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Research paper

The effect of medical cannabis laws on juvenile cannabis use

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ABSTRACT

Background: A number of states in the United States legally allow the use of cannabis as a medical therapy to treat an illness or to alleviate symptoms. Concern persists as to whether these types of laws are increasing juvenile recreational cannabis use. It is also plausible that medical cannabis laws engender an escalation of illicit non-cannabis drug use among juveniles because cannabis is frequently considered to be a gateway drug.

Methods: This study uses longitudinal data drawn from the National Survey on Drug Use and Health for the 50 U.S. states and a cross-sectional pooled-time series research design to investigate the effect of medical cannabis laws on juvenile cannabis use and on juvenile non-cannabis illicit drug use. Our study period encompasses five measurement periods calibrated in two-year intervals (2002–2003 to 2010–2011). This research design is advantageous in that it affords us the ability not only to assess the effect of the implementation of medical cannabis laws on juvenile drug use, but also to consider other state-specific factors that may explain variation in drug use that cannot be accounted for using a single time series.

Results: Findings show that medical cannabis laws amplify recreational juvenile cannabis use. Other salient predictors of juvenile cannabis use at the state-level of analysis include perceived availability of cannabis, percent of juveniles skipping school, severity of perceived punishment for cannabis possession, alcohol consumption, percent of respondents with a father residing in household, and percent of families in the state receiving public assistance. There is little empirical evidence to support the view that medical cannabis laws affect juveniles' use of illicit non-cannabis drugs.

Conclusion: Based on our findings, it seems reasonable to speculate that medical cannabis laws amplify juveniles' use of cannabis by allaying the social stigma associated with recreational cannabis use and by placating the fear that cannabis use could potentially result in a negative health outcome.

Background

Because of its purported medicinal value (Clark, 2000; Kramer, 2015; Lynch & Ware, 2015; Watson, Benson, & Joy, 2000), both the nationwide and worldwide popularity of legalizing cannabis for medical purposes has reached epic proportions. A 2010 Gallup poll found that approximately 70% of Americans are in favor of allowing doctors to prescribe cannabis to mitigate pain (Mendes, 2010), whereas a survey of 1446 physicians from 72 countries revealed that 76% of the physicians supported the use of cannabis for medical purposes (Adler & Colbert, 2013). Twenty states in the U.S. since 1999 and the District of Columbia have legalized the use of cannabis for medicinal purposes, and a number of additional states are expected to follow suit. The number of registered medical cannabis identification card holders in the United States (U.S.) as of April 2013 stands at 1,029,325, and this number is expected to grow in the coming years (ProCon.org, 2014).

Debate as to whether the labeling of cannabis as non-harmful not only facilitates its acceptability (Miech et al., 2015), but also ameliorates the perceived riskiness of its use continues to escalate as more states allow medical cannabis use (Khatapoush & Hallfors, 2004; Schuermeyera et al., 2014; Wall et al., 2011). Some argue that cannabis use is a tangible health risk (Hall, 2015), that alternative medications currently exist to deal with ailments typically treated with cannabis (Watson et al., 2000) and that medical cannabis laws amplify the recreational use of cannabis in the population (Clark, 2000; Gorman & Huber, 2007; Joy, Watson, & Benson, 1999).

A number of studies find evidence that medical cannabis laws amplify cannabis use in the population, particularly among youth.

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Wall et al. (2011) examined cannabis use among adolescents (12–17 year olds) in states with and without medical cannabis laws and found that on average cannabis use was higher among youths living in states that legalized medical cannabis. They also observed a marked decline in the perceived riskiness of cannabis use among youth following the passage of a medical cannabis law. In a cross-sectional study, Cerdá, Wall, Keyes, Galea, and Hasin (2012) evinced evidence that adults had a substantially higher likelihood of cannabis use in states that allowed the use of medical cannabis. Salomonsen-Sautel, Sakai, Thurstone, Corley, and Hopfer (2012) found that 73.8% of the individuals admitted to substance abuse treatment in the Denver metropolitan area reported that they had used the cannabis prescribed to another individual for medicinal purposes, although these medical cannabis users did admit that they were also more apt to use non-medicinal cannabis on a regular basis.

Despite the findings generated in these research studies, not everyone is fully convinced that medical cannabis laws influence the recreational use of cannabis (Clark, 2000). Khatapoush and Hallfors (2004) investigated whether attitudes regarding perceived dangers of cannabis use changed over time in California and 10 other comparable states. Although they noted a significant decrease in people's perceived harm of cannabis from 1995 to 1999, the rate of cannabis use in the population remained relatively stable. Gorman and Huber (2007) endeavored to establish whether cannabis use rose following legislation to legalize medical cannabis in several cities and metropolitan areas in four states from 1994 to 2002. Their interrupted time series analysis showed that cannabis use among criminal arrestees and people admitted to emergency rooms for drug overdoses did not increase substantially following the legalization of medical cannabis for any of the areas studied. In a replication of the Wall et al. (2011) study, Harper, Strumpf, and Kaufman (2012) used a difference-in-difference regression model to discern whether medical cannabis laws influenced recreational cannabis use. In contrast to the results reported in the Wall et al. study, Harper and his colleagues found that medical cannabis laws did not substantially elevate cannabis use among youth between the ages of 12–17. Finally, Lynne-Landsman, Livingston, and Wagenaar (2013) used data drawn from the Youth Risk Behavior Surveillance System to measure statewide prevalence rates of cannabis use. They examined four states – Montana, Delaware, Rhode Island, and Michigan – that each passed a medical cannabis law sometime between 2003 and 2011. Using logistic regression difference-in-difference models, Lynne-Landsmen and her associates found no statistically discernible rise in either self-reported prevalence or frequency of cannabis use among adolescents following the legislation of medical cannabis.

Methodological problems with prior research

Although certainly informative, much of the prior research examining the effect of medical cannabis legislation on attitudes toward cannabis use and on recreational cannabis use is problematic for a number of reasons making any conclusions tentative at best. Methodological problems include small and unrepresentative samples, an overreliance on cross-sectional data, inappropriate statistical methodology, and a general failure to investigate the possibility that medical cannabis laws increase non-cannabis drug use. First, many previous studies were based on small and non-representative samples often drawn from a few select geographical locations. For example, Salomonsen-Sautel et al. (2012) analyzed 164 cases, Thurstone, Lieberman, and Schmiege (2011) 80 cases, Lynne-Landsman et al. (2013) studied four states and Gorman and Huber (2007) examined only high-risk urban populations. The unrepresentiveness of these samples not only hinders one's ability to generalize the results generated in these studies, but it is also plausible that appreciable changes in sample composition might alter some or all of the effects observed in these studies.

Second, with a few noteworthy exceptions, most of what we currently know about the effect of medical cannabis laws on attitudes toward cannabis and cannabis use among youth comes from the examination of survey data collected at a single point in time (Cerdá et al., 2012; Salomonsen-Sautel et al., 2012; Thurstone et al., 2011). The analysis of cross-sectional data cannot easily identify the specific causal processes at work. To illustrate, just because a person living in a state with a medical cannabis law has a greater likelihood of cannabis use than an individual living in a state without such a law does not necessarily mean that the implementation of the medical cannabis law engendered this difference in the probability of cannabis use. People living in medical cannabis states might have always used more cannabis. In fact, more liberal attitudes in regards to cannabis use in these states might have been the initial impetus for the passage of the medical cannabis law. An analysis of longitudinal data is needed to determine more accurately the effect of medical cannabis laws on juvenile cannabis use. As Cerdá et al. (2012, p. 25) note, "Future studies should use large-sample survey data collected in years prior to and after enactment of cannabis laws in states with and without such laws, to compare prevalences and trends."

Third, while a few studies have heeded the call to analyze longitudinal data, these studies also have shortcomings that limit their ability to draw definitive conclusions. To determine whether cannabis use increased following legislation to legalize medical cannabis in several cities and metropolitan areas in different states, Gorman and Huber (2007) conducted an Autoregressive Integrated Moving Average (ARIMA) interrupted time series analysis with fewer than 50 pre-intervention quarterly time-periods. However, while an interrupted time series ARIMA analysis is generally considered a robust statistical procedure for interpreting aggregate change (McCleary & Hay, 1980), there needs to be an adequate number of pre-intervention periods so that trend and seasonality can be modeled appropriately. It is generally accepted that at least 50 measurement periods are needed in the pre-intervention series to model accurately trend and seasonality. Otherwise, ARIMA results can become unstable (McCain & McCleary, 1979, p. 235). Other longitudinal research studies were also problematic in that they had too short a post-intervention period to draw firm conclusions (Wall et al., 2011) or they had a limited time-period for evaluation purposes (Harper et al., 2012).

Finally, current research remains surprising silent on whether medical cannabis laws amplify juveniles' use of illicit drugs. An expansive literature suggests that cannabis use is correlated, at least in the short term, with an increase in the probability of an individual using other illicit drugs (Hall & Lynskey, 2005). For example, using a sample of young persons from the National Household Survey on Drug and Abuse, Kandel and Yamaguchi (2002) found that 90% of respondents reported using cannabis prior to cocaine. Fergusson, Boden, and Horwood (2006) analyzed data on 1200 New Zealand children from the Christchurch Health and Development Study over a 25-year period. They found that of those who reported using illicit drugs other than cannabis, 98% admitted to using cannabis within the same year or before using the illicit drug(s). However, it was also noted that the relationship between cannabis use and other drug use weakened as the respondents grew older. Van Gundy and Rebellon (2010) generated similar findings in their study of 1286 young adults living in South Florida. Using logistical regression and controlling for stress and life perspective variables, they observed that illicit drug use was higher for respondents who reported using cannabis in grades eight and nine. Despite the possibility of cannabis acting

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as a gateway drug, current research has not fully investigated the effect of medical cannabis laws on juveniles' use of illicit drugs.

The primary objective of this study is to examine the relationship between medical cannabis laws and juvenile cannabis use, correcting for some of the methodological problems encountered in earlier studies. Specifically, we use panel data drawn from the 50 U.S. states to probe the effect of the passage of medical laws on juvenile cannabis use. This research design is ideally suited for studying both the temporal and spatial patterns of cannabis use because it allows for the analysis of multiple units across multiple time-periods. In addition to exploring the relationship between medical cannabis laws and juvenile cannabis use, an attempt is made to verify empirically whether medical cannabis laws result in the escalation of illicit drug use among juveniles. This issue has been overlooked in previous research.

Data and methods

We analyze data for juveniles from 2002 to 2011 for the 50 U.S. states, which constituent political entities that share sovereignty with the United States federal government. Juveniles are defined as persons, 12–17 years of age. The data, which encompass five measurement periods calibrated in two-year intervals (2002–2003, 2004–2005, 2006–2007, 2008–2009, and 2010–2011), are derived from two different sources. These two sources include the National Survey on Drug Use and Health and Progcon.com. The National Survey on Drug Use and Health is a nationally representative sample of the U.S. population that is conducted by Substance Abuse and Mental Health Services Administration. This survey is uniquely suited for our purposes because it contains information on cannabis use and other drug use among the population along with individual demographic characteristics of the respondent. The dataset also contains geocode information that identifies the respondent's state of residence, which is the smallest geographical unit for which the data are made available to the public. These geographic identifiers can be used to determine whether or not a respondent resides in a state that passed a medical cannabis law. All relevant data on survey respondents were aggregated to the state-level. Our study period was determined by the online availability of the National Survey on Drug Use and Health data, which can be accessed at http://www.icpsr.umich.edu/icpsrweb/content/SAMHDA.

We obtained data pertaining to medical cannabis laws from Progcon.com. These data include the year that a given state passed a medical cannabis law and the amount of medical cannabis a person is legally allowed to possess in a state.

Dependent variables

Two dependent variables are analyzed in this study. The first dependent variable, the percent of juveniles reporting that they used cannabis in the month prior to being surveyed about their drug use, captures the prevalence of cannabis use among juveniles in the states. The second dependent variable is the percent of illicit drug use among juveniles in the month prior to being surveyed. These illicit drugs, which include cocaine, heroin, methamphetamines, hallucinogens, inhalants, and psychotherapeutics, are typically considered more dangerous than cannabis to a person's health.

Independent variables

The theoretically relevant independent variable in our analysis is the year that medical cannabis legislation was implemented in a state. This variable is coded one for the year that a state passed a medical cannabis law, zero otherwise. The following 16 states allowed the sale of medical cannabis during the study period: Alaska (1998), Arizona (2010), California (1996), Colorado (2000), Delaware (2011), Hawaii (2000), Maine (1999), Michigan (2008), Montana (2004), Nevada (2000), New Jersey (2010), New Mexico (2007), Oregon (1998), Rhode Island (2006), Vermont (2004), and Washington (1998). Seven states including Connecticut (2012), Illinois (2013), Maryland (2014), Massachusetts (2012), Minnesota (2014), New Hampshire (2013), and New York (2014) passed a medical cannabis law after 2011.

In addition to the medical cannabis law variable, several control variables are incorporated into our state-level analyses to help us avoid basing our conclusions on spurious or suppressed relationships. These variables include the medical cannabis possession limit, cannabis availability, percent juveniles believing that mandatory prison is the maximum penalty for cannabis possession, alcohol use, percent juveniles enrolled in a drug class, whether the respondent was previously arrested for a crime, percent of families receiving public assistance income, percent of juveniles who skipped school within the past 30 days, percent of families where the father resides in the household, percent of male juveniles and percent of white juveniles. The means, standard deviations and definitions for all the variables are displayed in Table 1.

Table 1
Means, standard deviations, and definitions for the variables used in the analysis.

	Mean	SD	Definition
Cannabis use	7.617	2.226	Percent cannabis use during past month (ages 12–17)
Illicit drug use	4.978	1.280	Percent illicit drug use except for cannabis during past month (ages 12–17). Includes hallucinogens, heroin, cocaine, inhalants and psychotherapeutics
Medical cannabis state	0.236	0.425	Coded 1 if state enacted law to legalize medical cannabis, 0 otherwise
Possession limit	1.522	4.832	Number of ounces permitted
Cannabis availability	50.376	5.355	Percent responding that cannabis was fairly or very easy to obtain (ages 12–17)
Mandatory prison	11.912	2.354	Percent responding that mandatory prison is the maximum penalty for first offense possession of an ounce or less of cannabis for personal use (ages 12–17)
Alcohol use	7.662	2.309	Percent who consumed alcohol at least once per week in past 12 months (ages 12–17)
Drug class	47.117	5.457	Percent enrolled in special class about drugs or alcohol in past 12 months (ages 12–17)
Prior arrest	7.592	1.971	Percent arrested and booked previously for breaking the law
Public assistance	3.952	1.968	Percent with family receiving public assistance income (ages 12–17)
Skipped school	11.418	2.665	Percent skipped school during past 30 days (ages 12–17)
Father in household	74.822	4.953	Percent with father residing in household (ages 12–17)
Male	51.127	0.188	Percent male (ages 12–17)
White	67.964	16.911	Percent white non-Hispanic (ages 12–17)

$N = 50$ states covering five 2-year time periods: 2002–2003, 2004–2005, 2006–2007, 2008–2009, and 2010–2011. Because the amount of medical cannabis a person was legally allowed to possess in Connecticut had not been determined when Connecticut passed its medical cannabis law, the mean for the medical cannabis possession amount variable was assigned to Connecticut.

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We include the medical cannabis possession limit variable, which measures the number of ounces of medical cannabis that an individual is legally permitted to possess in a state, as a control variable because research finds that drug use is correlated strongly with the supply of a drug (Stolzenberg & D'Alessio, 2003). The greater the availability of an illicit drug in the population, the more apt an individual is to test positive for that drug. cannabis availability is another indicator of the supply of cannabis. However, in contrast to the medical cannabis possession limit variable, cannabis availability is a measure based on perception. Respondents were queried whether they felt that cannabis was fairly or very easy for them to obtain. As the perception in regards to the ease of obtaining cannabis rises, juvenile cannabis use should also increase. Another potentially salient control variable included in this study is the perceived severity of the criminal sanction for cannabis possession. This variable measures deterrence. Advocates of the deterrence thesis maintain that individuals are free-will actors who rationally weigh the probable benefits and potential liabilities before engaging in criminal activities. They also argue that this individual calculation hinges on the severity of criminal sanctions imposed by law (Grasmick & Bryjak, 1980).

We also felt it appropriate to include alcohol use as a control variable because prior research demonstrates that cannabis and alcohol act as substitutes for each other (Anderson, Hansen, & Rees, 2013). Based on findings generated in this research, we expect that juvenile cannabis use will be lower in states where juveniles consume a greater amount alcohol. There is also an expectation that there will be a positive relationship between the percent of respondents enrolled in a special class about drugs or alcohol in the previous 12 months and juvenile cannabis use. The percent of respondents arrested and booked previously for a criminal offense (Tripodi & Bender, 2011), as well as socioeconomic status (Rogeberg, 2013), should both be associated with juvenile drug use. Finally, skipping school and family structure are reported by researchers to be correlated with increased substance abuse among juveniles. Roebucka, French, & Dennis (2004) reports that cannabis use is associated positively with school truancy, whereas Barrett and Turner (2006) evince evidence that adolescents and young adults from single-parent families have greater problems with substance use than those from families with a mother and father. Gender and race are also used as control variables. While studies find that male adolescents have an enhanced proclivity to use cannabis (Schepis et al., 2011), the literature on the relationship between race and cannabis use is more inconclusive. Although surveys indicate that cannabis use among blacks and whites is similar in the general population (Substance Abuse & Mental Health Services Administration, 2011), research based on the drug testing of urine finds that blacks are significantly more likely than whites to use cannabis (D'Alessio, Stolzenberg, & Flexon, 2015). Despite this inconsistency in the literature, we still felt it warranted to include a race control variable in our analyses.

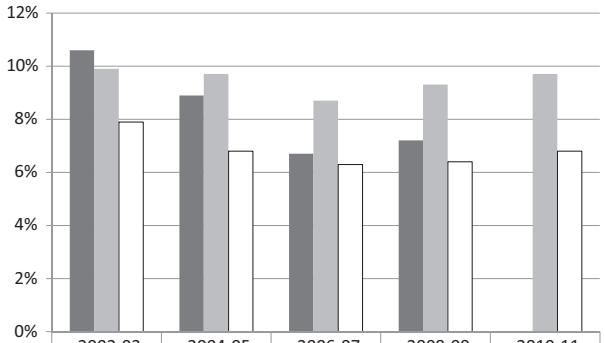
We use the panel regression procedure in LIMDEP to ascertain the effect of medical cannabis laws and the control variables on the two dependent variables (Greene, 2007). This type of analytic design is ideally suited for studying both the temporal and spatial patterns of recreational juvenile cannabis use because it can analyze multiple units across multiple time periods. This methodological strategy accounts for both cross-sectional and temporal complications of the data by enabling the consideration of variation across both state and time. We are thus able to account for state-specific variables that may explain variation in recreational cannabis use among juveniles that cannot be considered with a national time series. Another advantage is that the analysis of panel data does not require a large number of temporal observations, which is typically needed in a time series analysis.

A random effects model is used to estimate our equations. An important consideration when determining whether a fixed effects model or random effects model should be used in an analysis is whether the predictor variables vary or do not vary over time. If one or more of the predictor variables included in the equation are time-invariant, the fixed effects model cannot be estimated because its variance–covariance matrix cannot be inverted (Greene, 2007, pp. E11–44). The inclusion of time-invariant variables in the equation also precludes estimation of a Hausman test (Hausman & Taylor, 1981), which assess whether the fixed effects model and the random effects model produce statistically similar results (Greene, 2007, pp. E11–36). While the medical cannabis law variable is not time-invariant, it does have limited variability during the study period. Of the 16 states that passed a medical cannabis law before 2012, eight states implemented their medical cannabis law during the study period. Thus, because the dummy coded medical cannabis law variable has reduced variability, the random effects model is the appropriate choice for our estimation procedure.

Results

Fig. 1 shows the percent of cannabis use among juveniles in the 16 medical cannabis states before and after they passed a medical cannabis law. This figure also depicts the percent of juvenile cannabis use for the remaining states that did not pass a medical cannabis law during the observation period. A visual inspection of Fig. 1 reveals that juvenile cannabis use was consistently higher in states that passed, or that would eventually pass a medical cannabis law than and in states that did not pass a medical cannabis law. Although it is certainly plausible that the prevalence of cannabis use in a state is a causal factor in whether or not a state implements a medical cannabis law, Fig. 1 also shows that with the exception of the 2002–2003 period juvenile cannabis use was consistently higher in states following the passage of a medical cannabis law than in states that would eventually pass such a law. This finding suggests that the implementation of medical cannabis laws increase juvenile cannabis use rather than cannabis use influencing the passing of medical cannabis laws.

Table 2 reports the results of the equations estimating the influence of the control variables and the medical cannabis law variable on juvenile cannabis use over time for the 50 U.S. states. Model 1 is a baseline equation that includes the effects of only the



	2002-03	2004-05	2006-07	2008-09	2010-11
Before law	10.6%	8.9%	6.7%	7.2%	
After law	9.9%	9.7%	8.7%	9.3%	9.7%
No law	7.9%	6.8%	6.3%	6.4%	6.8%

Fig. 1. Percent cannabis use during past month among youth 12–17 years of age in states with and without legalized medical cannabis laws. *Note*: There is no data bar for the 2010–2011 time period because all the states that were going to pass a medical cannabis law had done so by 2011.

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Table 2
Two-way random-effects models estimating the impact of state legalized medical cannabis laws on past month cannabis use among youth 12–17 years of age.

	Model 1 Controls only		Model 2 With medical cannabis law	
	Coefficient	Std. error	Coefficient	Std. error
Medical cannabis state	–	–	0.861**	0.298
Possession limit	0.008	0.021	−0.029	0.024
Cannabis availability	0.224***	0.022	0.217***	0.022
Mandatory prison	−0.110**	0.039	−0.094*	0.039
Alcohol use	0.187***	0.043	0.179***	0.043
Drug class	−0.013	0.019	−0.011	0.019
Prior arrest	0.050	0.050	0.058	0.050
Public assistance	0.191***	0.047	0.170***	0.047
Skipped school	0.120***	0.036	0.092**	0.037
Father in household	0.050*	0.022	0.040	0.022
Male	0.516	0.479	0.396	0.475
White	0.005	0.007	0.010	0.007
Constant	−36.158	23.892	−29.249	23.716
R^2	0.563		0.597	

* $p < 0.05$ (two-tailed tests).
** $p < 0.01$ (two-tailed tests).
*** $p < 0.001$ (two-tailed tests).

Table 3
Two-way random-effects models estimating the impact of state legalized medical cannabis laws on past month illicit drug use among youth 12–17 years of age.

	Model 1 Controls only		Model 2 With medical cannabis law	
	Coefficient	Std. error	Coefficient	Std. error
Medical cannabis state	–	–	0.190	0.245
Possession limit	0.018	0.016	0.010	0.019
Cannabis availability	0.033	0.018	0.031	0.018
Mandatory prison	0.072*	0.033	0.076*	0.034
Alcohol use	0.125***	0.037	0.123***	0.037
Drug class	−0.063***	0.015	−0.063***	0.015
Prior arrest	0.120**	0.042	0.122**	0.042
Public assistance	0.044	0.038	0.038	0.039
Skipped school	0.072**	0.030	0.066*	0.031
Father in household	0.005	0.017	0.002	0.018
Male	−0.660	0.400	−0.689	0.402
White	0.004	0.005	0.005	0.005
Constant	35.596	19.908	37.328	20.047
R^2	0.323		0.323	

* $p < 0.05$ (two-tailed tests).
** $p < 0.01$ (two-tailed tests).
*** $p < 0.001$ (two-tailed tests).

control variables. A visual inspection of the Model 1 of Table 2 reveals that six of the 11 control variables reach statistical significance in the equation. One pronounced effect in the model is cannabis availability. Results show that as the perception of cannabis availability increases among juvenile respondents, so does cannabis use. Prior research suggests that drug availability measured by the price of a drug is correlated strongly with drug use (Stolzenberg & D'Alessio, 2003). A substantive positive relationship also exists between skipping school and the dependent variable, suggesting that juveniles who skip school are more apt to use cannabis. The observed relationship between mandatory prison sanction and cannabis use is consistent with deterrence theory since the severity of criminal punishment is related to juvenile cannabis use in the negative direction. Alcohol use and whether a father resides in household are also associated positively with juvenile cannabis use. Another pronounced effect in this model is the percent of families receiving public assistance. As the percent of families receiving public assistance rises in a state, juvenile cannabis use also climbs.

In Model 2 of Table 2 the dummy coded medical cannabis law variable was added to the baseline equation. Results for this model show a statistically discernible relationship between the dummy coded variable measuring whether a state has a medical cannabis law and the percent of juveniles reporting that they used cannabis during the past month prior to being surveyed. The coefficient for the medical cannabis law variable is statistically significant and in the positive direction, thereby indicating that medical cannabis laws elevate juvenile cannabis use even after accounting for the other independent variables included the equation. One can interpret this effect as compelling evidence supporting the assertion that medical cannabis legislation amplifies recreational juvenile cannabis use because the percent of juveniles using cannabis increased substantially following the passage of a medical cannabis law, controlling for other factors. The effects of the control variables in Model 2 are compatible with those reported in Model 1, except for the lack of statistical significance for the father in the household variable. The R^2 for this model is 0.60, whereas the R^2 for Model 1 was 0.56.

Another question of policy relevance is whether a noteworthy relationship exists between medical cannabis laws and juvenile use of drugs typically considered to be more dangerous than cannabis such as cocaine, heroin, and methamphetamines. It is plausible that juveniles' use of non-cannabis illicit drugs may be more pronounced in states that passed a medical cannabis law because of prior research indicating that cannabis acts as a gateway drug.

Model 1 of Table 3 shows the effects of the control variables on the prevalence of illicit drug use among juveniles, whereas in Model 2 the dummy coded medical cannabis law variable is added to the equation. The results reported in Model 1 of Table 3 show that several control variables have consequential effects. Mandatory prison sanction for cannabis possession, alcohol use, prior arrest, and skipping school all increase the use of illicit drugs among juveniles. Enrollment in a special class pertaining to drug and alcohol use also has a substantive effect on the dependent variable but in the negative direction.

Model 2 of Table 3 adds the medical cannabis law variable. The results generated for this analysis show that while the coefficient for the medical cannabis law variable is positive, it is not sizable. This finding suggests that juvenile illicit drug use is not more pronounced in states that allow the use of medical cannabis. The effects of the control variables are similar to those reported in Model 1. The R^2 for this model is 0.32.

Conclusion

Several prior studies link medical cannabis laws to amplified levels of cannabis use among juveniles and our analysis finds further credible evidence to support this research. The strong effect of the medical cannabis law variable persists even after controlling for a variety of potential rival causal factors. Such a finding supports opponents of medical cannabis laws who often argue that these laws lead to an intensification of recreational cannabis use among juveniles. That said we find no convincing evidence that medical cannabis laws engender a rise in juvenile non-cannabis illicit drug use.

One might wonder why the passage of medical cannabis laws results in an escalation of cannabis use among juveniles. It seems plausible to speculate that medical cannabis laws act to diminish the social stigma frequently associated with the recreational use of cannabis. By affiliating with medical cannabis users either directly or vicariously, people are themselves freed from the existing societal constraints against cannabis use. Furthermore, as time passes and the number of medical cannabis users living in an area

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grows increasingly larger in size, the social stigma attached to cannabis use is further weakened because of the greater chance that an individual will encounter or become aware of the fact that people are using cannabis legally for medical purposes. The fear that cannabis use could potentially result in a negative health outcome is also mollified in this scenario. Prior research buttresses this position by showing that medical cannabis laws attenuate the perceived riskiness of using cannabis (Khatapoush & Hallfors, 2004; Wall et al., 2011) and that the decriminalization of cannabis increases its acceptance among juveniles (Miech et al., 2015). It is also salient to note that a conglomeration of people with a similar interest in medical cannabis creates a fertile environment for the proliferation of specialized institutions such as organizations, newsletters and retail outlets related to medical cannabis use. The propagation of these types of specialized institutions in turn helps to further weaken the social stigma attached to cannabis use. The public's tolerance for recreational cannabis use is also magnified in these situations.

The current study has several advantages over previous research in this area. First, the National Survey on Drug Use and Health data are collected from a nationally representative sample of people living in the 50 U.S. states, so our findings are not likely the result of geographic or sampling bias. Second, our use of longitudinal data and a pooled cross-sectional research design helps to support a stronger inference about the effect of medical cannabis laws on juvenile cannabis use than is possible using a cross-sectional design. Our data and research design allow for the robust testing and elimination of alternative explanations of our results. We feel confident that the visually striking increase in juvenile cannabis use depicted in Fig. 1 is not the result of changes in extraneous factors such as poverty or cannabis availability. Finally, in contrast to previous research in this area, we felt it appropriate to examine whether these laws escalate juveniles use illicit drugs such as cocaine, heroin, and methamphetamines. These types of drugs are typically considered to be more deleterious to an individual's health and wellbeing than cannabis.

However, despite these advantages, this study still has a few limitations that warrant some consideration. There remains the chance that our model was incorrectly specified and that the exclusion of some influential variable from the analysis might have influenced our findings and conclusions. Notwithstanding this possibility, we believe that our model is accurate given the current knowledge on this topic. Second, because of sample size constraints, we were unable to disaggregate the data by a respondent's demographic characteristics. Thus, we cannot say whether our findings would vary by the sex or race of the juvenile. Finally, because we only assessed the effect of medical cannabis laws on the longitudinal prevalence of cannabis and non-cannabis illicit drug use, we were unable to determine the effect of these laws on the frequency or quantity of drug use. Future research might wish to investigate this issue further. These limitations are relatively minor, and we remain confident that the results rendered in this study represent the relationship between the medical cannabis laws and juvenile cannabis use.

At the outset of this study, we elaborated on the dearth of available research on the possibility that an escalation in cannabis use among juveniles occurs following the implementation of a medical cannabis law. The lack of research on this topic is more than of trivial concern because of the large number of states that have recently passed medical cannabis laws. Since 2011, which is the last year included in this study, seven states have passed medical cannabis laws and more states are expected to pass such laws in the immediate future. Additionally, Colorado and Washington recently passed laws to legalize cannabis, and the number of legalized cannabis states is expected to grow in the coming years. It is still unknown what effect the legalization of cannabis will have on juvenile use of cannabis. The federal government has also intimated that no attempt will be made to challenge the legality of these laws because cannabis use is illegal at the federal level (Perez, 2013).

We show in this study that medical cannabis laws provide some utility in explaining state differences in juvenile cannabis use. We emphasize, however, that the current study is only preliminary. Every study has shortcomings including the current study, but we feel that the research presented here furnishes a good starting point for future inquiries in this area. Until further analyses are conducted, it would premature to accept our findings and conclusions without some healthy skepticism. The effect of medical cannabis laws on juvenile cannabis use is a salient policy question that deserves additional attention. We hope that this study stimulates further research on this noteworthy topic.

Conflict of interest

There are no conflicts of interest associated with this publication.

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