Section 1. Medical science

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DOES MEDICAL MARIJUANA LEGALIZATION AFFECT ADOLESCENT MARIJUANA USE?

Abstract

Objective: Pennsylvania State legalized medical use of cannabis in year 2016. This study aims to examine if the medical marijuana legalization (MML) has any impact on adolescent marijuana use.

Methods: Data from the Youth Risk Behavior Surveillance System (YRBSS) were used. Data of the states of PA and VA in years 2015 and 2017 were used. For PA, year 2015 and 2017 are pre- and post-MML, respectively. VA state was included for comparison purpose as marijuana remained illegal in VA through 2015 to 2017. Propensity score matching (PSM) was employed, to select participants from two states that are similar in key demographic characteristics. Using the matched participants, Difference-in-differences (DID) analysis was performed to compare the changes in marijuana use rate between the two states from 2015 to 2017.

Results: there were some differences between two states in age and race/ethnicity before matching in both study years. PSM has improved the balance of both variables. using the matched samples, marijuana use remained stable in both states. DID analysis indicates that there's no difference in marijuana use rate change between the two states, which further means that there's no impact of medical marijuana legalization on marijuana use.

Conclusion: Using matched data from YBRS, we found that the medical marijuana legalization in Pennsylvania did not have negative impact on adolescents' marijuana use.

Keywords: medical marijuana legalization, adolescent marijuana use, comparative analysis, Difference-in-differences analysis, propensity score matching.

Introduction

Although the federal government still strictly prohibits marijuana, there have been changes in many states in regulations on pot. According to Wikipedia as of May 2019, the medical use of cannabis is legal (with a doctor's recommendation) in 33 states, and recreational use of cannabis is legal in 10 states [1].

On the other hand, there has been arguments against legalizing marijuana or loosening of cannabis laws. One of the most common arguments is that it may encourage teen use of marijuana.

In Pennsylvania State, medical use of cannabis was legalized in 2016 through a bill enacted by the state legislature. In this study, we aimed to assess the impact of medical marijuana legalization (MML) in

Pennsylvania State on adolescent marijuana use, by comparing change from year 2015 to 2017, with the state of Virginia.

Methods

Data source

Data from the Youth Risk Behavior Surveillance System (YRBSS) were used. (https://www.cdc.gov/healthyyouth/data/yrbs/index.htm)

YRBSS was developed in 1990 by the Centers for Disease Control and Prevention (CDC), aiming to monitor health-related behaviors that contribute to deaths and disabilities among youth and adults. It includes national, state, territorial, tribal government, and local school-based surveys of representative samples of students in 9th through 12th grade. These surveys are conducted every two years.

YRBSS monitors six categories of health-related behaviors:

- Behaviors that contribute to unintentional injuries and violence;
- Sexual behaviors related to unintended pregnancy and sexually transmitted diseases, including HIV infection;
- Alcohol and other drug use;
- Tobacco use;
- Unhealthy dietary behaviors;
- Inadequate physical activity.

This study used combined states data conducted by departments of health and education, which provide data representative of mostly public high school students in each jurisdiction.

Data of the states of PA and VA in years 2015 and 2017 were used. For PA, year 2015 and 2017 are pre- and post-MML, respectively. VA state was included for comparison purpose. It is a neighbor to PA geographically. More importantly, marijuana remained illegal in VA through 2015 to 2017. Therefore, by including VA as the comparison group, the study will be able to detect the effect of marijuana legalization in PA from any effect explained by other variables that influence the secular trend.

Definition of Outcome

In YRBS, Students were asked "During the past 30 days, how many times did you use marijuana?". Answers were:

A. 0 times B. 1 or 2 times C. 3 to 9 times D. 10 to 19 times E. 20 to 39 times F. 40 or more times

A variable "current marijuana use" was created, with current marijuana use =1 if students chose B, C, D, E, or F, and current marijuana use =0 if students chose A.

Data analysis

Step 1. propensity score matching (PSM)

There is some differences between the two states in terms of population size and composition in terms of age, race/ethnicity etc. [2]. Therefore, propensity score matching (PSM) was employed, to select participants from two states that are similar in key demographic characteristics. PSM is a statistical matching technique that attempts to balance two groups accounting for characteristics/covariates that are related to the group assignment (which, in this case, is state of residence).

In this study, PSM was performed for years 2015 and 2017 separately, using logistic regression model. In the model, "state" is the outcome variable, and explanatory variables included the following:

- Age;
- Gender;
- Grade;
- Race/ethnicity;
- Smoking;
- Drinking.

From the logistic model, a propensity score was calculated for every subject. Then matching was performed to match individuals based on the exact values of the score. We also assessed if the PSM was successful by comparing the distribution of the propensity score and Standardized Mean Differences (SMD) between the two states.

Step 2. Analysis based on the matched sample

Using the matched participants, marijuana use rates of the two states were calculated for years 2015

and 2017, respectively. Difference-in-differences (DID) analysis was performed to compare the changes in marijuana use rate between the two states from 2015 to 2017. DID is a statistical technique commonly used in econometrics and quantitative research. It is intended to mitigate the effects of selection bias (i.e., differences between two comparison groups) and extraneous factors [3]. In this study, to conduct DID analysis, an interaction term of state*year was included in logistic model [4]. The coefficient for the interaction is the differences-in-differences estimator. A significance level of alpha < 0.05(2-sided) is used for all analyses.

Results

Propensity Score matching results

Overall matching results:

The sample sizes before and after matching are summarized in (table 1).

Table 1.

		Virginia	Pennsylvania
2015	All	1889	1088
	Matched	1088	1088
	Unmatched/Discarded	801	0
2017	All	1716	1224
	Matched	1220	1220
	Unmatched/Discarded	496	4

To assess if the matching worked, we plotted the distribution of the propensity scores between the two states both before and after matching. We also used Standardized Mean Differences (SMD) as a balance measure of the two groups. A large SMD indicates that groups are different from one another for reliable comparison [5]. Some guidelines indicate that a SMD of 0.1 or 0.25 can be a reasonable cut-off for standardized biases [5].

Matching effect of year 2015 data:

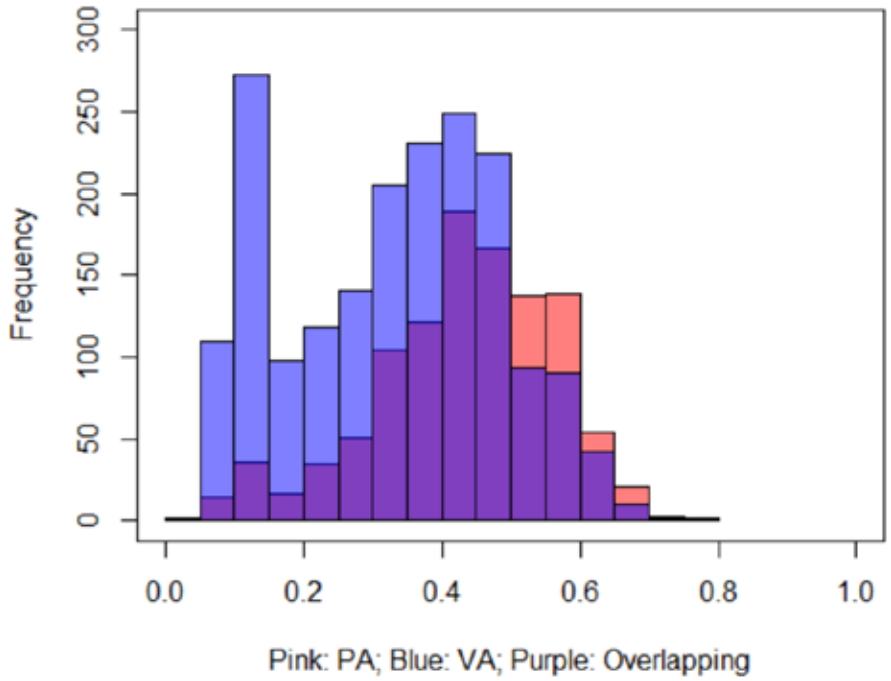

Figure 1. Propensity scores of year 2015, before matching

SMD for 2015, before matching

	VA	PA	SMD
n	1889	1088	
age_cat (%)			0.314
12-14	154 (8.2)	63 (5.8)	
15	356 (18.8)	117 (10.8)	
16	583 (30.9)	389 (35.8)	
17	626 (33.1)	348 (32.0)	
18	170 (9.0)	171 (15.7)	
male (mean (sd))	0.53 (0.50)	0.51 (0.50)	0.035
grade (mean (sd))	10.86 (1.01)	10.95 (0.96)	0.100
smoking (mean (sd))	0.14 (0.35)	0.13 (0.34)	0.027
drinking (mean (sd))	0.33 (0.47)	0.38 (0.48)	0.104
race_ethnicity (%)			0.586
Black	530 (28.1)	82 (7.5)	
Hispanic/Latino	249 (13.2)	157 (14.4)	
Others	187 (9.9)	88 (8.1)	
White	923 (48.9)	761 (69.9)	

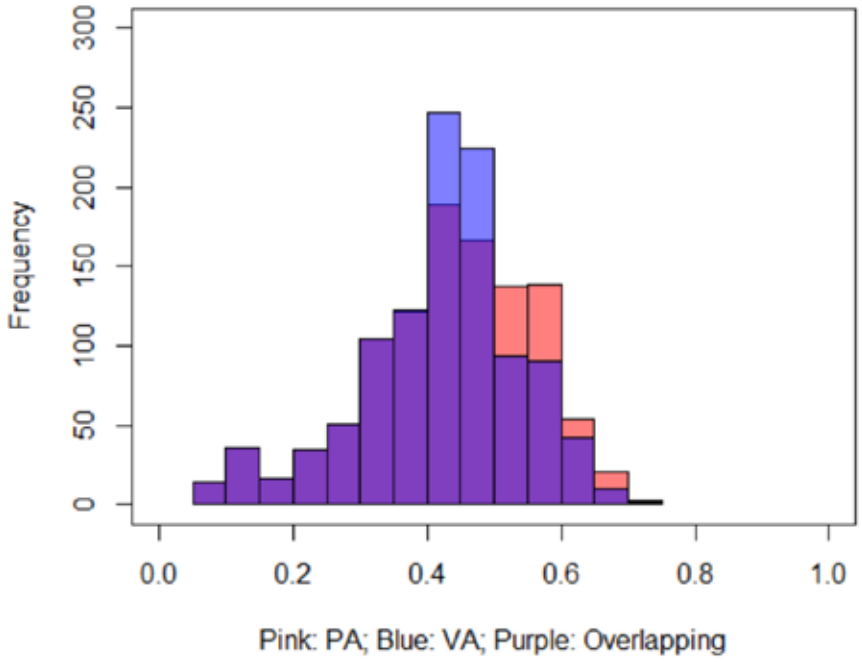

Figure 2. Propensity scores of year 2015, after matching

SMD for 2015, after matching

	VA	PA	SMD
n	1088	1088	
age_cat (%)			0.139
12-14	85 (7.8)	63 (5.8)	
15	121 (11.1)	117 (10.8)	
16	398 (36.6)	389 (35.8)	
17	358 (32.9)	348 (32.0)	
18	126 (11.6)	171 (15.7)	
male (mean (sd))	0.51 (0.50)	0.51 (0.50)	0.009
grade (mean (sd))	10.90 (1.00)	10.95 (0.96)	0.056
smoking (mean (sd))	0.12 (0.32)	0.13 (0.34)	0.031
drinking (mean (sd))	0.36 (0.48)	0.38 (0.48)	0.040
race_ethnicity (%)			0.067
Black	82 (7.5)	82 (7.5)	
Hispanic/Latino	181 (16.6)	157 (14.4)	
Others	93 (8.5)	88 (8.1)	
White	732 (67.3)	761 (69.9)	

It can be seen that, in year 2015, there were large differences between two states in age and race/ethnicity (SMD >0.25). PSM has improved the balance of both variables with lower SMDs after matching. For example:

- Distribution of age: Before matching, there were 9% of 18-year-old in Virginia versus 15.7% in Pennsylvania. After matching, the proportion difference was reduced.
- Distribution of race/ethnicity: Before matching, there were 28% of Black Americans in Virginia versus only 7.5% in Pennsylvania. After matching, the proportion difference was balanced to 7.5% of Black Americans in both states.

Matching effect of year 2017 data:

Similar pattern of improvement was seen for year 2017 as that in year 2015. Before matching, there were big difference in race and moderate difference in race/ethnicity. PSM improved SMDs in both of these variables.

SMD before matching:

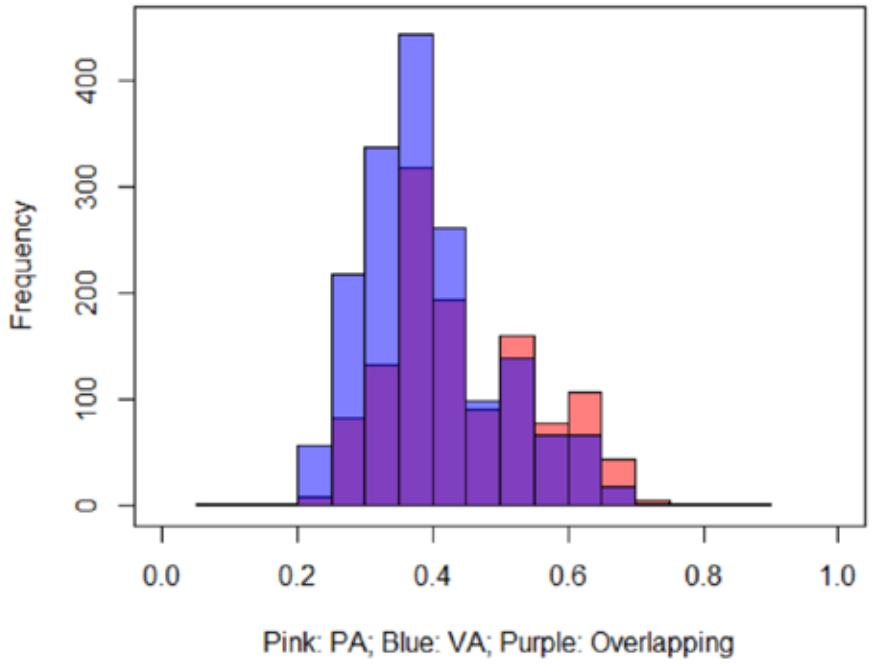

Figure 3. Propensity scores of year 2017, before matching

SMD for 2017, before matching

	VA	PA	SMD
n	1716	1224	
age_cat (%)			0.311
12-14	131 (7.6)	81 (6.6)	
15	308 (17.9)	147 (12.0)	
16	546 (31.8)	383 (31.3)	
17	608 (35.4)	416 (34.0)	
18	123 (7.2)	197 (16.1)	
male (mean (sd))	0.50 (0.50)	0.49 (0.50)	0.003
grade (mean (sd))	10.88 (0.99)	10.92 (1.03)	0.033
smoking (mean (sd))	0.07 (0.26)	0.09 (0.28)	0.057
drinking (mean (sd))	0.30 (0.46)	0.35 (0.48)	0.105
race_ethnicity (%)			0.203
Black	268 (15.6)	160 (13.1)	
Hispanic/Latino	303 (17.7)	218 (17.8)	
Others	254 (14.8)	114 (9.3)	
White	891 (51.9)	732 (59.8)	

SMD after matching:

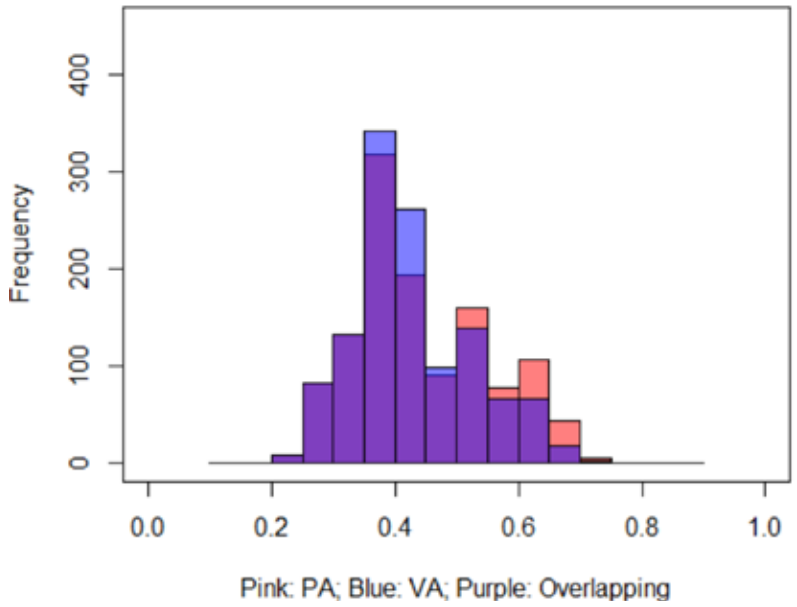

Figure 4. Propensity scores of year 2017, after matching

SMD for 2017, after matching

	VA	PA	SMD
n	1220	1220	
age_cat (%)			0.225
12-14	98 (8.0)	78 (6.4)	
15	113 (9.3)	147 (12.0)	
16	435 (35.7)	383 (31.4)	
17	455 (37.3)	416 (34.1)	
18	119 (9.8)	196 (16.1)	
male (mean (sd))	0.50 (0.50)	0.49 (0.50)	0.023
grade (mean (sd))	10.92 (1.00)	10.91 (1.03)	0.002
smoking (mean (sd))	0.08 (0.27)	0.09 (0.28)	0.024
drinking (mean (sd))	0.35 (0.48)	0.35 (0.48)	0.003
race_ethnicity (%)			0.027
Black	156 (12.8)	160 (13.1)	
Hispanic/Latino	222 (18.2)	217 (17.8)	
Others	104 (8.5)	112 (9.2)	
White	738 (60.5)	731 (59.9)	

Marijuana use rates

From unmatched data, it seemed that adolescents' marijuana slightly increased in PA while slightly decreased in VA. However, using the matched samples, marijuana use remained stable in both states, and the trend seemed to be very similar.

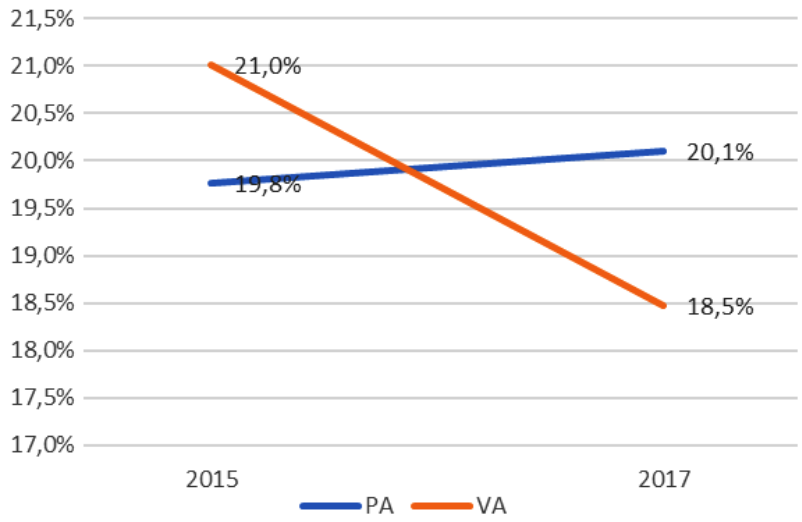

Figure 5. Marijuana use rate before matching

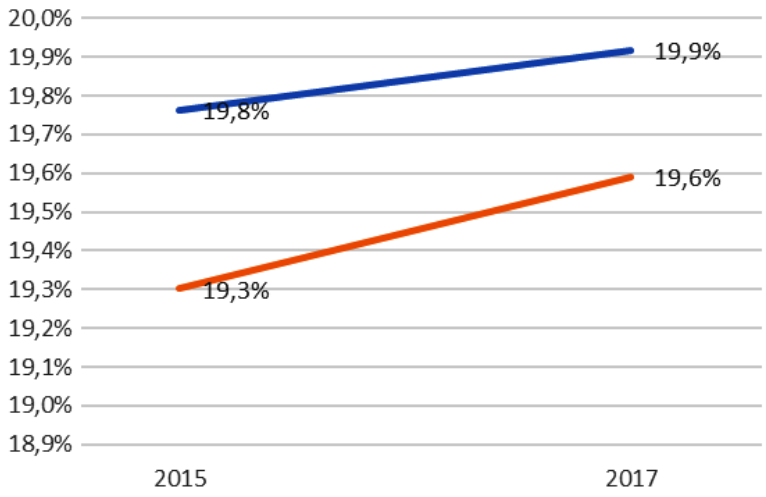

Figure 6. Marijuana use rate before matching

Impact of medical marijuana legalization on marijuana use: results from DID analysis

As mentioned above, when testing the impact of medical marijuana legalization on marijuana use using DID analysis, the metric to look for is the interaction term between state and year.

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Coefficients:
                          Estimate Std. Error z value             Pr(>|z|)
(Intercept)              -1.401298   0.076136 -18.405 <0.0000000000000002 ***
sitecodeVA               -0.029242   0.108155  -0.270                0.787
as.factor(year)2017       0.009872   0.104572   0.094                0.925
sitecodeVA:year 2017     -0.001882   0.148570  -0.013                0.990
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The P-value of the interaction term of state*year was 0.99. This indicates that there's no difference in marijuana use rate change between the two states, which further means that there's no impact of medical marijuana legalization on marijuana use.

Discussion

In this study, we specifically examined if the medical marijuana legalization had any impact on adolescents' marijuana use. In order to make a fair comparison, we used Virginia as control group, so that any other factors at the same time as the MML such as other policy changes are taken into account. Virginia is a good control option since marijuana has remained illegal through the study years. Meanwhile, these two states are close geographically.

We did notice that there are demographic differences between these two states, mainly in age and race/ethnicity. By employing propensity score matching, we were able to select comparison groups that are better balanced in key demographic characteristics. From the matched samples, marijuana use rates in both states remained stable from year 2015 to 2017. From the DID analysis, we found no difference in the marijuana use change between the two states. Therefore, it can be argued that the medical marijuana legalization in Pennsylvania did not negatively impact the marijuana use of the state.

This is consistent with findings from other states. For example, a federal report reveals that teen marijuana use in Colorado did not increase since adult use marijuana was legalized in 2012 [6]. Meanwhile, a state-run survey of 37.000 middle and high school students in Washington state finds that rates of marijuana use among adolescents have remained virtually flat **since** the state legalized recreational marijuana in 2012 [7]. A lot of data showed that not only does legalization not increase teen marijuana use, but also the loosening of cannabis laws doesn't make it any easier for teens to access marijuana. Nor does it influence their attitudes toward marijuana [6].

According to the Marijuana Policy Project spokesperson Mason Tvert, "… it should be particularly welcome news for those who opposed the state's legalization for fear it would lead to an explosion in teen use. Hopefully it will allay opponents' concerns in other states where voters or lawmakers are considering proposals to legalize and regulate marijuana for adult use" [6].

Our findings added one more piece to the evidence of no negative effect of MML on adolescent marijuana use. Like Mason Tvert stated, " Rather than debating whether marijuana should be legal for adults, let's focus on how we can regulate it and control it to make it less available to teens" [6].

Summary

Using matched data from YBRS, we found that the medical marijuana legalization in Pennsylvania did not have negative impact on adolescents' marijuana use.

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