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The impact of recreational cannabis laws on cannabis use disorder during "treat and release" visits to hospital emergency departments in four U.S. states, 2017–2020

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ABSTRACT

States' legalization of cannabis influences cannabis use and may increase cannabis use disorder (CUD)—a problematic pattern of use leading to significant impairment. Few studies have examined the influence of recreational cannabis legalization on CUD in the emergency department (ED). We used four years of data from the State Emergency Department Databases (SEDD) (2017–2020) from three states (CO, MD, OR) and three years of SEDD from Rhode Island (2017–2019) to examine the relationship between the recreational legalization of cannabis and CUD among "treat and release" ED visits. During the study period, CO and OR were legal for recreational cannabis while it was illegal in MD and RI. We examined the proportion of ED visits for CUD and used multivariate logistic regression to examine the association between recreational legalization and CUD diagnosis. The sample had 17,434,655 ED visits (56.2 % female). The proportion of ED visits for CUD was 0.63 %. Annual rates ranged from 0.67 % (2017) to 0.59 % (2019) and state-level rates were 0.39 % (CO), 0.35 % (OR), 1.03 % (MD), and 0.79 % (RI). Compared to ED visits in legal states, a higher proportion of ED visits in non-legal states were from women (56.8 % versus 55.7 %) and Blacks (40.9 % versus 5.9 %). Compared to states where recreational cannabis was illegal, legalizing cannabis for recreational use was associated with nearly a 50 % decrease in the adjusted odds of CUD (AOR = 0.49, 95 % CI 0.47, 0.52). In summary, CUD rates among "treat and release" ED visits were significantly lower in legalized states than in non-legal states.

Cannabis is the most commonly used psychoactive and regulated drug in the world after alcohol and tobacco. Based on 2021 data, 18.7 % of people aged 12 + years (more than 52 million people) and 35.4 % of young adults (18–25 years of age) in the United States reported past-year cannabis use (Center for Behavioral Health Statistics and Quality, 2022). The number of cannabis users in the U.S. has steadily climbed—from 2002 through 2020, the U.S. experienced a 20.2 % increase in past-year cannabis use and a 27.3 % increase in past-year cannabis initiates (Substance Abuse and Mental Health Services Administration [SAMHSA], 2021).

While occasional cannabis use by adults has not been associated with significant problems, frequent and early use of cannabis is associated with cannabis use disorder (National Academies of Sciences, Engineering, and Medicine [NASEM], 2017). Cannabis use disorder (CUD) is characterized by a "continued problematic pattern of use despite negative consequences that causes significant distress or impairment in functioning" (Sherman and McRae-Clark, 2016, p. 511). For example, people with CUD have a higher likelihood of interpersonal, financial, legal, and health-related problems (Gutkind et al., 2021). CUD has been linked to a variety of specific adverse outcomes: delinquency and criminal activity; motor vehicle accidents; decline in social functioning; unemployment and low income; lower educational attainment; overdose injuries; suicide; impaired respiratory function among smokers; adverse pregnancy outcomes; schizophrenia and other psychoses; and cognitive impairments in learning, memory, and attention (Connor et al., 2021; NASEM, 2017).

In 2021, the federal government estimated that 5.8 % of Americans aged 12 + years—approximately 16 million people—had cannabis use

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disorder (Center for Behavioral Health Statistics and Quality, 2022). Among lifetime cannabis users, approximately 27 % develop CUD (Feingold et al., 2020). Anthony estimates that 50–80 recent-onset cannabis users will develop cannabis dependence syndrome each day of the year (Anthony, 2006). Recent increases in CUD have been more significant among men, young adults, Blacks, Hispanic men, low-income groups, and urban residents (Hasin et al., 2015; Hasin et al., 2019).

State cannabis policies influence people's use of cannabis. For example, residents of states with more liberal cannabis policies have a higher prevalence of early cannabis initiation (Taylor et al., 2019), cannabis use, and CUD (Budney and Borodovsky, 2017; Budney et al., 2019; Cerdá et al., 2020). A 2023 review of the evidence examining the effects of recreational cannabis laws on CUD identified five studies, which generally found an increase in CUD prevalence post-legalization (Aletraris et al., 2023).

While legalization may be associated with increased cannabis use and CUD, few studies have examined state policy environments' relationship with cannabis-related utilization and/or CUD treatment. To expand on what is known about the relationship between states' policy environments and CUD-related healthcare utilization, we explored the relationship between states' legalization status of recreational cannabis and ED visits for CUD. Our study adds to what is known about the legalization-ED relationship in the United States by going beyond a single-state sample. We used data from four states, which included two states that were legal (Colorado [CO] and Oregon [RI]) and two that were illegal (Maryland [MD] and Rhode Island [RI]) for recreational cannabis use during the study period. Additionally, instead of examining cannabis-related ED visits, generally, we examined the proportion of ED visits with CUD.

1. Methods

1.1. Data Source

The primary data sources for this study were the State Emergency Department Databases (SEDD), which are repeated cross-sections of all-payer data that are part of the Healthcare Cost and Utilization Project (HCUPS), a family of healthcare databases developed through a federal-state partnership and sponsored by the U.S. Department of Health and Human Services, Agency for Healthcare Research and Quality (AHRQ) (Agency for Healthcare Research and Quality (AHRQ), Healthcare Cost and Utilization Project (HCUP), 2017–2020). SEDD data include discharges from all hospital-affiliated "treat and release" ED visits—those are ED visits that did not result in a hospital admission.

We used four years of SEDD data (2017–2020) from three states (CO, MD, OR), and three years of data from Rhode Island (2017–2019) because RI data from 2020 were unavailable. These state-years were selected because they have the best availability of SEDD data. Specifically, states opt in/out of SEDD; thus, some states do not participate in SEDD each year. (For the availability of states across years, see https://www.hcup-us.ahrq.gov/db/availability_public.jsp.) Additionally, not all SEDD states collect all the variables of interest every year. (For the availability of data elements by state-year see https://hcup-us.ahrq.gov/db/state/sedddist/sedddist_ddeavailbyyear.jsp). Furthermore, these four states represented two different policy environments: CO and OR were legal for recreational cannabis while MD and RI were illegal for recreational cannabis for the entire study period. (NOTE: All four states were legal for medical cannabis the entire study period.) To obtain the variables needed for our analysis, and to ensure our sample included states where cannabis was entirely legal and entirely illegal for recreational use, it was ideal to use the four-state sample.

1.2. Inclusion Criteria

We included the subsample of emergency department records (STATE_ED = 1) for patients 12 years of age and older, who resided in one of the four states being studied (CO, MD, OR, RI), and had data for any of the three reason for visits variables (I10_DX_Visit Reason) or any of the 60 ICD-10-CM diagnostic code variables (I10_DXn) used to identify CUD; patient visits that were completely missing/blank on these 63 variables were excluded.

1.3. Measure of CUD

As other studies have done (Masonbrick et al., 2021), we identified cases of CUD using ICD-10-CM codes for cannabis abuse and cannabis dependence (Table 1). A patient visit was considered a CUD visit if any of the relevant ICD-10-CM codes were present in any of the three reasons for visit variables or any of the 60 diagnosis code variables. The outcome variable was binary and coded "1″ if the patient visit was identified as a CUD visit and "0" otherwise.

1.4. Measure of states' policy environments

We supplemented SEDD data with an inventory of states' cannabis policies using publicly available data from the National Conference of State Legislatures (https://www.ncsl.org/civil-and-criminal-justice/cannabis-overview) to determine the legal status of recreational cannabis in each state-year. While Colorado and Oregon enacted and implemented recreational cannabis laws before 2017, recreational cannabis was illegal in both Maryland and Rhode Island from 2017 to 2020. The timing of these policies allowed us to create a single, binary variable representing each state's recreational cannabis policy environment (legal = CO, OR; illegal = MD, RI) during the study period (1 = legal in that state-year, 0 = otherwise). (NOTE: As indicated, there were no differences in medical cannabis policies across these four states; they were all legal.).

Table 1
ICD-10-CM coding for cannabis use disorder (i.e., cannabis abuse and cannabis dependence).

F12.1 Cannabis abuse
F12.10 …… uncomplicated
F12.11 …… in remission
F12.12 Cannabis abuse with intoxication
F12.120 …… uncomplicated
F12.121 …… delirium
F12.122 …… with perceptual disturbance
F12.129 …… unspecified
F12.15 Cannabis abuse with psychotic disorder
F12.150 …… with delusions
F12.151 …… with hallucinations
F12.159 …… unspecified
F12.18 Cannabis abuse with other cannabis-induced disorder
F12.180 Cannabis abuse with cannabis-induced anxiety disorder
F12.188 Cannabis abuse with other cannabis-induced disorder
F12.19 …… with unspecified cannabis-induced disorder
F12.2 Cannabis dependence
F12.20 …… uncomplicated
F12.21 …… in remission
F12.22 Cannabis dependence with intoxication
F12.220 …… uncomplicated
F12.221 …… delirium
F12.222 …… with perceptual disturbance
F12.229 …… unspecified
F12.23 …… with withdrawal
F12.25 Cannabis dependence with psychotic disorder
F12.250 …… with delusions
F12.251 …… with hallucinations
F12.259 …… unspecified
F12.28 Cannabis dependence with other cannabis-induced disorder
F12.280 Cannabis dependence with cannabis-induced anxiety disorder
F12.288 Cannabis dependence with other cannabis-induced disorder
F12.29 …… with unspecified cannabis-induced disorder
F12.98 Cannabis use, unspecified with other cannabis-induced disorder
F12.988 Cannabis use, unspecified with other cannabis-induced disorder
F12.99 …… with unspecified cannabis-induced disorder

1.5. Covariates

We incorporated a variety of sociodemographic (e.g., age, gender, race), clinical (e.g., point of origin of the patient to the hospital setting), and geographic variables (e.g., rural) into our model as covariates. Using public data sources (e.g., census data), we constructed additional control variables that reflected state-level factors that could influence the outcome of interest (e.g., substance abuse treatment facilities per million population, percent of the population with a bachelor's degree or higher). Our final logistic regression model included the variables listed in Table 2.

1.6. Statistical analysis

We pooled the SEDD data for each state-year and estimated the proportion of ED visits with CUD, overall, annually, and for each state. We also looked at the proportion of CUD visits by primary, secondary, and tertiary reason for visit/diagnosis. Prevalence was calculated as the proportion of ED visits with a CUD diagnosis among all "treat and release" ED visits.

To estimate the relationship between states' legal status of recreational cannabis and CUD, we first used bivariate analysis. To see if treatment (legal states) and control samples (non-legal states) were similar on covariates, we compared the distributions/means for the explanatory variables by treatment status. We examined the overlap in these proportions' 95 % confidence intervals to determine whether differences were statistically significant.

Next, we used multivariate logistic regression analysis to generate the adjusted odds ratio of CUD when recreational cannabis was legal versus when it was illegal. We controlled for patient characteristics, and, to the extent possible, we controlled for other state-level factors that could influence the outcome of interest (e.g., availability of drug treatment facilities, percentage of the population with a bachelor's degree or higher). The parameter of greatest interest was the coefficient for the first independent variable and reflects the *change in the odds of CUD during a "treat and release" hospital ED visit in a state that has legalized recreational cannabis compared to a state that has not legalized recreational cannabis, holding all else constant*.

Additionally, given that the size of the effect of a change in the independent variable in nonlinear models depends on the values of the other independent variables and the challenge of interpreting odds ratios (Muller and MacLehose, 2014; Norton et al., 2019), we used post-estimation analysis to generate predicted probabilities for each exposure—that is, the predicted probability of CUD by exposure level (legal versus non-legal). By estimating predicted probabilities, we were able to describe the probability of CUD if everyone in the sample lived in a legal state (or illegal state) while the other independent variables were held at their means.

Finally, because we had an unbalanced sample—that is, we had four years of data from three states (CO, MD, OR) but only three years of data from Rhode Island—we felt it prudent to rerun our predicted probabilities using three years of data for all four states.

All analyses were conducted using Stata/MP version 17.0 (StataCorp., 1985–2021) and the study was determined to be exempt by Rutgers Institutional Review Board (IRB; Pro2022001250).

Table 2
Covariates included in the logistic regression model.

Demographic Characteristics	SEDD Variable Name
Age group (12–21, 22–31, 32–41, 42–51, 52–64, 65 +)	AGE
Gender (male, female)	FEMALE
Race/Ethnicity (White non-Hispanic, Black non-Hispanic, Hispanic, Asian or Pacific Islander, Native American, other)	RACE
Primary payor (Medicare, Medicaid, private, self-pay, no charge, other)	PAY1
Metro status (urban, rural)	PL_CBSA
Clinical Characteristics	
Point of origin (non-facility, facility)	PointOfOriginUB04
Population Characteristics	
Substance abuse treatment facilities per million population	NA
Population with a bachelor's degree or higher	NA
Percent rural population	NA
Median household income by quartile	MEDINCSTQ
Year (2017, 2018, 2019, 2020)	NA

2. Results

The pooled sample had 21,623,169 observations. After exclusions (n = 4,188,514), which were detailed in the Inclusion Criteria section, the sample had 17,434,655 ED visits across the four states (CO, OR, MD, RI). The overall proportion of ED visits with CUD was 0.63 % and annual rates ranged from 0.67 % in 2017 to 0.59 % in 2019. State rates were 0.39 % (CO), 0.35 % (OR), 1.03 % (MD), and 0.79 % (RI). There were 10,410 observations that were coded as having CUD as the primary reason for visit/diagnosis (0.07 %), 27,133 as the secondary reason for visit/diagnosis (1.38 %), and 25,012 as the tertiary reason for visit/diagnosis (3.53 %).

2.1. Characteristics of CUD visits

The sample characteristics are described in Table 3. On all characteristics examined, the sample varied by state's legal status for recreational cannabis. For example, compared to ED visits in legal states, a higher proportion of ED visits in non-legal states were from women (56.8 % [95 % CI 56.7, 56.8] versus 55.7 % [95 % CI 55.7, 55.8]) and Blacks (40.9 % [95 % CI 40.9, 41.0] versus 5.9 % [595 % CI 5.9, 5.9]). A lower proportion of ED visits in non-legal states were from non-Hispanics (8.8 % [95 % CI 8.7, 8.8] versus 15.4 % [95 % CI 15.4, 15.5]). Additionally, ED visits in non-legal states had a higher mean ratio of substance abuse treatment facilities per million population (76.1 versus 70.6) and a higher mean percentage of the population with at least a bachelor's degree (40.1 % versus 33.0 %). At the same time, a lower mean percentage of ED visits in non-legal states were from patients living in rural areas (3.2 % [95 % CI 3.2, 3.2] versus 16.9 % [95 % CI 16.9, 16.9]). The proportion of ED visits with CUD was higher in non-legal states than in legal states (1.0 % [95 % CI 1.0, 1.0] versus 0.4 % [95 % CI 0.4, 0.4]).

2.2. Relationship between states' recreational legalization and CUD visits

Results from the logistic regression are presented in Table 4. Based on these results, legalizing cannabis for recreational use was associated with nearly a 50 % decrease in the adjusted odds of CUD (AOR = 0.49, 95 % CI 0.47, 0.52). Other factors were also associated with a decrease in the adjusted odds of CUD—for example, being older, female, Hispanic, private pay or self-pay, having a facility point of origin, or living in a non-metropolitan statistical area (MSA). Being 22–31 years of age, Black, and having a higher median income all increased the adjusted odds of CUD.

2.3. Probability of CUD by State's legal status

The predicted probabilities were 0.24 and 0.49, respectively—this indicates that the probability of CUD is 0.24 if everyone in the sample lived in a legal state and had the mean characteristics of the sample; the probability of CUD is 0.49 if everyone in the sample lived in an illegal state and had the mean characteristics of the sample. (NOTE: As previously noted, we reran the model using only the three years available for all four states (2017–2019). Estimates, which were similar [see Appendix], substantiate the results presented in Table 4).

Table 3
Characteristics of the four state sample of "treat and release" emergency department visits among adults by states' legal status for recreational cannabis, 2017–2020 (N = 17,434,655).

Characteristic	Not Legal for Recreational Cannabis (MD, RI) (7,217,270, 41.4 %) (%, 95 % CI)	Legal for Recreational Cannabis (CO, OR) (10,217,385 58.6 %) (%, 95 % CI)
Demographics		
Age (mean, sd)[1,2]	44.9, 20.2	45.4, 21.0
Age group[1,2]		
12–21	12.5 (12.5, 12.5)	13.4 (13.4, 13.5)
22–31	19.5 (19.5, 19.6)	18.6 (18.6, 18.6)
32–41	16.6 (16.6, 16.7)	16.7 (16.7, 16.7)
42–51	14.1 (14.0, 14.1)	13.3 (13.3, 13.4)
52–64	18.8 (18.8, 18.8)	16.5 (16.5, 16.6)
65+	18.5 (18.4, 18.5)	21.4 (21.3, 21.4)
Gender		
Male	43.2 (43.1, 43.3)	44.3 (44.2, 44.3)
Female	56.8 (56.7, 56.8)	55.7 (55.7, 55.8)
Race/Ethnicity[2]		
White non-Hispanic	45.9 (45.9, 46.0)	72.5 (72.4, 72.5)
Black non-Hispanic	40.9 (40.9, 41.0)	5.9 (5.9, 5.9)
Hispanic	8.8 (8.7, 8.8)	15.4 (15.4, 15.5)
Asian or Pacific Islander	1.5 (1.4, 1.5)	1.7 (1.7, 1.8)
Native American	0.3 (0.3, 0.3)	1.1 (1.1, 1.2)
Other	2.6 (2.6, 2.6)	3.2 (3.2, 3.2)
Primary payer		
Medicare	21.8 (21.8, 21.8)	25.1 (25.0, 25.1)
Medicaid	34.1 (34.1, 34.2)	36.0 (36.0, 36.0)
Private	30.7 (30.7, 30.7)	26.2 (26.2, 26.3)
Self-pay	9.4 (9.4, 9.4)	6.4 (6.3, 6.4)
No charge	0.2 (0.2, 0.2)	0.8 (0.8, 0.8)
Other	3.8 (3.8, 3.8)	5.6 (5.6, 5.6)
Metro status[2,3]		
Rural	3.2 (3.2, 3.2)	16.9 (16.9, 16.9)
Year		
2017	28.0 (28.0, 28.0)	25.7 (25.7, 25.7)
2018	27.5 (27.4, 27.5)	25.9 (25.9, 26.0)
2019	27.0 (26.9, 27.0)	25.9 (25.9, 25.9)
2020	17.6 (17.5, 17.6)	22.4 (22.4, 22.5)
Clinical characteristics		
Length of stay (mean, sd)	0.3, 0.7	0.2, 0.6
Cannabis use disorder[3]	1.0 (1.0, 1.0)	0.4 (0.4, 0.4)
Point of origin[2]		
Non-facility/community	96.1 (96.0, 96.1)	97.6 (97.6, 97.6)
Disposition[2]		
Home	93.2 (93.2, 93.2)	94.4 (94.4, 94.4)
Facility[4]	3.7 (3.6, 3.7)	4.5 (4.5, 4.5)
Left against medical advice	2.9 (2.9, 2.9)	1.0 (1.0, 1.0)
Died	0.2 (0.2, 0.2)	0.1 (0.1, 0.1)
Population characteristics		
Substance abuse treatment facilities per million population (mean, sd)[3]	76.1, 9.1	70.6, 8.7
% population with a bachelors degree or higher (mean, sd)[3]	40.1, 2.6	33.0, 14.1
% rural population (mean, sd)[3]	13.6, 1.9	16.4, 2.7
Median household income by quartile[5]		
1st quartile	38.5 (38.4, 38.5)	34.1 (34.1, 34.2)
2nd quartile	25.3 (25.3, 25.3)	26.9 (26.8, 26.9)
3rd quartile	20.9 (20.9, 20.9)	21.5 (21.5, 21.5)
4th quartile	15.3 (15.3, 15.4)	17.5 (17.5, 17.5)

Source: State Emergency Department Databases (SEDD), Healthcare Cost Utilization Project (HCUP), Agency for Healthcare Research and Quality (AHRQ) from CO, MD, OR (2017–2020) and RI (2017–2019).
CI = confidence interval.
[1] Sample excludes children (<12 years of age).
[2] Excludes missing data.
[3] Based on patient's state of residence.
[4] Includes discharges/transfers to a short-term hospital or inpatient care, designated cancer center for children's hospital, or home care.
[5] Based on patient's zip code.

Table 4
Association between living in a state that legalized recreational cannabis (CO and OR) and cannabis use disorder among "treat and release" emergency department visits by adults, 2017–2020 (N = 14,004,140).

Independent Variable	Adjusted Odds Ratio	95 % Confidence Interval
Legalized Recreational Cannabis (CO and OR)[2]	0.49**	0.46, 0.52
Age group (Ref: 12–21)[1,2]		
22–31	1.06**	1.04, 1.08
32–41	0.71**	0.69, 0.73
42–51	0.45**	0.44, 0.46
52–64	0.30**	0.29, 0.31
65+	0.06**	0.05, 0.06
Gender (Ref: Male)		
Female	0.48**	0.47, 0.49
Race/Ethnicity (Ref: White non-Hispanic)[2]		
Black non-Hispanic	1.72**	1.69, 1.76
Hispanic	0.78**	0.76, 0.80
Asian or Pacific Islander	0.64**	0.59, 0.69
Native American	1.06	0.97, 1.15
Other	1.01**	0.97, 1.05
Primary payer (Ref: Medicare)		
Medicaid	0.92**	0.89, 0.95
Private	0.50**	0.49, 0.52
Self-pay	0.82**	0.79, 0.85
No charge	0.42**	0.37, 0.48
Other	0.42**	0.39, 0.44
Metro status (Ref: urban)[2,3]		
Rural	0.90**	0.88, 0.93
Point of origin (Ref: Non-facility)[2]		
Facility[4]	0.86**	0.82, 0.90
Substance abuse treatment facilities per million population[3]	1.01*	1.00, 1.02
Population with a bachelors degree or higher[3]	1.00	0.97, 1.03
Rural population[3]	1.03**	1.02, 1.04
Median household income by quartile (Ref: 1st)[5]		
2nd	1.02*	1.00, 10.4
3rd	1.09**	1.07, 1.12
4th	1.13**	1.10, 1.15
Year (Ref: 2017)		
2018	0.97*	0.95, 1.0
2019	0.89**	0.86, 0.92
2020	0.97	0.92, 1.02

Source: State Emergency Department Databases (SEDD), Healthcare Cost Utilization Project (HCUP), Agency for Healthcare Research and Quality (AHRQ) from CO, MD, OR (2017–2020) and RI (2017–2019).
** $p \leq 0.01$.
* $p \leq 0.05$.
[1] Sample excludes children (<12 years of age).
[2] Excludes missing data.
[3] Based on patient's state of residence.
[4] Includes discharges/transfers to a short-term hospital or inpatient care, designated cancer center for children's hospital, or home care.
[5] Based on patient's zip code.

3. Discussion

We used the nation's leading source of data on emergency department visits and compared the proportion of ED visits for CUD in two states that had legalized recreational cannabis and two that had not. We found that CUD rates among "treat and release" ED visits were significantly lower in legalized states than in non-legal states—a finding that is counterintuitive. The few, existing studies on this topic have found higher cannabis-related utilization—although not CUD visits—post-legalization. For example, a 2021 study by Masonbrink et al. found that cannabis-related hospitalizations significantly increased following the legalization of recreational cannabis, but the study was focused on adolescents, 11–17 years, who are relatively low utilizers (Masonbrink et al., 2021). A Canadian study of boys aged 10–14 years also found that

cannabis-related hospitalization rates increased from 5.2 per 100,000 before recreational legalization to 9.5 per 100,000 after legalization although the increase was not statistically significant (Auger et al., 2021). Similarly, Wang et al. (2017) found that rates of hospitalization with cannabis-related billing codes more than doubled in Colorado after recreational cannabis legalization. Pottieger et al. (2022) examined the relationship between cannabis diagnoses incidence among hospital inpatients and policy environment, and they had mixed results—that is, in some liberal regions, increases were modest compared to those in less progressive regions. Conversely, Shi (2017), who examined medical cannabis legalization, found no evidence to support a legalization-hospitalization relationship.

As it specifically relates to ED utilization, two studies found an increase in cannabis-related ED visits after the legalization of recreational cannabis, but these researchers limited their examinations to Colorado, and neither study focused on CUD as the outcome of interest (Kim and Monte, 2016; Wang et al., 2017). A Canadian study by O'Brien et al. (2022) found that the number of cannabis-related ED visits significantly increased from 2.56 per 1,000 prior to legalization to 3.56 per 1,000 following legalization for recreational use.

Notably, there have been studies that have demonstrated a decrease in CUD treatment admissions to publicly funded substance use disorder treatment programs following the legalization of recreational cannabis (Bourdon et al., 2021; Mennis and Stahler, 2020; Mennis et al., 2021; Rhee and Rosenheck, 2022). Even so, we believe ours is the first study to find evidence of this same negative, statistically significant association between the legalization of recreational cannabis and CUD among ED visits.

What might predict this relationship? The researchers who have found declining CUD admissions to substance use disorder treatment programs following legalization have hypothesized that decreased stigma and increased social acceptability of cannabis use may explain their findings (Mennis et al., 2021; Rhee and Rosenheck, 2022). If, in states that have legalized cannabis, providers are more tolerant of cannabis use and less likely to recognize problematic behavior associated with CUD (e.g., persistent or recurrent social or interpersonal problems, cravings, withdrawal), they may be less likely to diagnose and document CUD in the medical record. This could account for lower CUD prevalence in the ED in legalized states. If these findings are valid, policymakers could continue to pass recreational cannabis laws—for all the reasons states are enacting such legislation—without risking the public health and/or safety of "treat and release" ED patients.

4. Limitations

Of course, it is possible that our data and/or methods could have introduced bias in our estimates. As indicated, SEDD data do not include ED visits that result in hospitalizations. If differential rates of hospitalization among CUD patients occurred in legalized and non-legalized states, selection bias could have been introduced. For this reason, research, which includes ED visits that result in hospitalizations—using the National Emergency Department Sample (NEDS) (see https://hcup-us.ahrq.gov/nedsoverview.jsp)—would be productive.

Alternatively, our construction of a dichotomous variable for states' legal status could have been imprecise. We know of some heterogeneity in states' laws. Merely as one example, while both Colorado and Oregon are legal for recreational cannabis, larger quantities of cannabis can be purchased in Colorado than in Oregon (Ketchum, 2016). If this heterogeneity existed and influenced CUD outcomes, our binary variable would be insufficient to detect relevant trends and/or variations.

Additionally, we examined the proportion of adult, "treat and release" ED visits for CUD rather than CUD prevalence, which would include the total, at-risk population. If Colorado and Washington, which were legal for recreational marijuana, were also differentially subjected to some other phenomena that caused a dramatic increase in ED visits for a different cause (e.g., influenza outbreak), the proportion of CUD visits would be lower in those states than in Maryland and Rhode Island. The nature of the SEDD data did not allow us to calculate true prevalence rates.

Furthermore, while our dataset included four state-years, we did not possess data for the pre-treatment periods in either Colorado or Oregon. This prevented us from exploring causal inferences. For this reason, we recommend expanding the number of years of data to ensure the inclusion of observations from the pre-treatment periods in both states and using methodological approaches such as differences-in-differences. While this would require at least 10 years of data, it would enable the approximation of causal relationships.

Along with these recommendations, we suggest that our analyses be repeated using alternative sources of primary and/or secondary data as well as in alternative care settings. As it relates to the former, replication using the National Hospital Ambulatory Medical Care Survey (NHAMCS) may be particularly useful; as it relates to the latter, the relationship between recreational cannabis laws and CUD visits in physician offices and inpatient settings should be prioritized.

Finally, given our counterintuitive results, qualitative research that explores ED clinicians' attentiveness to CUD and willingness to document it by policy environment could be very illuminating.

5. Conclusion

Using SEDD from four states—Colorado, Oregon, Maryland, and Rhode Island—we examined the prevalence of CUD among "treat and release" emergency department visits. Our findings, which demonstrate lower rates of CUD in states that enacted and implemented recreational cannabis laws (CO and OR) compared to those that did not (MD, and RI), could inform policymakers' actions—i.e., recreational cannabis laws may not place public health and safety at risk; however, given the counterintuitive nature of our findings, we recommend additional research and exploration of the CUD-legalization relationship be pursued in EDs and other care settings.

Declaration of Competing Interest

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

Data availability

The authors do not have permission to share data.

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Appendix:. Association between living in a state that has legalized recreational cannabis and cannabis use disorder among "treat and release" emergency department visits, 2017–2019 (N = 10,622,211)

Independent Variable	Adjusted Odds Ratio	95 % Confidence Interval
Legalized Recreational Cannabis[2]	0.53**	0.49–0.58
Age group (Ref: 12–21)[1,2]		
22–31	1.04**	1.01–1.06
32–41	0.70**	0.69–0.72
42–51	0.45**	0.43–0.46
52–64	0.31**	0.30–0.32
65+	0.06**	0.06–0.07
Gender (Ref: Male)		
Female	0.47**	0.46–0.48
Race/Ethnicity (Ref: White non-Hispanic)[2]		
Black non-Hispanic	1.67**	1.64–1.71
Hispanic	0.77**	0.74–0.79
Asian or Pacific Islander	0.64**	0.59–0.70
Native American	1.00	0.92–1.11
Other	1.03	0.98–1.08
Primary payer (Ref: Medicare)		
Medicaid	0.90**	0.87–0.93
Private	0.49**	0.47–0.51
Self-pay	0.81**	0.77–0.84
No charge	0.44**	0.39–0.51
Other	0.37**	0.35–0.40
Metro status (Ref: urban)[2,3]		
Rural	0.94**	0.91–0.97
Point of origin (Ref: Non-facility)[2]		
Facility[4]	0.98	0.92–1.03
Substance abuse treatment facilities per million population[3]	1.01	1.00–1.03
Population with a bachelors degree or higher[3]	1.00	0.96–1.04
Rural population	1.02**	1.00–1.04
Quartile of the estimated median household income (Ref: 1st)[5]		
2nd	0.98	0.96–1.00
3rd	0.98	0.96–1.01
4th	1.04**	1.02–1.08
Year (Ref: 2017)		
2018	0.99	0.96–1.01
2019	0.92**	0.89–0.95

Source: State Emergency Department Databases (SEDD), Healthcare Cost Utilization Project (HCUP), Agency for Healthcare Research and Quality (AHRQ) from CO, MD, OR and RI (2017–2019).

[1]Sample excludes children (<12 years of age).

[2]Excludes missing data.

[3]Based on patient's state of residence.

[4]Includes discharges/transfers to a short-term hospital or inpatient care, designated cancer center for children's hospital, or home care.

[5]Based on patient's zip code.

** $p \leq 0.01$.

* $p \leq 0.05$.

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