

Research Paper

Cannabis decriminalization: A study of recent policy change in five U.S. states



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ABSTRACT

Background: A number of public health professional organizations support the decriminalization of cannabis due to adverse effects of cannabis-related arrests and legal consequences, particularly on youth. We sought to examine the associations between cannabis decriminalization and both arrests and youth cannabis use in five states that passed decriminalization measures between the years 2008 and 2014: Massachusetts (decriminalized in 2008), Connecticut (2011), Rhode Island (2013), Vermont (2013), and Maryland (2014).

Methods: Data on cannabis possession arrests were obtained from federal crime statistics; data on cannabis use were obtained from state Youth Risk Behavior Survey (YRBS) surveys, years 2007–2015. Using a “difference in difference” regression framework, we contrasted trends in decriminalization states with those from states that did not adopt major policy changes during the observation period.

Results: Decriminalization was associated with a 75% reduction in the rate of drug-related arrests for youth (95% CI: 44%, 89%) with similar effects observed for adult arrests. Decriminalization was not associated with any increase in the past-30 day prevalence of cannabis use overall (relative change = −0.2%; 95% CI: −4.5%, 4.3%) or in any of the individual decriminalization states.

Conclusions: Decriminalization of cannabis in Massachusetts, Connecticut, Rhode Island, Vermont, and Maryland resulted in large decreases in cannabis possession arrests for both youth and adults, suggesting that the policy change had its intended consequence. Our analysis did not find any increase in the prevalence of youth cannabis use during the observation period.

Introduction

In 2015, the Committee on Substance Abuse and Adolescence of the American Academy of Pediatrics (AAP) issued an updated policy statement and accompanying technical report on cannabis and cannabis policy (American Academy of Pediatrics Committee on Substance Abuse, & American Academy of Pediatrics Committee on Adolescence, 2004; Ammerman, Ryan, Adelman, & American Academy of Pediatrics Committee on Substance Abuse, 2015). As with their 2004 policy statement, the AAP remained opposed to the commercial legalization of recreational or medical cannabis (Joffe & American Academy of Pediatrics Committee on Substance Abuse, & American Academy of

Pediatrics Committee on Adolescence, 2004). However, the committee supported decriminalization and encouraged its members to advocate for policies that prevent harsh criminal penalties for the use or possession of cannabis by youth. Among the reasons for this change in position, the AAP cited the overrepresentation of minority youth among those who incur criminal penalties, the consequences of carrying a criminal record, the loss of educational and employment opportunities, and less obvious effects such as the trauma associated with arrest and short-term detention, even in the absence of criminal conviction. With this updated policy statement, the AAP joined several other public health-oriented organizations in expressing opposition to punitive approaches to address cannabis use, including the American Public Health

Abbreviations: AAP, American Academy of Pediatrics; CDC, Centers for Disease Control and Prevention; CI, confidence interval; OR, odds ratio; UCR, Uniform Crime Reporting; YRBS, Youth Risk Behavior Survey

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Association and the American Academy of Family Physicians (American Academy of Family Physicians, 2016; American Public Health Association, 1970).

A number of U.S. states reduced penalties for cannabis possession during the 1970s, with some reclassifying possession of small amounts as a civil, rather than criminal, offense. Although it might seem obvious that reclassification of cannabis possession to a non-criminal offense would lead to reductions in the number of cannabis-related arrests, this is not necessarily the case. In a 2005 analysis, Pacula et al. found that states that had reclassified possession of small amounts of cannabis to a civil offense during the 1970s had similar arrest rates to states that retained criminal status for possession (Pacula et al., 2005). One interpretation of this observation is that enforcement of cannabis laws is only weakly related to statutory cannabis policy, in which case changes in policy may not lead to changes in arrest rates (Caulkins, Kilmer, & Kleiman, 2016). It may be that individual criminal justice actors' behaviors remain committed to former approaches even in the presence of significant policy change (Lynch, 1998).

Opposition to decriminalization might stem from concerns about potential unintended consequences, namely, increases in the prevalence of cannabis use and related problems, particularly among youth (DuPont & Voth, 1995; Sabet, 2007). Such concerns arise from a potential decrease in willingness of both police and others to admonish cannabis use and an increase in motivation for young people to use as norms against use are removed. These factors are key components to theories of opportunity for crime and deviance (Cohen & Felson, 1979). However, reviews of the literature on state cannabis policy liberalization measures that were implemented in 11 U.S. states during the 1970s—which are commonly but in some cases incorrectly labeled “decriminalization”—found little or no increase in cannabis use associated with the passage of more lenient policies that relaxed criminal penalties for possession of small amounts of cannabis (Johnston, 1981; Maloff, 1982; Saveland & Bray, 1981; Single, 1989). On the other hand, Pacula et al. later pointed out that these studies did not account for the heterogeneity among the policy changes that occurred during this period (Pacula, Chriqui, & King, 2003). For example, two of the states that relaxed penalties still classified possession as a misdemeanor, and several others reduced penalties only for first offenders. By treating 11 separate state policy changes as homogenous, early analyses may have missed differences between states that implemented substantial reductions in penalties and those that implemented more incremental changes. In their more detailed examination of between-state differences in cannabis policy, Pacula et al. found that—in a cross-sectional analysis—severity of penalties was negatively associated with 30-day prevalence of cannabis use among youth, suggesting that decriminalization or reduction of criminal penalties for cannabis possession might lead to increased youth cannabis use (Pacula et al., 2003).

In recent years, a number of U.S. states have reclassified the possession of small amounts of cannabis as a civil offense, regardless of first-offender status, meeting the generally accepted definition of decriminalization. We are aware of only one study of any recent decriminalization measures, and that study suggested that decriminalization might lead to increased rates of cannabis use among high-school students. Miech et al. (2015) focused on the state of California, which reclassified possession of 1 ounce or less of cannabis from a misdemeanor to a civil offense. Data from the school-based Monitoring the Future survey showed that decriminalization was associated with a concomitant elevation in 30-day prevalence of cannabis use for 12th graders, but not for 8th or 10th grade students. The investigators argued that there may have been an age-dependent response to media coverage and public discussion of the decriminalization measure that occurred prior to its passage. In other words, the changes in social norms accompanying change in policy may have “sent a signal” about public approval and perceived safety to which that cohort was particularly responsive. Thus, that finding presents a further challenge to earlier literature concluding that decriminalization or reduction of criminal

penalties are unlikely to increase cannabis use rates among youth (Caulkins et al., 2016; Johnston, 1981; MacCoun & Reuter, 2001; Maloff, 1982; Single, 1989).

The international literature on decriminalization is more consistent with earlier U.S. findings that use rates are largely unaffected by reductions or elimination of criminal penalties for cannabis use. In perhaps the most well-known case, MacCoun and Reuter (MacCoun & Reuter, 2001; MacCoun, 2011) argued that cannabis use in the Netherlands fell during a period of depenalization and limited *de facto* legalization, and only rose with commercialization. Similar conclusions regarding use rates were also reached in comparisons of trends in the Netherlands to those in the United States and Canada (Reinarman, Cohen, & Kaal, 2004; Simons-Morton, Pickett, Boyce, ter Bogt, & Vollebergh, 2010). Studies of the decriminalization of all drugs in Portugal found decreasing youth cannabis use rates and substantial reductions in drug arrests (Hughes & Stevens, 2010). Studies of decriminalization in the Czech Republic also noted no evidence that the policy affected age of cannabis initiation (Červený, Chomynová, Mravčík, & van Ours, 2017). Finally, in an analogous example to that of states in the United States, Australian states that decriminalized cannabis did not experience increases in use among adolescents compared to states that had not (Donnelly, Hall, & Christie, 2010; Williams, 2004). However, a more recent study of policy changes within Australia suggested that decriminalization may shift cannabis initiation to younger ages, but that this effect fades about five years after implementation (Williams & Bretteville-Jensen, 2014).

The objective of this study is to evaluate both the intended and unintended consequences of cannabis decriminalization policies in five states that downgraded sanctions for possession of small amounts of cannabis from a criminal to a civil offense between 2008 and 2014: Massachusetts, Connecticut, Vermont, Rhode Island, and Maryland. Prior to the change, each of the five decriminalization states imposed a fine and possible jail time, though probation and eventual sealing of criminal records were possible in some cases. Following adoption of the decriminalization policies, the penalty for possession in each state for first and subsequent offenses was reduced to comparatively small fines.

Our first goal was to examine whether the policy change in these states led to reductions in arrest rates for both adults and minors. The purpose of these analyses was to assess whether the change in policy led to a reduction in criminal arrest rates as intended, and also to highlight any effects of the policy changes on youth arrest rates, thereby examining whether this recent wave of decriminalization was beneficial by the standards of the AAP and other bodies that have expressed concern about the consequences of criminalization and cannabis-related arrests for youth (American Academy of Family Physicians, 2016; Joffe & American Academy of Pediatrics Committee on Substance Abuse, & American Academy of Pediatrics Committee on Adolescence, 2004; American Public Health Association, 1970). Additionally, we sought to determine whether the policy change in these states may have had unintended consequences in the form of increased prevalence of cannabis use among youth in the period following decriminalization, which ranged from one to six years for the period under study.

Methods

Overview

Data on arrests for cannabis possession were from the Uniform Crime Reporting statistics collected by the U.S. Federal Bureau of Investigation. Data on youth cannabis use were collected from the school-based Youth Risk Behavior Survey. Both of these data sources are described in greater detail below. For both outcomes, we utilized a difference-in-difference regression framework in which outcome variables were modeled as a function of policy, with state and year dummy variables included as covariates. In this manner, policy regression coefficient estimates reflect the change in the mean level of the

outcome variable in relation to change in policy. In other words, effect estimates are based on within-state variation in outcome in relation to change in policy while taking into account temporally invariant state characteristics as well as national trends (Angrist & Pischke, 2008). For our primary analyses, we treat decriminalization as a binary policy variable. But decriminalization policies may be heterogeneous (Pacula et al., 2003), and therefore effect sizes may vary by state. Accordingly, in addition to primary analyses, subsidiary analyses were conducted in which each decriminalization state was separately contrasted with control states.

Policy comparisons

Decriminalization states were initially identified using a summary of state cannabis policies from the [Marijuana Policy Project \(2017\)](#). We verified that these policies were passed and implemented using the NexisUni criminal justice database. We also examined the pre- and post-decriminalization policy details and abstracted the penalties before and after decriminalization, the maximum quantities at which possession is considered a civil offense, and the policy implementation dates.

To focus specifically on states that implemented decriminalization policies during the observation period, we excluded from the analysis states that legalized cannabis for recreational use prior to 2015. We also excluded California, which decriminalized cannabis possession in 2010, but does not administer a state YRBS. The state of New York was excluded due to changes in enforcement policies in New York City (See Supplementary Table 1). Additional states were excluded from the cannabis use analyses, but not the arrest analyses, because prior work suggests that cannabis use prevalence is correlated with severity of some types of penalties (Pacula et al., 2003). Therefore, we excluded states that changed penalties for the lowest level of cannabis possession offenses during the study period. In some cases, penalties were increased by raising or updating fines. In other cases, penalties were decreased, but possession remained a criminal offense. Minnesota and Hawaii were excluded because state YRBS data were not available. States included and excluded from the cannabis use analyses are enumerated in Supplementary Table 1. For all states included in the cannabis use analyses, we verified that the penalties were the same at the beginning and end of the study period. This was done by examining the text of the policies in the NexisUni Criminal Justice Database. These penalties are summarized in Supplementary Table 2. After exclusions, we analyzed data from 5 decriminalization states and 27 non-decriminalized control states.

We did not exclude states that adopted medical cannabis policies because medical cannabis programs implemented during the 2007–2015 period have generally had low enrollment rates compared to older programs and have not been shown to impact cannabis use rates among youth. (Pacula & Smart, 2017; Williams, Olfson, Kim, Martins, & Kleber, 2016). Instead, we included a medical cannabis policy indicator among our set of potential state covariates, described below.

Independent variable specification

The decriminalization variable was coded as binary for both the arrest and cannabis use analyses with fractional values used during transition years (e.g., Rhode Island was coded as 0.75 because the policy went into effect on 4/1/2013). Because YRBS does not include exact date of interview, it is possible that policy exposure was misclassified for states that changed policy mid-year. For example, it is possible that the Rhode Island YRBS was administered in early 2013, prior to implementation, or in the fall of 2013, after implementation. The situation is similar for Connecticut and Vermont, which implemented their policies mid-year. Thus, we conducted a series of robustness checks in which we assumed that all interviews in a given

state were completed prior to decriminalization (indicator = 0) or that all interviews were completed after decriminalization (indicator = 1). We did this for all eight combinations of 0/1 values across the three states.

State arrests for Cannabis Possession

County-level data on cannabis possession for years 2007–2015 were obtained from the Uniform Crime Reporting (UCR) Data series maintained by the Inter-University Consortium for Political and Social Research maintained at the University of Michigan ([Institute for Social Research, 2015](#)). The UCR program is maintained by the Federal Bureau of Investigation and compiles crime statistics from more than 18,000 law enforcement agencies and is considered a complete census of arrests ([Federal Bureau of Investigation, 2014](#)). Uniform reporting is maintained by providing the agencies with a handbook detailing specific codes for crime offenses. We extracted arrest data from the “Arrests by age, sex, and race” data files, which compile the number of arrests by agency for specific offenses in various demographic categories. We compiled the number of arrests for cannabis possession by state and year for individuals 18 and under, and separately for adults over 18. We used this age cutoff because it is a common demarcation in reporting crime statistics. To convert numbers of arrests into arrest rates, we used population data from the “Surveillance, Epidemiology, and End Results” (SEER) program maintained by the National Cancer Institute, which curates annual estimates from the U.S. Census Bureau (“[Survey of Epidemiology and End Results \(SEER\) Survey of Epidemiology and End Results \(SEER\) U.S. State and County Population Data \(2018\)](#)”).

State youth risk behavior survey data

De-identified individual-level data on cannabis use were obtained from state Youth Risk Behavior Survey (YRBS) surveys, years 2007–2015. The YRBS is one of the primary sources of information about youth risk behavior in the United States. State YRBS surveys are conducted every two years to examine trends in substance use and other health risk behaviors among 9th–12th grade students. Most state surveys are administered in the spring, though there is some variability in the timing (Kann et al., 2016). The YRBS utilizes a two-stage cluster sampling process to provide representative samples within states, with schools first selected with probability proportional to school size and classes randomly selected within those schools. After obtaining parental permission, classroom surveys are administered through self-administered questionnaires. Survey participation is anonymous and voluntary. State surveys using the two-stage design with a response rate of $\geq 60\%$ are weighted to adjust for student and demographic variables. We used data from all states that met the weighting criteria. Data were obtained from the CDC and from individual state agencies. The total sample size for 2007–2015 YRBS data for states included in the study for 2007–2015 was 622,848. Sample sizes varied widely by state, with state sample sizes ranging from 2975 (Iowa) to 115,473 (Maryland). Individual administrations (state-year units) ranged from $n = 1035$ to $n = 55,596$. Additional details on YRBS survey methods are published elsewhere (Brener et al., 2013).

Cannabis use over the past 30 days was queried with the item: “During the past 30 days, how many times did you use marijuana?” Multiple-choice response options included: 0 times, 1 or 2 times, 3–9 times, 10–19 times, 20–39 times, 40–99 times, and 100 or more times. We collapsed the response options for past-month cannabis use frequency to: “0 times” as reference, “1–2 times,” “3–9 times,” and “10 or more times.” Age was recoded to ≤ 12 to 14 years, 15–16 years, and 17 to ≥ 18 years. (Age range for typical U.S. high school trajectory is 14–18; however, advanced students may be younger and students who fail a grade may be older). Race/ethnicity categories were combined into White, Black, Hispanic, and others.

Table 1

Pre- and post-decriminalization policies in the five decriminalization states (Massachusetts, Connecticut, Rhode Island, Vermont, and Maryland) and the two that adopted decriminalization in 2016 (Delaware and Illinois).

State	Pre-Decriminalization		Post-decriminalization		Effective	Amount (grams) ^b	Citations
	Fine ^a	Jail (Max.)	Fine	Youth Provision			
Massachusetts ^c	\$500	6 months	\$100	Yes, < 18	December 4, 2008	28	ALM GL ch. 94C, § 32L ALM GL ch. 94C, § 32M ALM GL ch. 94C, § 34
Connecticut	\$1,000	1 year	\$150	No	July 1, 2011	14	Conn. Gen. Stat. §21a-279, Conn. Gen. Stat §21a-279a
Rhode Island	\$200-\$500	1 year	\$150 ^d	Yes, < 18	April 1, 2013	28	R.I. Gen. Laws § 21-28-4.01
Vermont	\$600	6 months	\$200	Yes, < 21	July 1, 2013	28	18 V.S.A. § 4230a–d
Maryland	\$500	90 days	\$100	Yes, < 21	October 1, 2014	10	Md. Crim. Code Ann. § 5-601
<i>Decriminalized in 2016</i>							
Delaware	\$575	3 months	\$100	Yes, < 21	December 18, 2015 ^e	28	16 Del. C. § 4764
Illinois	\$1500	6 months	\$200	No	July 29, 2016	10	720 ILCS 550/4

^a Maximum fines were specified, with the exception of Rhode Island, which specified both minimum and maximum fines.

^b Maximum amount under which possession is considered to be “for personal use.”

^c Massachusetts legalized cannabis in 2017, though commercial sales were postponed until 2018.

^d Frequent offenders (3 citations in an 18-month period) may be sentenced to jail time.

^e Delaware implemented decriminalization in the final weeks of 2015, but because state YRBS data are generally collected in the Fall and Spring, we consider Delaware to be a non-decriminalization state for 2015.

Statistical analysis

Arrest Rates. In graphical analyses, we plotted time-trends in the cannabis possession arrests rates for individuals 18 and under in the decriminalization states and compared those to the non-decriminalization states. For regression analyses, we analyzed the logarithms of arrest rates for both the 18 and under and 19 and over age groups. We report the proportional change in arrest rates, which is derived from the exponentiated regression coefficient: $p = \exp(\beta) - 1$. In addition to decriminalization policy indicators, state and year dummy variables were included in the model and a series of state-level covariates were considered for inclusion in extended models. We only included state-level covariates that were associated with the dependent variable after adjusting for state and year effects using a p-value threshold of $p < 0.1$. We did this to ensure that only potential confounding variables were incorporated into the model, because the inclusion of covariates that are not associated with the dependent variable can decrease precision of estimates (Austin, 2011). Final state-level covariates included demographic characteristics (percentage of individuals in various age and race/ethnicity groups), economic characteristics (per-capita income, average annual unemployment rate, poverty rate, percentage of population with a college degree), a measure of citizen political ideology, and the number of police officers per 10,000 residents. These covariates, data sources, and covariates considered but not included in final models are described more fully in Supplementary Table 3.

Analyses were conducted in SAS version 9.4 using the “PROC SURVEYREG” procedure to specify state-level clustering and thereby account for correlation among residuals within states in estimating standard errors (Angrist & Pischke, 2008; Arellano, 1987; Bertrand, Duflo, & Mullainathan, 2004). Each state-year observation was weighted by the state population for that year; the 18 and under population was used for the youth arrest rate analyses and the 19 and over population was used for the adult arrest rate analyses.

Statistical analysis: Cannabis use

Graphic analyses contrasted trends in the past-30 day prevalence of cannabis use in the combined decriminalization states compared to the control states and then in each individual decriminalization state contrasted with control states. Log-linear regression was used to model cannabis use as a function of decriminalization policy, adjusting for state and year fixed effects, as above. Individual-level demographic variables (age, sex, and race) were incorporated into all models, and

extended models incorporated state-level covariates. As with the arrest-rate analyses, state-level covariates were screened for association with the dependent variable and incorporated into extended models if they were associated (See Supplementary Table 3). Final state-level variables included per capita income, poverty rate, unemployment rate, and number of police per capita. For policy-by-demographic interaction tests, which require a reasonably large number of observations in each state-year-demographic cell, we opted to combine minority groups to ensure adequate numbers. Specifically, race/ethnicity was categorized as a binary non-Hispanic White vs. non-white; this decision was made because some specific race/ethnicity categories are severely under-represented in some states. Analyses were conducted in STATA using survey procedures to account for state-level clustering and sampling weights. The regression coefficient from log-linear models corresponds to the logarithm of the risk ratio (RR) for decriminalization relative to criminalization, which was converted to proportional change (RR-1).

To examine whether decriminalization might lead to delayed increases in cannabis use, we conducted a “lag” analysis in which the decriminalization variable for each state was assigned to the value that it had one period (two years) earlier. To consider the possibility that policy adoption might accompany changes in social norms that lead to increased prevalence of cannabis use among youth, and that these changes might occur prior to policy implementation, we conducted a “lead” analysis in which the decriminalization indicator was similarly assigned the value that it had one period later. The lead analyses included Delaware and Illinois as decriminalization states because they implemented decriminalization in 2016 (see Results, Table 1). Likewise, in the lag analysis, Maryland is not counted among the policy-change states because its policy was not implemented until 2015. Finally, we modeled cannabis use frequency (rather than prevalence) in relation to decriminalization policies using multinomial logistic regression. In this case, the outcome variable was frequency of past-month using the frequency categories described above in the YRBS description, and the independent variables and covariates were the same as used from prevalence analyses.

Results

Decriminalization policy summaries

Table 1 summarizes policies in the five decriminalization states and in two states that decriminalized after the period under study but that are included in “lead” analyses. The maximum penalties in all seven of

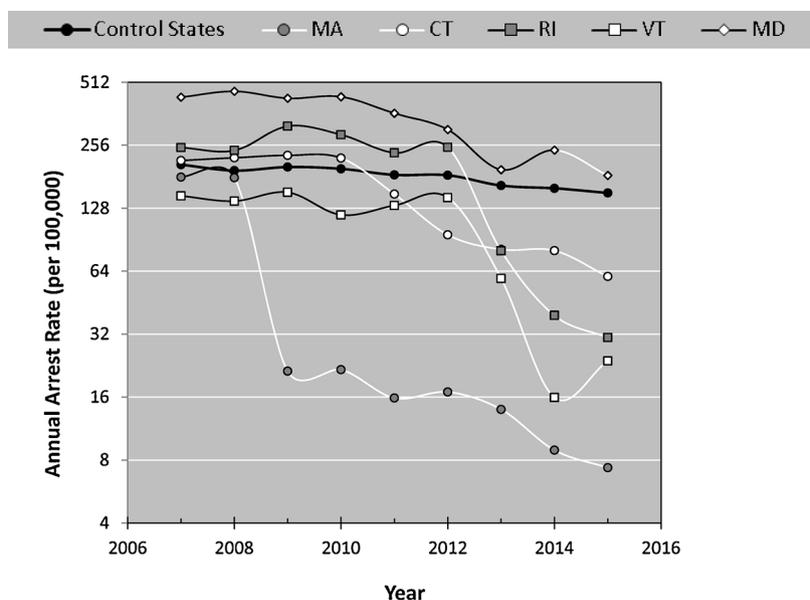


Fig. 1. Youth arrest rates for cannabis in each of the five decriminalization states compared with combined control states.

these states prior to decriminalization included imprisonment and maximum fines ranging from \$500 to \$1500 dollars. While some states had provisions for probation and record expungement under certain circumstances, imprisonment and a criminal record were possible for some offenders. In each case, decriminalization eliminated the possibility of imprisonment, and fines were reduced. Importantly, possession of amounts for personal use was specified as a civil offense in each state, and this applied to first and subsequent offenses. Only in one state (Rhode Island) was there a possibility of imprisonment for multiple offenses, and only if they occurred within a specified time frame.

Arrests for Cannabis Possession

The annual arrest rates for cannabis possession for individuals 18 and under are plotted in Fig. 1, with rates from each decriminalization state plotted separately and the combined control states plotted as a single trend line. In 2007, before any of the states analyzed here had implemented decriminalization, arrest rates per 100,000 ranged from 180 to 250. By 2015, arrest rates in control states declined by about 25%, whereas arrest rates in all decriminalization states declined by 50% or more.

Results of linear regression models for both youth and adult arrest rates are summarized in Table 2; models controlling only for state and year fixed effects as well as models controlling for time-varying state-level covariates were estimated. Table 2 lists only the association between decriminalization and arrest rate, expressed as proportional change in arrests; full regression model parameters for the extended model are provided in Supplementary Tables 4 and 5. The arrest rate for cannabis possession declined by 75% in decriminalization states for youth and 78% for adults, and estimates changed minimally after the addition of state-level covariates. There was substantial variation in the magnitude of the decline by state. The largest declines of about 90% were observed in Massachusetts and the smallest were observed in Maryland: on the order of 40% for youth and slightly less for adults. All results were statistically significant at the $p < .05$ threshold (most $p < .001$) with the exception of Vermont adults, for which the estimate was comparable to that for other states but wide confidence intervals may have resulted from the low population.

YRBS sample demographics (Cannabis use analyses)

Unweighted sample demographics for the state YRBS samples are

presented in Table 3. Note that state surveys are conducted independently, so some states are comparatively over-represented. As a result, those living in states that decriminalized during the observation period comprised 36% of the unweighted sample, while participants from control states comprised the remaining 64%. Other demographic characteristics are represented in approximate proportion to the composition of the population.

Table 3 also describes the prevalence of past-month cannabis use, which was 20.3% overall, and the prevalence of regular use, defined as 10 or more times in the past 30 days, which was 8.5%. Notably, both figures were higher in the decriminalized states than in the control states, though Maryland was similar to the non-decriminalized states in all-year prevalence.

Cannabis use

Trends in past-month cannabis use from 2007 to 2015 are plotted in Fig. 2a, with each decriminalization state plotted separately and contrasted with the aggregated control states. In Fig. 2b, aggregate prevalence estimates from the five decriminalization states are contrasted with those from control states. Although cannabis use prevalence was higher in decriminalization states for all years, this was true prior to the implementation of decriminalization, and trends from the two groups of states were very similar over the observation period.

Regression modeling results for past-month cannabis use as a function of state decriminalization policy are summarized in Table 4; full regression model parameters for the extended model are provided in Supplementary Tables 4 and 5. Decriminalization was not significantly associated with past-30 day cannabis use in either the basic model or the model adjusted for state-level covariates; in fact, the estimated association between cannabis use prevalence and decriminalization was very close to zero (-0.002; 95% CI: -0.045, 0.043; $p = 0.91$). However, there was significant heterogeneity in the effect sizes. Specifically, a model in which effect sizes were estimated separately for each decriminalization state (i.e., by specifying decriminalization policy indicators for each decriminalization state) exhibited a better fit than the model in which a single effect size was assumed for each state ($Wald-\chi^2 = 62, df = 4, p < .001$). Thus, Table 4 also lists the state-specific associations between decriminalization policy and prevalence of cannabis use. In the model that allowed for heterogeneous effects, there were no significant positive associations between decriminalization and cannabis use. However, the regression coefficient for Rhode

Table 2
Association between cannabis decriminalization and arrest rates for cannabis possession by youths and adults.

Decriminalization policy effects	Model I ^a Proportional Change ^b (95% CI)	Model II Proportional Change (95% CI)
Youth (≤ 18) Arrests		
All Decriminalized States	−0.75 (−0.91, −0.34)	−0.75 (−0.89, −0.44)
Massachusetts Only	−0.90 (−0.92, −0.89)	−0.90 (−0.92, −0.87)
Connecticut Only	−0.53 (−0.60, −0.45)	−0.51 (−0.68, −0.27)
Rhode Island Only	−0.80 (−0.82, −0.78)	−0.79 (−0.85, −0.71)
Vermont Only	−0.45 (−0.65, −0.15)	−0.53 (−0.74, −0.14)
Maryland Only	−0.35 (−0.40, −0.30)	−0.42 (−0.59, −0.18)
Adult (> 18) Arrests		
All Decriminalized States	−0.76 (−0.90, −0.45)	−0.78 (−0.89, −0.52)
Massachusetts Only	−0.89 (−0.90, −0.87)	−0.89 (−0.92, −0.85)
Connecticut Only	−0.66 (−0.72, −0.60)	−0.70 (−0.81, −0.51)
Rhode Island Only	−0.77 (−0.80, −0.75)	−0.80 (−0.86, −0.72)
Vermont Only	−0.46 (−0.76, 0.22)	−0.56 (−0.83, 0.15) ^c
Maryland Only	−0.25 (−0.33, −0.18)	−0.35 (−0.56, −0.05)

Notes: This table lists only the association between decriminalization and arrest rate. See Supplementary Tables 4 and 5 for full covariate listing.

^a Model I incorporates only state and year fixed effects as covariates. Model II incorporates additional state-level covariates that were associated with the dependent variable in fixed effects models.

^b Proportional change derived from regression coefficient (exp(β)-1).

^c Not statistically significant at conventional threshold (p < 0.05).

Table 3
State YRBS sample demographics and the weighted prevalence of past-month cannabis use.

	N (Unweighted)	% of Sample (Unweighted)	Prevalence of Cannabis Use	
			Any	≥ 10 Times
By State				
All Decriminalized States	216,085	40.8	23.4 (22.7, 24.0)	9.6 (9.1, 10.1)
Massachusetts	13,964	2.6	25.8 (24.7, 26.9)	11.1 (15.4, 11.9)
Connecticut	11,035	2.1	23.0 (22.1, 24.1)	8.9 (8.1, 9.6)
Rhode Island	14,384	2.8	24.7 (23.2, 26.3)	10.3 (9.3, 11.2)
Vermont	65,138	12.3	23.9 (22.8, 25.0)	10.8 (11.1, 11.5)
Maryland	111,114	21.0	20.5 (19.4, 21.6)	8.1 (7.2, 8.9)
Control States	313,913	59.2	19.9 (19.5, 20.2)	8.4 (8.2, 8.6)
By Sex				
Male	269,220	50.8	17.9 (17.6, 18.3)	17.9 (5.9, 0.1)
Female	260,778	49.2	22.6 (22.2, 22.9)	22.6 (11.1, 0.1)
By Age				
≤ 14	72,632	13.7	12.6 (12.1, 13.2)	4.8 (4.4, 5.1)
15-16	279,527	52.7	18.2 (17.9, 18.6)	7.1 (6.9, 7.3)
17-18	177,839	33.6	25.0 (24.5, 25.6)	11.4 (11.1, 11.7)
By Race				
White	309,041	58.3	21.5 (21.1, 22.0)	9.0 (8.8, 9.3)
Non-White	220,957	41.7	19.3 (18.9, 19.7)	8.1 (7.9, 8.4)
TOTAL	529,998	100.0	20.3 (20.0, 20.6)	8.5 (8.3, 8.0)

Island was significantly less than zero and suggested a potential 4% decrease in cannabis use (p = 0.001).

Interactions between the unitary decriminalization indicator, i.e., modeling a homogenous effect across states, and demographic variables were all non-significant: for sex, Wald-χ² = 0.02, df = 1, p = 0.89; for age category, Wald-χ² = 2.4, df = 2, p = 0.30, and for race/ethnicity Wald-χ² = 0.01, df = 1, p = 0.97. These results suggest that there are no major sub-group differences in the association between cannabis use and decriminalization.

The absence of exact interview date in YRBS creates uncertainty about policy exposure in the three states that implemented policy mid-year during YRBS years. Thus, we examined the degree to which the decriminalization regression coefficient changed under the assumptions that all students took the YRBS either before or after decriminalization in each state. This results in eight combinations of alternative indicators, and the estimates from specifications for each set are summarized in Supplementary Table 7. The range for the coefficients (cast as proportional change) was very narrow, ranging from -0.004 (95% CI: -0.043, 0.038) to 0.000 (-0.041, 0.043), which are very close to the

values for the original estimate.

Results of the lead analysis, which examines the possibility of changes in cannabis use prior to policy implementation, are also summarized in Table 4. The coefficient indicated a significant negative or protective association consistent with a decrease in cannabis use of about 6% (p = .008). Results of the lag analyses, in which policy variables were lagged by one period to examine the possibility of delayed associations between decriminalization policies and cannabis, are also listed in Table 4. This association was also negative (-0.03), but not significant at conventional levels (p = .07). Finally, we conducted a multinomial logistic regression analysis in which the dichotomous past-30 day use variable was replaced with a 4-level frequency-of-use variable. There were no significant associations between decriminalization and any level of cannabis use (Table 5).

Discussion

Between 2009 and 2014, five north and central-eastern states in the United States removed criminal penalties for possession of small

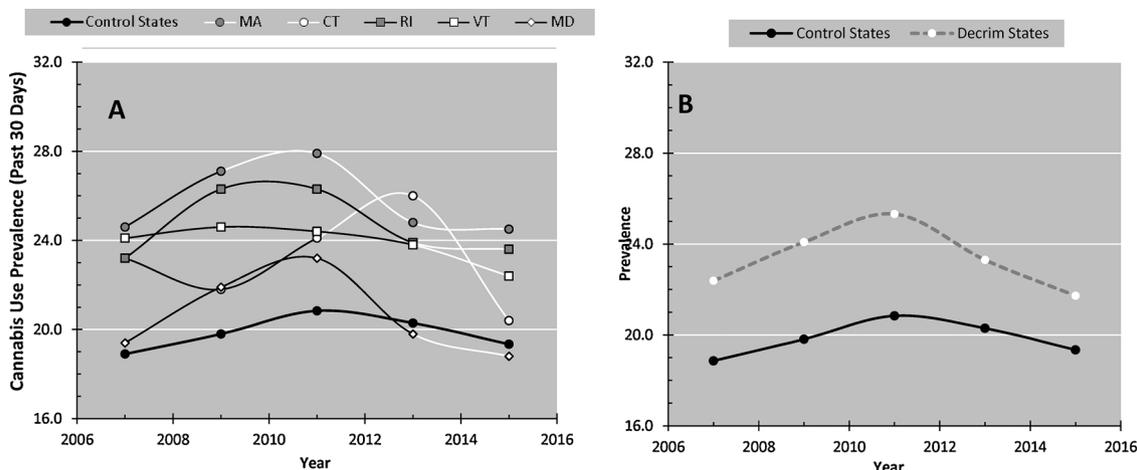


Fig. 2. Trends in past-month cannabis use from 2007 to 2015 are shown in Fig. 2a, with youth in each of the five decriminalized states compared with combined control states. Black lines between data points indicate pre-decriminalization years; white lines follow post-decriminalization or transition years. Fig. 2b compares the combined decriminalization states with the combined control states.

amounts of cannabis. The threshold amounts beneath which possession was sanctioned as a civil offense varied from 10 to 28 g. Prior to decriminalization, possession of those same amounts were potentially punishable by imprisonment and maximum fines ranging from \$500 to \$1500. After decriminalization, fines were limited to \$200 or less and an offender would not be arrested or imprisoned—with one exception in the state of Rhode Island for frequent offenders. These policy changes were accompanied by large and immediate decreases in drug-related arrests for both youth and adults. The drop in arrest rate for cannabis possession ranged from 42% to 90%. The decline was lowest in Maryland, perhaps because Maryland had the lowest threshold amount for the lowest level of possession offense (10 g). Police may still issue civil citations in these states, but these are not recorded in FBI statistics. Thus, a drop in arrests does not necessarily mean a drop in enforcement. Nonetheless, the sharp drop in arrest rates indicates that these policies had their intended consequence of reducing the number of people involved with the criminal justice system for cannabis possession offenses.

Importantly, state-level decriminalization was not associated with increased cannabis use either in aggregate or in any of the five states analyzed separately, nor did we see any delayed effects in a lag analysis, which allowed for the possibility of a two-year (one period) delay in policy impact. In fact, the lag analysis suggested a potential protective effect of decriminalization. The prevalence of cannabis use was notably higher in the decriminalization states, but this was true prior to the adoption of the policies (see Table 3 and Fig. 2). One might argue that the elevated rates of use in these states stem from the relaxation of

Table 5

Association between decriminalization policy and frequency of cannabis use (past-30 days, vs. 0 times).2007–2015

	Model I ^a β (95% CI)	Model II β (95% CI)
All Decriminalized States		
1-2 times	0.026 (−0.063, 0.114)	0.022 (−0.066, 0.110)
3-9 times	−0.072 (−0.207, 0.063)	−0.084 (−0.176, 0.007)
≥ 10 times	−0.003 (−0.069, 0.063)	−0.016 (−0.121, 0.089)

^a Model I incorporates only state and year fixed effects and individual demographics as covariates. Model II incorporates additional state-level covariates that were associated with the dependent variable in fixed effects models.

social norms surrounding cannabis that might occur in the period preceding implementation of decriminalization policies (Miech et al., 2015). However, models examining a potential lead or “anticipation” effect suggested a protective association, i.e., that cannabis use prevalence in decriminalization states declined in pre-implementation years compared with non-decriminalization states.

We also found a small, negative association between decriminalization and cannabis use in Rhode Island. Notably, in their study of policy changes in Vermont, Caulkins et al. found that the total number of recorded cannabis offenses increased by about 20% following decriminalization, though the vast majority of these were civil citations and not criminal offenses (Caulkins et al., 2015). Although we do not have data on civil citations in Rhode Island or other states, the Vermont

Table 4

Association between cannabis decriminalization policy and past-30 day cannabis use.

Decriminalization policy effects	Model I ^a Proportional Change ^b (95% CI)	Model II Proportional Change (95% CI)
All Decriminalized States	−0.006 (−0.044, 0.033)	−0.002 (−0.046, 0.043)
Massachusetts Only	0.002 (−0.032, 0.037)	0.038 (−0.006, 0.084)
Connecticut Only	0.009 (−0.026, 0.045)	−0.019 (−0.051, 0.013)
Rhode Island Only	−0.054 (−0.087, −0.019)	−0.045 (−0.070, −0.019)
Vermont Only	−0.059 (−0.099, −0.018)	−0.032 (−0.081, 0.021)
Maryland Only	−0.014 (−0.065, 0.039)	−0.034 (−0.078, 0.013)
All Decriminalized States-Lead	−0.052 (−0.084, −0.019)	−0.062 (−0.104, −0.019)
All Decriminalized States-Lag	−0.040 (−0.071, −0.009)	−0.034 (−0.070, 0.003)

Notes: Bold indicates $p < 0.05$. Notes: This table lists only the association between decriminalization and arrest rate. See Supplementary Table 6 for full covariate listing.

^a Model I incorporates only state and year fixed effects and individual demographics as covariates. Model II incorporates additional state-level covariates that were associated with the dependent variable in fixed effects models.

^b Proportional change derived from regression coefficient, $\exp(\beta)-1$.

study confirms that decriminalization does not necessarily lead to lower rates of enforcement. Combined with the results of lead and lag analyses, the slight decrease in Rhode Island raises the question of whether cannabis use among youth might decrease under decriminalization. We had no *a priori* reason to anticipate these results, and so we emphasize the need for replication prior to concluding that decriminalization might result in lower rates of use in some situations. An alternative explanation, for example, is that prevalence of use was fairly high for most decriminalization states and the apparent protective associations might reflect regression to the national mean. But it is also possible that public debate or media coverage of policy change called attention to the fact that juveniles might still face serious consequences for cannabis possession. For example, in Rhode Island, minors (under 18) caught possessing cannabis are required to appear before family court, pay a fine, and be evaluated for substance use disorder. In Vermont, those under 21 caught in possession of cannabis face fines and driver's license suspension.

The only comparable study of recent state decriminalization policy that we are aware of focused on the state of California and found an increase in cannabis use among 12th graders, but not among 8th or 10th graders, in 2012, the year after the law went into effect. The authors argued that this increase provided evidence for a “signaling hypothesis” in which increases in use are a response to changes in social norms that precede policy implementation and send a signal to youth that cannabis is safe (DuPont & Voth, 1995; Miech et al., 2015). Under this hypothesis, changes in cannabis policy are expected to be observable over the short term. In contrast to that study, we did not observe any increase in cannabis use in any of the five states we examined, with follow-up times ranging from one to seven years. We did not find evidence for differential effects by age, nor did we find evidence for pre-implementation increases or delayed effects on cannabis use.

Thus, our findings do not support the signaling hypothesis articulated by Miech et al. (2015) but attributed to DuPont and Voth (1995). Perhaps theoretical approaches to youth cannabis use under decriminalization—and possibly even under legalization—must consider the fact that cannabis use is still an illegal behavior for minors. For example, under criminological theories of opportunity, influencing factors include not only the motivation of potential offenders—which is the sole focus of the signaling hypothesis—but also changes in guardianship such as police enforcement and changes in availability of cannabis through illicit markets (Cohen & Felson, 1979). We have already discussed that decriminalization does not necessarily decrease, and in some situations might increase the frequency of enforcement through civil sanction (Caulkins et al., 2015). We did not have access to measures of motivation in this study, but decriminalization of possession does not necessarily lead to changes in markets, which are still criminalized. The lack of increase in youth cannabis use is consistent with opportunity theory. Further, if frequency of enforcement increases—even in the context of penalty reduction—a decrease in cannabis use prevalence could also be consistent with opportunity theory.

Several limitations must be kept in mind when interpreting these results. First, YRBS is a school-based survey; those who have dropped out of school are not part of the sampling universe. This is an important limitation given the negative association between heavy cannabis use and educational attainment (Hall & Lynskey, 2016). If increases in cannabis use prevalence were highly concentrated among those who dropped out of school, they may be overlooked by analyses of the YRBS. Second, as a biennial survey, it may not be as sensitive to short-term effects of policy change (e.g., a temporary increase that subsides after a year). Third, the data are based on self-report. It is generally believed that social desirability considerations would lead students to under-report their use of cannabis; however, the anonymous nature of the survey and the fact that responses are not provided directly to an interviewer may mitigate this somewhat (Tourangeau & Smith, 1996). It is also important to note that this would only bias our estimates if the magnitude of under-reporting changed differentially over time and

across states. This may be the case if decriminalization is associated with greater social acceptability of cannabis use, but this would likely bias the associations upward, making it appear as though decriminalization resulted in higher prevalence of use. Fourth, we did not have access to the precise date of interview for YRBS participants, which introduces potential error in policy exposure measurement for three states (Connecticut, Rhode Island, and Vermont) that implemented decriminalization mid-year during YRBS years. However, robustness checks verified that any influence of this uncertainty on estimates was minimal. Finally, we emphasize the need for replication of these results in other data sets and, more importantly, for monitoring of long-term trends in states that have implemented decriminalization.

Some might question the relevance of a study on cannabis decriminalization in a policy environment where a majority of the public in the United States and other countries supports commercial legalization of cannabis, and the number of citizens with access to legalized cannabis continues to grow both nationally and internationally (Cerdeira & Kilmer, 2017; Hajizadeh, 2016; McCarthy, 2017; Mendiburo-Seguel et al., 2017). However, there is an international trend toward decriminalization of possession for all drugs, and results of cannabis policy changes may help predict consequences of similar policy changes for other drugs (MacCoun & Reuter, 2001). About a dozen countries have adopted decriminalization or other measures designed to reduce penalties for possession of small quantities of drugs other than cannabis (Rosmarin & Eastwood, 2012). A well-known example is Portugal, which decriminalized all drugs for personal use in 2001. Though many feared a marked rise in drug use, this did not occur (Murkin, 2014), and more people opted to seek treatment, in part due to the shift to a public health approach in which treatment is encouraged, but not required (Domosławski, 2011). A number of other European countries have decriminalized possession of both cannabis and other drugs, and although specifics of these policies have varied by country, a cross-sectional analysis of the national-level drug policies in the European Union found that young people's use of illicit drugs was markedly lower in countries that had eliminated punishments for possession for personal use (Vuolo, 2013). Our results provide additional evidence that decriminalization can be accomplished without an increase in youth drug use.

For over four decades, expert panels commissioned by the United States and other Western governments have recommended that decriminalization be considered as a “middle ground” policy that avoids potential increases in youth cannabis use stemming from commercial legalization while mitigating the financial and human costs of punitive drug control policies (reviewed in Iversen, 2008). However, decriminalization policies have received little recent attention from researchers even as many new studies of the effects of medical and recreational legalization have appeared (Pacula & Smart, 2017). The question of whether decriminalization has impacted arrest rates has also received scant attention in the peer-reviewed literature. Arrests can impact health through lost job and educational opportunities as well as more severe life consequences such as incarceration, and therefore arrests are a necessary focus of comprehensive public health policy studies. We conclude that implementation of cannabis decriminalization likely leads to a large decrease in the number of arrests among youth (as well as adults), and we see no evidence of increases in youth cannabis use. These findings are consistent with the interpretation that decriminalization policies likely succeed with respect to their intended effects and that their short-term unintended consequences are minimal.

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Conflicts

The authors declare no conflicts of interest relevant to this work.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <https://doi.org/10.1016/j.drugpo.2018.06.016>.

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