The Medical Marijuana Laws and Marijuana Use among U.S. Adolescents: Evidence from Michigan Youth Risk Behavior Surveillance Data

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Abstract

Research findings are inconsistent regarding a positive association between the passage of state medical marijuana laws (MML) and adolescent access and use marijuana. We utilized a novel analytical approach to examine this issue with multi-year data from the 1997-2013 Youth Risk Behavior Surveillance System (YRBSS) of the State of Michigan. After controlling for the historically declining trend in marijuana use prior to the passages of MML in Michigan, we found that marijuana use among adolescents had increased subsequent to the passage of state MML. Study findings suggest the need for considering the increased risk of marijuana use among adolescents as the number of states with laws permitting marijuana use is increasing.

Key Words: Medical marijuana laws; Adolescents; Marijuana use; YRBS; Michigan

Introduction

A large and increasing number of adolescents and young adults use marijuana, exerting a significant public health burden globally (National Institute on Drug Abuse, 2017; WHO, 2017). Policies and regulations represent one of the evidence-based approaches to prevent marijuana use among adolescents (Pacula, Boustead, & Hunt, 2014). However, a number of developed countries, including Australia, Canada, Germany, Italy, Netherlands, and Spain have established different types of laws and regulations decriminalizing the use of marijuana products (European Monitoring Centre for Drugs and Drug Addiction, 2016, 2017; Fischer, Kuganesan, & Room, 2015; Korf, 2002; Mulligan et al., 2012). In the United States (U.S.), laws were first passed in California in 1996 to permit marijuana use for medical purposes. To date, 29 of the 50 U.S. states and the District of Columbia have passed state medical marijuana laws (MML). Although these laws differ from one state to another with regard to the detailed law provisions, they all make it legal to use marijuana for a set of specified medical conditions (Global Smokefree Partnership, 2009).

Regulation of marijuana in the United States

For people living in states with MML, it is legal to use marijuana for medical purposes. To support marijuana use for medical purposes, MML in most states also includes provisions permitting their citizens to possess, distribute, and cultivate marijuana (Pacula et al., 2014). Proponents of the medical use of marijuana argue that cannabidiol (CBD), an anti-psychoactive ingredient in marijuana could be beneficial for health (Schweinsburg, Brown, & Tapert, 2008). Research data indicate that CBD can help control negative emotions and relieve pains in patients (Bello, 2010; Haney, 2002; Kepple & Freisthler, 2012). Findings from this line of research provide the neurobiological and pharmacological arguments for legalizing marijuana for medical use (Morris, TenEyck, Barnes, & Kovandzic, 2014; Wagenaar & Burris, 2013).

Although marijuana use becomes legal in the states with marijuana laws, marijuana remains regulated by federal laws as a Schedule I illicit drug (i.e., high potential for abuse, no currently accepted medical use, and lack of accepted safety guidelines for use) (Cohen, 2015). Research findings attribute the negative effect of marijuana to tetrahydrocannabinol (THC), a primary psychoactive ingredient of marijuana (Ashton, 2001). Exposure to marijuana is associated with a number of negative consequences, including neurocognitive impairment, unsafe driving, tobacco smoking, alcohol consumption, unprotected sex and delinquent behaviors (Gundy & Reebellon, 2010; Hendershot, Magnan, & Bryan, 2010; Keen & Turner, 2014; Peters, Budney, & Carroll, 2012; Terry-McElrath, O'Malley & Johnston, 2014).

Medical Marijuana Laws in Michigan

Michigan, a Midwest state bordered by the Great Lakes, has a population of 9.9 million (Schuermeyer et al., 2014). The topic of medical marijuana use was initiated in 2000 by the Ann Arbor Libertarians, but no local legislation regarding medical marijuana use was passed until 2004 when voters in Detroit first approved a city MML. Following Detroit, several Michigan cities passed municipal MML, including Ann Arbor in 2004, Ferndale and Traverse City in 2005 and Flint in 2007 (NORMAL, 2017). Michigan enacted its state MML in November 2008 after years of statewide public debate and voting (NCSL, 2015). The Michigan MML includes four major provisions: a) Patient registry/ID card, b) regulation of medical practice, c) regulations of possession and limits, and d) legal defense and protection of users.

Evaluation Challenges and Inconsistent Findings

Studies have been conducted to assess the impact of medical marijuana legalization on marijuana abuse, but no consistent conclusions have been reached. Several studies have found no association between MML and marijuana abuse with data collected from different

populations, including adolescents and adults from the general population, juveniles from the criminal justice system, and patients from medical care facilities (Gorman & Huber, 2007; Lynne-Landsman, Livingston, & Wagenaar, 2013; Pacula, Powell, Heaton, & Sevigny, 2013; Stiglitz, 1989). Several other studies have detected lower rates of marijuana use among adolescents in states with laws permitting medical marijuana use compared to those in states without such laws (Harper, Strumpf, & Kaufman, 2012; Lynne-Landsman et al., 2013). A third group of studies found mixed results with positive associations for some subpopulation groups (e.g. juveniles, young children) and no associations for others (e.g., adolescents in the general population) (Stolzenberg, D'Alessio, & Dariano, 2016; Wall et al., 2016; Wang, Roosevelt, & Heard, 2013).

One explanation for the inconsistent findings from different studies could be the complexity in assessing the effect of MML on marijuana abuse (Friedman, Terras, & Glassman, 2003; Stolzenberg et al., 2016). Passage of state MML differs from implementation of an intervention trial in a number of ways. Unlike an intervention trial, no state is randomized to pass MML. As a result, no real comparison group can be scientifically established as a control to detect the effect of MML. This difference also makes the commonly used statistical methods ineffective for evaluation studies to detecting both the within- and between-group differences. Further, since the passage of MML is a public process, information regarding marijuana legislation in one state can easily be spread to other states, including the states without MML. Information diffusion therefore reduces validity of the non-MML states serving as controls to assess the between-state difference (Chen, 2016; Friedman et al., 2003; Miech et al., 2015; Stolzenberg et al., 2016). Finally, although MML of a state is enacted in a specific year,

completing MML legislation takes time, often lasting for several years. This timing factor must be considered in a study to evaluate the effect of MML.

Purpose of this Study

In this study, we proposed a new analytical approach considering the evaluation challenges described above, and applied it in evaluating the potential impact of state MML on adolescent marijuana use in Michigan. As described above, adolescents are highly vulnerable to marijuana because of the imbalance of cognitive and physical development. Although a number of studies have investigated the impact of state MML on adolescent marijuana use/abuse as described in the previous section, no consistent conclusion has been reached regarding the relationship between MML and adolescent marijuana use while the number of states with MML is increasing. The large number of states with state legislation on marijuana use for medical purposes and YRBS data in Michigan provide an opportunity to examine the issue. The goal of this study is to provide empirical data for decision-makers and the general public to strengthen current adolescent drug use prevention while legalizing marijuana use, and to inform future research to investigate the connection between MML and adolescent marijuana abuse if there is a positive relationship between MML and adolescent marijuana.

Materials and Methods

Data Sources and Study Population

Data used for this study were derived from the Michigan Youth Risk Behavior Survey (YRBS), 1997-2013 (http://www.cdc.gov/healthyyouth/data/yrbs/data.htm). The survey participants were students in grades 9-12, selected using a two-stage cluster random sampling method. First, schools were selected with probability proportionate to enrollment size from the school sampling frame in which all public schools were included. Second, classes within the

participating schools were selected randomly; data from all students in the selected classes were included. Students completed the self-administered questionnaire (Brener et al., 2013). The study was approved by the Institutional Review Board of the University of Florida.

Measurement

Never-users: This variable was defined as those students who reported never having used marijuana. Participants were coded as never-users if they selected "*0 times*" to the question: "During your lifetime, how many times have you used marijuana?" with seven answer options (0 times, 1 or 2 times, 3-9 times, 10-19 times, 20-39 times, 40-99 times, and 100 or more times).

Current users: Participants were coded as current marijuana users if they reported any use of the drug in their lifetime and also having used it at least one time in the past 30 days, based on their responses to the question: "During the past 30 days, how many times did you use marijuana?" Answer options to this question include 0 times, 1-2 times, 3-9 times, 10-19 times, 20-39 times, and 40 or more times.

Demographic variables were age (in years), gender (male/female), and race (White, Black and others). These variables were used to characterize the sampled participants and their variations at different years of survey.

Statistical Analysis

We employed a historical trend analysis approach to test the hypothesis that the passage of MML in Michigan is associated with increased marijuana use among adolescents. The principle of our method is the same as the interrupted time series analysis commonly used in analyzing the effect of policy change (Keen & Turner, 2014; Murphy, Durako, Muenz, &

Wilson, 2000). We hypothesized the existence of a turning point associated with MML after which the increasing trend in the number of youth reporting never having used marijuana slows down and the declining trend in the number of current marijuana users levels off. We detected linear trends before and after MML using a linear regression model, followed by a piece-wised testing method (Auslander, Thompson, & Gerke, 2014) to statistically locate the turning point.

The statistical analysis was conducted at both the aggregate-level, and individual-level. At the aggregate level, the prevalence rates of current use and never-use for each survey year were estimated. The PROC SURVEYMEANS in SAS was used to compute the prevalence rates considering the sampling design. The time trends before and after the state MML were modeled with two separate linear regression models, and the differences in the two regression slopes were assessed using Z test.

At the individual level, current user (y/n) and never-user (y/n) were modeled separately using the PROC GENMOD in SAS with the survey year as the predictor variable. The survey year was first modeled as a continuous variable to capture the linear trends prior to and post state MML. A non-inclusive 95% CI between the two regression slopes was used as evidence of significant difference. The survey year was further modeled as a categorical variable to quantify the association between MML and marijuana use.

Mathematical rotations were conducted to control confounding from the declining historical trend in marijuana use prior to the passage of MML. The continuous declining trend makes the conventional pre-post comparison ineffective, resulting in contradictory conclusions even if the MML might have stopped the declining trends in adolescent marijuana use. The rotation method was used to help overcome this limitation by turning overall time trends in the

two marijuana-use measures during 1997-2013 such that the slope became zero for the period prior to the state MML.

Our effort to locate one or more non-MML states to serve as a control failed because none of these states showed a trend similar to that of Michigan regarding marijuana use before 2008 (Appendix Fig A1). Therefore no single state can be employed as a control to assess MML for Michigan. The advantages of the historical analytical approach we used were: a) building on historical trend, rather than being biased by it; b) utilizing multi-wave survey data of one state to test the study hypothesis; and c) taking advantage of a *self-control* design to assess within-state differences in marijuana use before and after MML while controlling confounders (Gundy & Reebellon, 2010). This method has been used to evaluate tobacco control programs at the state level (Chen, Li, Unger, Liu, & Johnson, 2003).

Results

Characteristics of the study sample

Data from nine waves of YRBS survey for a total of 29,000 participants 12-17 years of age were included. Among the total sample (Table 1), 48.33% were male and 69.24% were white, 16.02% black, and 14.74% other races.

Table 1 Sample Characteristics of the YRBS Participants, 1997-2013, Michigan, USA

Year	Total	Gender		Race		
		Male	**Female**	**White**	**Black**	**Others**
1997	3616 (12.29)	1657 (45.82)	1959 (54.18)	1471 (41.02)	1748 (48.75)	367 (10.23)
1999	2481 (8.43)	1171 (47.20)	1310 (52.80)	1935 (79.43)	293 (12.03)	208 (8.54)
2001	3262 (11.09)	1554 (47.64)	1708 (52.36)	2408 (74.62)	399 (12.36)	420 (13.02)
2003	3138 (10.66)	1551 (49.43)	1587 (50.57)	2180 (70.03)	407 (13.07)	526 (16.90)
2005	2965 (10.08)	1368 (46.14)	1597 (53.86)	2145 (72.81)	313 (10.62)	488 (16.56)
2007	3171 (10.78)	1581 (49.86)	1590 (50.14)	2264 (72.49)	253 (8.10)	606 (19.40)
2009	3051 (10.37)	1552 (50.81)	1499 (49.13)	2229 (74.20)	309 (10.29)	466 (15.51)
2011	3854 (13.10)	1886 (48.94)	1968 (51.06)	2854 (75.11)	391 (10.29)	555 (14.61)
2013	3888 (13.21)	1901 (48.89)	1987 (51.11)	2634 (68.86)	543 (14.20)	648 (16.94)
Total	29426 (100.00)	14221 (48.33)	15205(51.67)	20120 (69.24)	4656 (16.02)	4284 (14.74)

Prevalence rates of current marijuana users and never-users

Results in Table 2 indicate that the prevalence of current marijuana use among Michigan adolescents showed a spike in 2009 and, correspondingly, the prevalence of never-users showed a dip in 2009. This result was true for the overall sample and by gender and racial groups.

Table 2. Estimated Prevalence, % [95% CI] of Adolescent Marijuana Use, 1997-2013 YRBS Data, Michigan, the United States

Year	Total	Gender		Race		
		Male	**Female**	**White**	**Black**	**Others**
Current users						
1997	28 [25, 32]	32 [27, 36]	25 [20, 29]	28 [23, 32]	28 [21, 34]	34 [27, 42]
1999	26 [23, 30]	30 [26, 34]	23 [19, 27]	25 [22, 29]	30 [19, 40]	29 [22, 37]
2001	24 [22, 27]	25 [22, 28]	24 [20, 27]	25 [22, 28]	21 [16, 26]	22 [19, 26]
2003	24 [20, 28]	26 [20, 31]	23 [20, 26]	24 [19, 28]	27 [20, 35]	24 [20, 28]
2005	19 [16, 22]	20 [16, 24]	18 [15, 20]	18 [15, 21]	22 [17, 28]	26 [21, 32]
2007	18 [16, 21]	20 [17, 23]	17 [14, 20]	18 [15, 21]	20 [16, 24]	20 [15, 26]
2009	21 [19, 23]	22 [19, 25]	20 [17, 22]	21 [18, 23]	21 [14, 28]	25 [20, 31]
2011	19 [16, 21]	22 [19, 25]	16 [13, 19]	19 [16, 21]	18 [11, 24]	20 [15, 25]
2013	18 [16, 19]	19 [17, 21]	17 [15, 19]	18 [16, 19]	18 [13, 22]	21 [16, 26]
Never-users						
1997	52 [47, 57]	49 [44, 54]	54 [48, 61]	53 [47, 59]	46 [39, 53]	48 [39, 57]
1999	53 [50, 57]	50 [46, 54]	56 [52, 61]	54 [50, 58]	48 [37, 60]	51 [44, 58]
2001	56 [52, 60]	55 [50, 59]	58 [54, 62]	56 [51, 60]	60 [53, 67]	53 [47, 59]
2003	56 [51, 60]	53 [49, 58]	58 [53, 63]	57 [52, 61]	50 [41, 59]	56 [51, 62]
2005	62 [58, 66]	60 [54, 65]	64 [60, 69]	65 [61, 69]	50 [42, 59]	54 [47, 61]
2007	64 [61, 68]	62 [57, 67]	67 [62, 71]	65 [61, 70]	61 [54, 68]	60 [54, 67]
2009	63 [61, 66]	62 [58, 66]	65 [62, 68]	64 [61, 67]	62 [57, 68]	60 [55, 66]
2011	66 [62, 69]	62 [58, 65]	70 [65, 74]	68 [64, 71]	61 [51, 70]	61 [55, 67]
2013	67 [65, 70]	66 [63, 69]	69 [66, 72]	69 [66, 71]	62 [53, 71]	65 [59, 71]

Note: Michigan passed its state Medical Marijuana Laws in November 2008.

Trends in marijuana use pre and post MML

Fig. 1 depicts the time trend of current marijuana use for the total sample. The prevalence rate showed an overall declining trend from 28.20% in 1997 to 18.75% in 2005 with

an interruption during 2001-03 prior to the approval of the Detroit MML in 2004. The declining

trend slowed down from 2005 to 2007, followed by a sudden increase with a peak rate of 20.67%

in 2009 before it started to decline and ended at 18.22% in 2013. Results from piece-wise testing

indicate that the *turning point* of the overall trend was 2006.
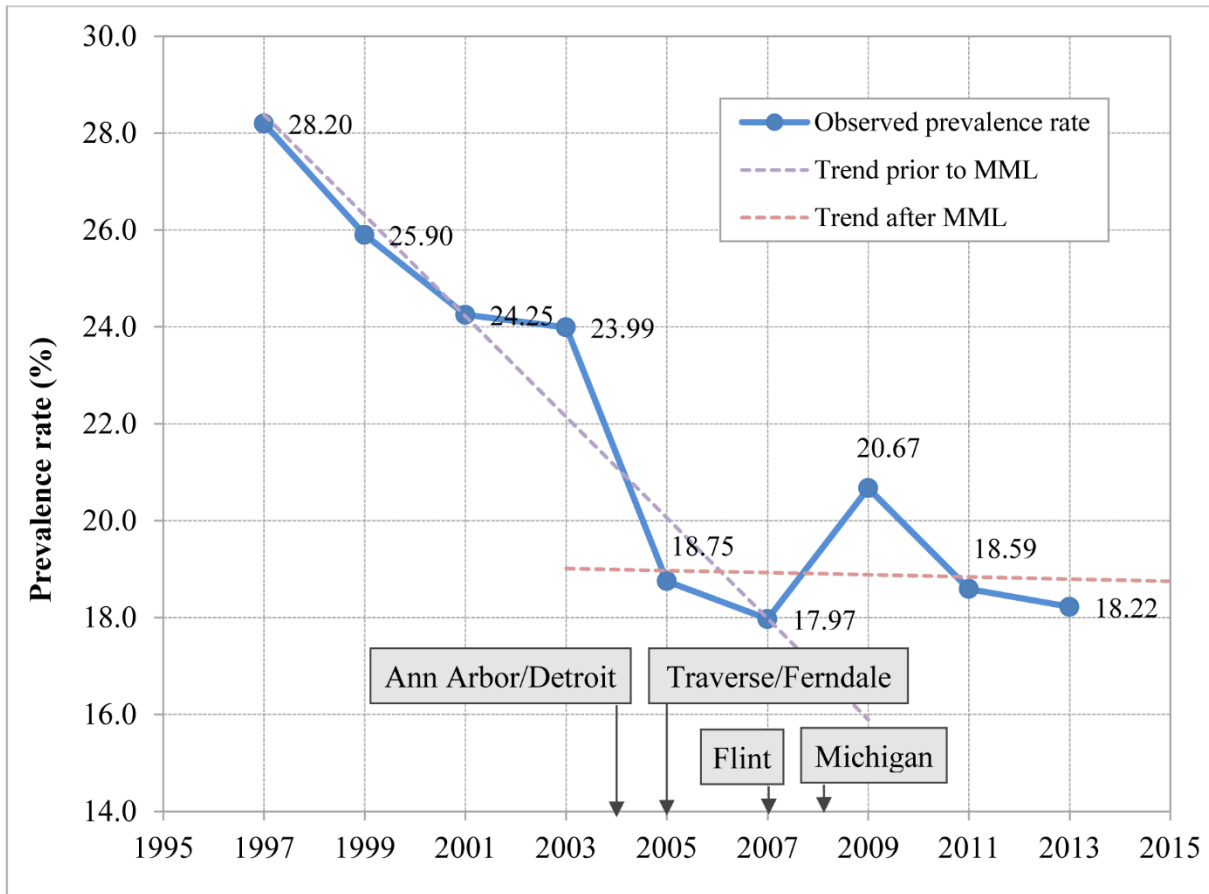
Fig 1. Changes in the prevalence of current marijuana use among Michigan adolescents and the passage of Medical Marijuana Laws in five local cities and the Michigan State

Note: The dashed straight lines in purple and red describe the linear trends before and after MML in Michigan and were derived by fitting the prevalence rates to a linear model during the two periods respectively.

Data source: 1997-2013 Michigan YRBS

Fig 2 shows the time trends of the prevalence of adolescents who reported having never used marijuana. Consistent with the findings in Fig 1, up to 2005 there was a progressive increase in this rate; and the speed of increase started to slow down from 2005 to 2007, followed by an obvious drop during the 2007-09 before a growing trend resumed, but with a flatter slope. Results from the piece-wise test indicated that the turning point of the two trends also occurred in 2006.
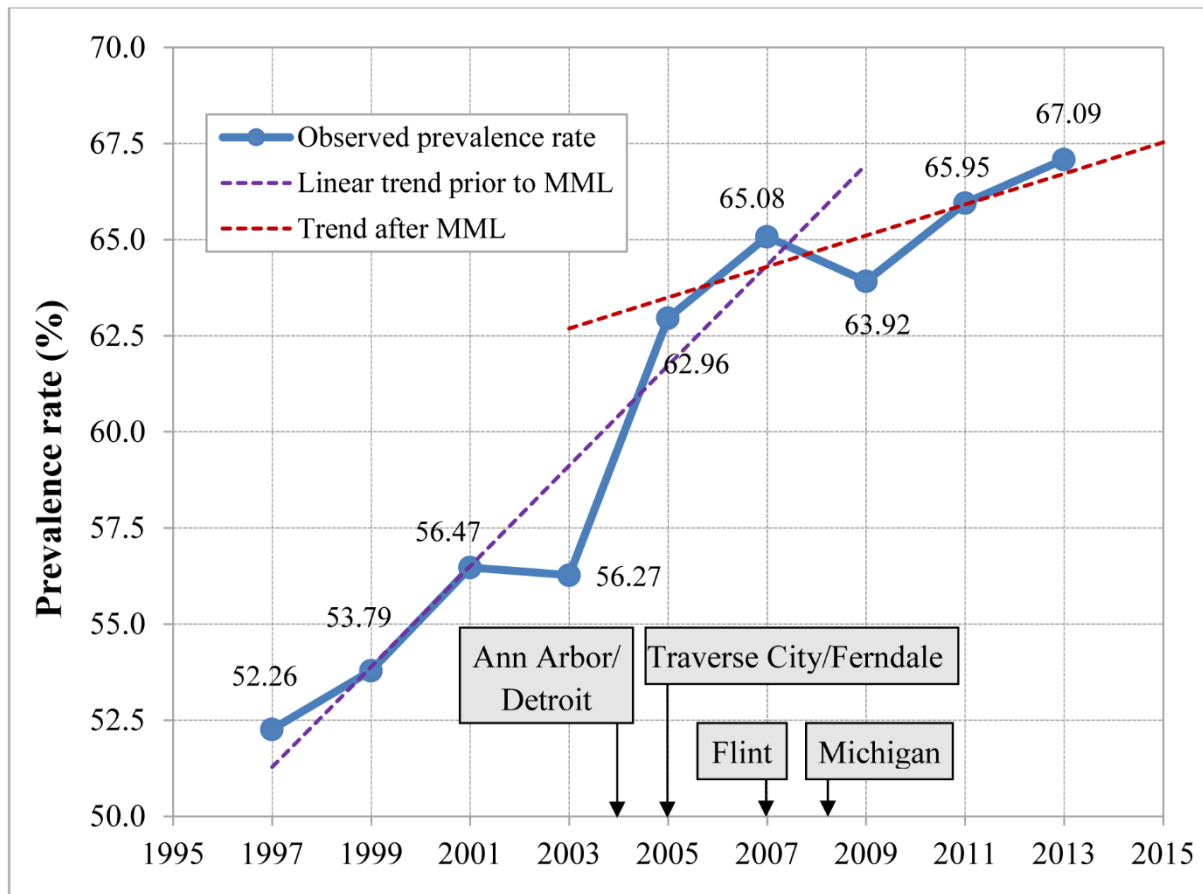
Fig 2. Changes in the prevalence of marijuana never-users among Michigan adolescents before and after the Medical Marijuana Laws in Michigan

Note: The dashed straight lines in purple and red describe the linear trends before and after MML in Michigan and were derived by fitting the prevalence rates to a linear model during the two periods respectively.

Data source: 1997-2013 Michigan YRBS

Comparison of the trend of marijuana use measures pre and post MML

A comparison of the beta coefficients of the two linear regression lines of the current marijuana user trend (the upper panel of Table 3) indicate a significant decrease in the reduction of current marijuana use after MML. Since there was no YRBS data in 2006, the detected turning point, we used both 2005 and 2007 as the turning points to statistically test the effect. When 2007 was used as the turning point, the beta coefficient [95% CI] was -.0567 [-.0576, -.0559] for the trend from 1997 to 2007, and -.0114 [-.0131, -.0097] after 2007, the difference was statistically significant. A similar result was observed when the year 2005 was used as the turning point.

Results from the lower panel of Table 3 indicate significant reductions in the growing trend of the proportion of never-users after the state MML, regardless as to whether year 2005 or 2007 was used as the turning point.

Associations assessed at the individual level

Results in the upper panel of Table 4 indicate that after rotating the prevalence of marijuana use over time such that the trend for the period before MML became flat, there were significant positive relationships between MML and current marijuana use in all survey years. When year 2007 was used as the reference, the rotated model coefficient was .2718 (OR=1.31) in 2009, .2240 (OR=1.25) in 2011 and .2893 (OR=1.34) in 2013, p<.01 for all. A stronger association was observed when year 2005 was used as the reference.

Likewise, results in the lower panel of Table 4 indicate a significant negative association between MML and never-users when either 2005 or 2007 was used as the reference year.

Table 3 Comparison of the Trends in Marijuana Use among Michigan Adolescents before and after the Passage of the State Medical Marijuana Laws: Results from the aggregate level analysis

Marijuana users	*B*	*SE*	95% CI	
			Lower	Upper
Current use				
Trend prior to MML up to 2007				
Trend before MML	-0.0567	0.0004	-0.0576	-0.0559
Trend after MML	-0.0114	0.0009	-0.0131	-0.0097
Trend prior to MML up to 2005				
Trend before MML	-0.0551	0.0006	-0.0562	-0.0540
Trend after MML	-0.0114	0.0009	-0.0131	-0.0097
Never-used				
Trend prior to MML up to 2007				
Trend before MML	0.0528	0.0004	0.0521	0.0535
Trend after MML	0.0237	0.0007	0.0223	0.0251
Trend prior to MML up to 2005				
Trend before MML	0.0471	0.0005	0.0461	0.0480
Trend after MML	0.0237	0.0007	0.0223	0.0251

Note: The two beta coefficients of marijuana use indicators for the two comparison periods were estimated by fitting a linear model of the data for the corresponding periods assuming a binary distribution of marijuana use. The difference in the beta between the two comparison periods was judged with the 95% confidence interval (CI), with no inclusion of the two CIs as the indication of statistical significance at $p < .05$ level (two-sided).

Table 4. Positive associations between MML and risk of current marijuana use among adolescents in Michigan: Results from the individual level data analysis

Year	2007 as the turning year		2005 as the turning year	
	Rotated	**Original (SE)**	**Rotated**	**Original (SE)**
Current use				
1997	-0.0133	0.5402 (.0052)**	0.0537	0.4773 (.0051)**
1999	0.0080	0.4508 (.0053)**	0.0702	0.3879 (.0052)**
2001	0.0242	0.3563 (.0053)**	0.0816	0.2934 (.0052)**
2003	0.1253	0.3467 (.0052)**	0.1779	0.2838 (.0051)**
2005	-0.0478	0.0629 (.0054)**	Reference	Reference
2007	Reference	Reference	0.0043	-0.0629 (.0054)**
2009	0.2718**	0.1611 (.0054)**	0.3100**	0.0982 (.0053)**
2011	0.2240**	0.0026 (.0054)**	0.2574**	-0.0603 (.0053)**
2013	0.2893**	-0.0428 (.0057)**	0.3179**	-0.1057 (.0056)**
Never-used				
1997	0.0028	-0.5007 (.0045)**	-0.0423	-0.3975 (.0044)**
1999	-0.0399	-0.4427 (.0045)**	-0.0731	-0.3395 (.0044)**
2001	-0.0489	-0.3510 (.0045)**	-0.0702	-0.2478 (.0044)**
2003	-0.1488	-0.3502 (.0044)**	-0.1582	-0.2470 (.0043)**
2005	-0.0025	-0.1032 (.0044)**	Reference	Reference
2007	Reference	Reference	-0.0057	0.1032 (.0044)**
2009	-0.1208**	-0.0201 (.0045)**	-0.0945**	0.0831 (.0045)**
2011	-0.0899**	0.1115 (.0045)**	-0.0517**	0.2147 (.0044)**
2013	-0.1462**	0.1559 (.0047)**	-0.0961**	0.2591 (.0046)**

Note: Age, sex and race were included as covariates to account for their variations in the study sample across years. The rotation of the estimated coefficients was made by setting the slope = 0 for a linear trend before 2007 and 2005 respectively.

Discussion

The growth in marijuana use among adolescents since 2005 has emerged as a significant challenge in the United States (Johnston, O'Malley, Bachman, & Schulenberg, 2011).

Furthermore, this challenge is accompanied by a growing number of states that permit marijuana use through state legislature. In this study, we examined the association between state MML and risk of marijuana use among students in grade 9-12 in Michigan using the YRBS data. Findings of this study provide new evidence supporting a positive relationship between state MML and marijuana use, underscoring the need for further research to understand the mechanisms underpinning the complex underlying the positive relationship. The data also suggest a possible need for strengthening drug use prevention programs simultaneous with efforts advocating for legalization of marijuana through state legislature.

Findings from our analysis showed a significant and positive association between the state MML and adolescent marijuana use in Michigan, including increased risk of marijuana initiation and current use and declines in the number of never-users. The effect peaked at 2009 and remained significant through 2013 when the most recent survey data were available for evaluation when this research was conducted. Findings of this study are consistent with and support those from several reported studies that state MML can increase the risk of marijuana use (Chu, 2014; Schuermeyer et al., 2014; Thurstone, Lieberman, & Schmiege, 2011; Wang et al., 2013); but contradict those reporting a protective effect (Harper et al., 2012), or no effect at all (Choo et al., 2014; Friese & Grube, 2013; Hasin et al., 2015; Khatapoush & Hallfors, 2004; Wall et al., 2016).

According to the findings of our analysis, the passage of MML in Michigan was associated with increased risk of adolescent marijuana use. Along with the process of passing the state MML, the historically declining trend in adolescent marijuana use leveled off; and the numbers of adolescent marijuana users increase. Given the total 535,452 students in grades 9-12 in Michigan during the 2008-09 school year (US Census data), an estimate of additional 25,541

adolescents might have initiated marijuana use in the state in 2009 alone. If this study finding can be verified using data from other states, the states with either extant MML or considering legislation to pass MML for adults should consider concomitant legislation to prevent potential increased marijuana accessibility to adolescents. Consideration should also be given to developing and/or intensifying extant public health policies and health education programs for adolescent marijuana use prevention.

Several mechanisms have been proposed to explain the association between state MML and marijuana use among adolescents. MML may increase the risk of marijuana use by increasing marijuana availability and the accessibility (Cerdá, Wall, Keyes, Galea, & Hasin, 2012; Miech et al., 2015; Pacula et al., 2013; Sevigny, Pacula, & Heaton, 2014; Stolzenberg et al., 2016; Wall et al., 2011). As well, information spread of the public debate on marijuana through the mass media prior to enactment of MML legislation may make adolescents perceive marijuana as less harmful (Friese & Grube, 2013; Khatapoush & Hallfors, 2004). Lastly, state MML may increase peer approval of marijuana use, and alter attitudes and social norms in favor of marijuana use (Lipperman-Kreda, Grube, & Paschall, 2010; Lipperman-Kreda & Grube, 2009). Additional studies are needed to examine these mechanisms.

Consistent with the findings of this study, the American Academy of Child and Adolescent Psychiatry (AACAP) has issued a statement expressing concerns about the negative effects of medical marijuana on youth. "Medicalization" of marijuana has distorted the perception of the known risks and purported benefits of this drug (American Academy of Child & Adolescent Psychiatry, 2012). Likewise, in 2015, the American Academy of Pediatrics (AAP) reaffirmed its opposition to legalizing marijuana (American Academy of Pediatrics, 2015). Findings from newly published studies indicate that more and more adolescents are now

initiating marijuana use (Chen, Yu, Lasopa, & Cottler, 2017). No MML in any of the 29 states in the US contain components to prevent marijuana abuse among adolescents either by strengthening current drug use prevention programs or establish new prevention programs. Consideration should be given to increasing the current drug-use prevention efforts across the country, particularly the states with states laws legalizing marijuana use.

Limitations

There are limitations to this study. First, we analyzed data from only one state – Michigan. Caution is needed if generalizing the findings of this study to other states. Second, the YRBS, including Michigan YRBS is conducted every other year. It prevented us from assessing the state MML on an annual basis, particularly during 2004-2008 when several local municipals passed their MML before the statewide legislation. Third, marijuana use was measured using self-reported data. Misreport cannot be ruled out without biomarker validation, such as THC from urine drug test. Finally, this analysis was essentially a pre- and post-comparison by design with the years when MML were established as the only comparison variable. Many other factors may also be associated with adolescent marijuana use after enactment of MML and discrimination of marijuana use, such as changes in marijuana availability and accessibility, social norms of and attitudes toward marijuana, perceived harm of marijuana and peer-approval of marijuana use. Despite these limitations, findings of this study provide useful data supporting further research to address these factors, to enhance our understanding of the relationship between state MML and marijuana use, and to inform efficient marijuana legislation and prevision adolescent drug-use prevention.

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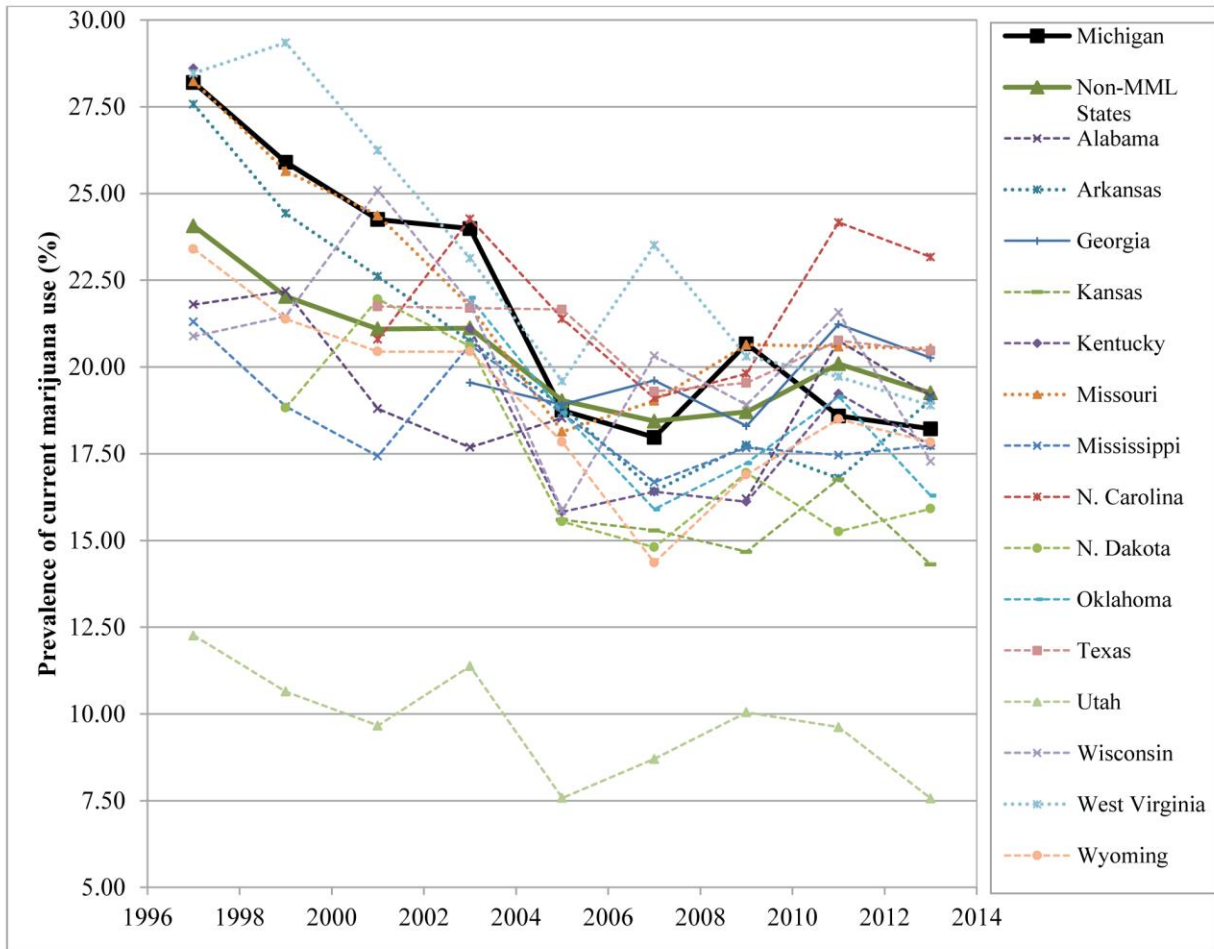
Figure A1. The trend of current marijuana use among Non-MML states and the State of Michigan