialty CUD treatment, 2004-2014**		**Specialty CUD treatment, 2015-2019**	
	Adjusted state prevalence	*aOR (95% CI)*	*Adjusted state prevalence*	*aOR (95% CI)*
Never MCL	6.97%	1.01 (0.83, 1.23)	6.07%	1.38 (0.96, 1.98)
Before MCL	6.91%	Ref	4.50%	Ref
After MCL without dispensary provisions	5.56%	**0.79 (0.64, 0.98)**	3.26%	0.71 (0.41, 1.23)
After MCL with dispensary provisions	4.76%	**0.67 (0.53, 0.84)**	4.46%	0.99 (0.69, 1.42)
	aPD (95% CI)		*aPD (95% CI)*	
MCL without dispensary provisions vs before MCL	**-1.35 (-2.51, -0.18)**	**-**	-1.24 (-3.16, 0.69)	-
MCL with dispensary provisions vs before MCL	**-2.15 (-3.29, -1.00)**	**-**	-0.04 (-1.55, 1.47)	-
MCL with dispensary provisions vs. MCL without dispensary provisions	-0.80 (-1.94, 0.34)	-	1.20 (-0.38, 2.77)	-

Note: CUD= cannabis use disorder; sample included people with past-year CUD based on DSM-5 proxy CUD criteria or had a last/current treatment episode in a specialty facility in the past year for marijuana; aPD=adjusted prevalence difference; aOR=adjusted odds ratio; CI = confidence interval. All multi-level logistic models controlled for survey year and had a random state intercept. Models adjusted for year, age (12-17, 18-34, 35+), sex, race, urbanicity, income, and state-level covariates (% ages 10 to 24, % male, % non-Hispanic White, unemployment rate). Bold values indicate $P < 0.05$. Exact sample sizes are not provided per SAMHSA guidelines to use the National Survey on Drug Use and Health restricted files.

Table 3: Model-based state prevalence and adjusted odds of past-year specialty CUD treatment use by state cannabis policy and dispensary provisions among individuals with past-year CUD, NSDUH 2004-2019

Medical cannabis laws and dispensary provisions	**Specialty CUD treatment, 2004-2014**		**Specialty CUD treatment, 2015-2019**	
	Adjusted state prevalence	*aOR (95% CI)*	*Adjusted state prevalence*	*aOR (95% CI)*
Never MCL	3.51%	1.04 (0.83, 1.31)	2.52%	1.38 (0.80, 2.39)
Before MCL	3.38%	Ref	1.84%	Ref
After MCL without dispensary provisions	3.22%	0.95 (0.74, 1.24)	1.79%	0.97 (0.43, 2.17)
After MCL with dispensary provisions	2.47%	**0.72 (0.54, 0.97)**	2.10%	1.14 (0.68, 1.92)
	aPD (95% CI)		*aPD (95% CI)*	
MCL without dispensary provisions vs before MCL	-0.15 (-0.97, 0.66)	-	-0.05 (-1.48, 1.37)	-
MCL with dispensary provisions vs before MCL	**-0.91 (-1.68, -0.13)**	-	0.26 (-0.69, 1.21)	-
MCL with dispensary provisions vs. MCL without dispensary provisions	-0.75 (-1.59, 0.08)	-	0.31 (-0.90, 1.53)	-

Note: CUD= cannabis use disorder; sample included people with past-year CUD based on DSM-5 proxy CUD criteria; aPD=adjusted prevalence difference; aOR=adjusted odds ratio; CI = confidence interval. All multi-level logistic models controlled for survey year and had a random state intercept. Models adjusted for year, age (12-17, 18-34, 35+), sex, race, urbanicity, income, and state-level covariates (% ages 10 to 24, % male, % non-Hispanic White, unemployment rate). Bold values indicate $P < 0.05$. Exact sample sizes are not provided per SAMHSA guidelines to use the National Survey on Drug Use and Health restricted files.

Table 4: Model-based state prevalence and adjusted odds of past-year specialty CUD treatment use by medical and recreational cannabis law status among individuals who needed CUD treatment, NSDUH 2004-2019

Medical and recreational state cannabis law status	**Specialty CUD treatment, 2004-2014**		**Specialty CUD treatment, 2015-2019**	
	Adjusted state prevalence	*aOR (95% CI)*	*Adjusted state prevalence*	*aOR (95% CI)*
Never MCL	6.99%	1.00 (0.83, 1.23)	6.13%	1.32 (0.93, 1.87)
Before MCL	6.94%	Ref	4.72%	Ref
After MCL, no recreational	5.23%	**0.74 (0.61, 0.89)**	4.59%	0.97 (0.69, 1.36)
After recreational	2.82%	**0.39 (0.16, 0.92)**	3.18%	0.66 (0.41, 1.05)
	aPD (95% CI)		*aPD (95% CI)*	
After MCL, no recreational vs before MCL	**-1.70 (-2.72, -0.69)**	-	-0.13 (-1.63, 1.36)	-
After recreational vs before MCL	**-4.12 (-6.58, -1.65)**	-	-1.54 (-3.31, 0.23)	-
After recreational vs after MCL, no recreational	**-2.41 (-4.76, -0.06)**	-	**-1.41 (-2.59, -0.23)**	-

Note: CUD= cannabis use disorder; sample included people with past-year CUD based on DSM-5 proxy CUD criteria or had a last/current treatment episode in a specialty facility in the past year for marijuana; aPD=adjusted prevalence difference; aOR=adjusted odds ratio; CI = confidence interval. All multi-level logistic models controlled for survey year and had a random state intercept. Models adjusted for year, age (12-17, 18-34, 35+), sex, race, urbanicity, income, and state-level covariates (% ages 10 to 24, % male, % non-Hispanic White, unemployment rate). Bold values indicate $P < 0.05$. Exact sample sizes are not provided per SAMHSA guidelines to use the National Survey on Drug Use and Health restricted files.

Table 5: Model-based state prevalence and adjusted odds of past-year specialty CUD treatment use by medical and recreational cannabis law status among individuals with past-year CUD, NSDUH 2004-2019

Medical and recreational state cannabis law status	**Specialty CUD treatment, 2004-2014**		**Specialty CUD treatment, 2015-2019**	
	Adjusted state prevalence	*aOR (95% CI)*	*Adjusted state prevalence*	*aOR (95% CI)*
Never MCL	3.52%	1.04 (0.83, 1.32)	2.53%	1.37 (0.80, 2.36)
Before MCL	3.38%	Ref	1.86%	Ref
After MCL, no recreational	2.89%	0.85 (0.68, 1.07)	2.13%	1.15 (0.69, 1.92)
After recreational	2.51%	0.74 (0.28, 1.92)	1.81%	0.97 (0.49, 1.92)
	aPD (95% CI)		*aPD (95% CI)*	
After MCL, no recreational vs before MCL	-0.48 (-1.17, 0.20)	-	0.27 (-0.69, 1.22)	-
After recreational vs before MCL	-0.87 (-3.23, 1.50)	-	-0.05 (-1.27, 1.17)	-
After recreational vs after MCL, no recreational	-0.38 (-2.68, 1.91)	-	-0.32 (-1.24, 0.60)	-

Note: CUD= cannabis use disorder; sample included people with past-year CUD based on DSM-5 proxy CUD criteria; aPD=adjusted prevalence difference; aOR=adjusted odds ratio; CI = confidence interval. All multi-level logistic models controlled for survey year and had a random state intercept. Models adjusted for year, age (12-17, 18-34, 35+), sex, race, urbanicity, income, and state-level covariates (% ages 10 to 24, % male, % non-Hispanic White, unemployment rate). Bold values indicate $P < 0.05$. Exact sample sizes are not provided per SAMHSA guidelines to use the National Survey on Drug Use and Health restricted files.