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JOINT EFFECTS: HOW MEDICAL MARIJUANA LEGALIZATION AFFECTS STATE-LEVEL MARIJUANA USE AND NON-MEDICAL PAIN RELIVER USE

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Abstract

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Hyewon Yoon

This study examines the potential link between the passage of medical marijuana laws and two types of illicit drug use: marijuana use and non-medical pain reliever (NMPR) use. It uses state-level data of 2002 to 2011 extracted from the National Survey of Drug Use and Health (NSDUH), the Marijuana Policy Project, the Center for Disease Control, US Department of Labor, US Census Bureau, and US Department of Education. The results show that there is generally a modest, positive association between medical marijuana legalization (MML) and marijuana use and MML and state-level prevalence of NMPR usage by individuals aged 12 to 17 and 18 to 25. The results also show that marijuana and NMPR use by individuals aged 18 to 25 increases more than those by individuals aged 12 to 17 when a state legalizes medical marijuana. The main implication of this current study is that the increased accessibility of marijuana through MML could encourage more prescription pain reliever abuse among individuals aged 12 to 25. However, it is difficult to determine whether the increase in NMPR use is being directly driven by the marijuana gateway effect.

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I. Introduction

Although its production used to be encouraged by the American government in the 17th century in order to produce rope, sails, and clothing, marijuana is now the most used illicit drug in the United States (NIDA 2012). In the early 1900's, Mexican immigrants introduced the recreational use of marijuana to the US and soon this dry, shredded green mass of flowers and leaves of the hemp plant Cannabis sativa became associated with the Spanish-speaking newcomers. Fear of marijuana began mounting in the US during the Great Depression when massive unemployment increased public resentment and fear towards Mexican immigrants. Soon, researchers began linking marijuana to violent crime and other socially deviant behaviors, mostly committed by the underclass, the majority being Mexican immigrants. By 1931, 29 states had outlawed marijuana. Six years later, the federal government passed the Marijuana Tax Act that criminalized the possession or transfer of cannabis unless for industrial or medical purposes, in which case the drug was heavily taxed (PBS 2013). According to the Controlled Substances Act (CSA), marijuana is currently the most commonly used scheduled 1 controlled substance, which is defined as a substance that has a high potential for abuse and has no currently accepted medical use for treatment in the US (DEA 2013). However, as of 2013, 19 states and the District of Columbia have legalized medical marijuana and many more states are in the process of following suit.

Medical marijuana refers to cannabis used for therapeutic purposes, such as treating disease or alleviating pain. Although laws pertaining to acquiring medical marijuana are different by state, in general it can be purchased at medical marijuana dispensaries or – in some states – grown in a personal residence as long as the patient has the medical papers to prove his legitimacy of needing medical marijuana. Since 1996 when California became the first state to

legalize medical marijuana, more than 2,300 medical marijuana dispensaries have opened and made the medical marijuana business a multimillion industry (Fairchild 2012).

Proponents of medical marijuana are in favor for the use of the cannabis plant for medical purposes, claiming that marijuana offers effective medical benefits and is safer than prescription drugs that are used as its alternative. According to former US Surgeon General Joycelyn Elders, there is overwhelming evidence that "marijuana can relieve certain types of pain, nausea, vomiting and other symptoms caused by such illnesses as multiple sclerosis, cancer and AIDS – or by the harsh drugs sometimes used to treat them." (Grinspoon 1995) For instance, the state research program in New Mexico conducted an extensive research on the medical use of marijuana from 1978 through 1986 by providing marijuana to 260 cancer patients receiving chemotherapy after conventional medications failed to control their nausea and vomiting. A physician who worked with the program testified at a DEA hearing that for these patients marijuana was clearly superior to chlorpromazine, a drug used for controlling severe nausea and vomiting (Grinspoon 1995). In addition, there is no known case of lethal overdose of marijuana whereas in the US there are over 20,000 cases of accidental prescription drug overdose annually (Gupta 2013). On the other hand, those against legalization of medical marijuana argue that it is a front for recreational use and that the potential dangers of marijuana make it an inadequate alternative for legal drugs. For instance, Callaghan and Allebeck (2013) found "initial longitudinal evidence that cannabis use might elevate the risk of lung cancer" and Budney et al. (2001) conducted a study that provided evidence demonstrating the possibility of marijuana addiction. However, the dominant concern of opponents of medical marijuana is the drug's potential gateway effect, a phenomenon where the use of less deleterious drugs can lead to future risk of using more dangerous hard drugs such as heroin and cocaine (Vanyukov et al., 2012).

Although there has been abundant research on the correlation between marijuana usage and that of alcohol, cigarettes, and hard drugs, there is a surprising lack of research done on the association between usage of marijuana and the second most prevalent type of illicit drug use in the US (SAMHSA 2010): the abuse of prescription pain relievers.

According to the US National Library of Medicine, pain relievers are drugs that "reduce or relieve headaches, sore muscles, arthritis, or other aches and pains." These drugs are largely categorized into two groups: over-the-counter (OTC) medicines and prescription pain relievers. When OTC drugs, such as acetaminophen (Tylenol®) and nonsteroidal anti-inflammatory drugs (NSAIDs), are not effective enough, patients can obtain drugs with stronger pain-relieving effects with a doctor's prescription. While many individuals take these drugs with proper prescription for legitimate medical reasons, others abuse these drugs by taking them – usually without a prescription – to simply become "high."

In July 2010, the Substance Abuse and Mental Health Services Administration (SAMHSA) announced a startling report that the percentage of substance abuse treatment admissions of those over the age of 12 involving abuse of prescription pain relievers increased by over 400% from 2.2% in 1998 to 9.8% in 2008 (Hartland 2010). The report also stated that individuals admitted to medical facilities due to abuse of prescription pain relievers in 2008 were "more than 3 times likely [than] those in 1998 to be age 18 to 24" (SAMHSA 2010). Interestingly, the report found that "increases in percentages of admissions reporting pain reliever abuse cut cross age, gender, race/ethnicity, eduction, employment, and region" (SAMHSA 2010). With the number of pain reliever overdose deaths exceeding deaths caused by heroin and cocaine combined in the US, abuse of prescription pain relievers is becoming a national concern, especially because of their easy accessibility (CDC 2011).

This current study examines the statistical relationship between medical marijuana legalization (MML) and state-level marijuana use and between MML and state-level non-medical pain reliever (NMPR) use. Information on the state-level prevalence of marijuana and NMPR usage among individuals in the age groups 12 to 17 and 18 to 25 was gathered from the National Survey of Drug Use and Health (NSDUH) conducted from 2002 to 2012. Other data – from the years 2002 to 2011 – used as control variables was gathered from databases from federal organizations such as the US Census Bureau, the Center for Disease Control and Prevention (CDC), the US Department of Education, and the US Department of Labor.

This current study's major contribution will be its focus on the relationship between MML and NMPR usage, a topic that has previously not covered extensively using state-level data. Although there have been prior studies that have focused on the association between marijuana use and use of hard drugs, such as cocaine and heroin, or trends in pain reliever abuse, there has yet been a paper centered around the statistical association between medical marijuana laws and pain reliever abuse using nation-wide state-level data.

The results of this current study indicate that there is a positive relationship between MML and marijuana use and MML and state-level prevalence of NMPR usage. This implies that increased accessibility to marijuana due to MML may increase the tendency of individuals to abuse prescription pain relievers. However, it is difficult to determine whether MML directly causes this increase in pain reliever abuse, mostly because despite medical marijuana laws, prescription pain relievers are much more accessible nation-wide than marijuana. Nevertheless, a state should consider having stricter regulations to monitor accessibility of pain relievers and install prevention and education programs that could prevent prescription drug abuse before legalizing medical marijuana.

II. Literature Review

The focus of this study is to determine whether and how MML affects state-level marijuana use and NMPR use. The assumption that legalization of medical marijuana may affect an individual's tendency to abuse prescription pain relievers is based on the gateway effect of marijuana, a much-studied topic in academia. Therefore, before one examines the relationship between MML and NMPR use, the first part of this study's topic question needs to be asked: what is the effect of MML on state-level marijuana use and is marijuana truly a gateway drug?

In general, the evidence on the effect of decriminalization of marijuana, of which MML is a form, on marijuana use – whether illicit or medical – is mixed. Previous studies, such as the 2012 study published in the *Drug and Alcohol Dependence* journal, provide evidence that states with MML laws have higher rates of marijuana use and higher odds of marijuana abuse or dependence by its residents than the states without such laws (Cerda et al., 2012). A 2010 study published in *The B.E. Journal of Economic Analysis & Policy* found results with a similar implication. According to this study that was based on the data from the Arrestee Drug Abuse Monitoring (ADAM) program, reductions in perceived user-risk decreased user sanctions on marijuana, leading to an increase in marijuana usage (Pacula et al., 2010). This implies that MML, which decreases legal risk of marijuana possession, can result in increased use of marijuana. Model's 1993 study published in the *Journal of the American Statistical Association* also had the same implication. Based on hospital emergency room drug episodes collected by the Drug Abuse Warning Network (DAWN), Model found that "marijuana decriminalization was accompanied by…an increase in marijuana episodes," which led her to conclude that marijuana use is higher where marijuana is decriminalized (Chaloupka 1999).

On the other hand, there are also studies that found that MML did not increase marijuana use, especially among youths. Anderson, Hansen, and Rees' 2012 paper "Medical Marijuana Laws and Teen Marijuana Use" found that youth marijuana consumption did not increase with MML, most likely because there are stricter regulations for underage individuals acquiring medical marijuana. Similarly, Johnston, O'Malley, and Bachman found that decriminalization had no effect on marijuana use in their 1981 study based on cross-section data of drug use by high school seniors (Chaloupka 1999). Moreover, in their 2013 study on legalization of medical marijuana and marijuana use among youths, Friese and Grube found that living in a county with more medical marijuana cards was not related to lifetime or 30-day marijuana use among teenagers. However, they did find a positive correlation between voter approval of medical marijuana and lifetime and 30-day use among youths.

Much like the evidence on the effect of decriminalization on marijuana use, evidence on the gateway effect of marijuana is also mixed. For instance, Golub and Johnson found that "marijuana use nearly always precedes use of more serious substances such as cocaine, crack, and heroin" (Golub et al., 1998) in their 1998 study published in the *Journal of Studies on Alcohol.* Golub and Johnson's findings are further supported by various other studies, most notably by Wagner and Anthony, who found that among individuals aged 12 to 25 with opportunities to use cocaine, those with prior marijuana use were more likely to take cocaine than were those with no prior marijuana use (Wagner et al., 2002). Hall and Lynskey's 2005 paper published in the *Drug and Alcohol Review* even implied that there is biological evidence of marijuana's gateway effect by mentioning that "animal studies have raised possibility that regular cannabis use may have pharmacological effects on brain function that increase the likelihood of using other drugs" (Hall et al., 2005). However, there are studies that contradict

previous findings of evidence on the marijuana gateway effect. A prime example is a 2010 study that investigated whether initiation of drug use, including marijuana usage, is due to "causal effects of specific earlier drug use promoting progression, or to influences of other variables such as drug availability and attitudes" (Degenhardt et al., 2010). According to this study based on data from World Health Organization (WHO) World Mental Health (WMH) Surveys, the gateway pattern at least "partially [reflected] unmeasured common causes rather than causal effects of specific drugs on subsequent use of others" (Degenhardt et al., 2010), implying that successful prevention of using specific gateway drugs may not lead to significant decrease in the use of later drugs. Morral, McCaffrey, and Paddock made similar findings in their 2002 study that focused solely on the marijuana gateway effect. Using parameter estimates derived from US household surveys of drugs use conducted between 1982 and 1994, they designed a common-factor model of youth hard drug use initiation in the US with the assumption that neither use nor opportunity to use marijuana is associated with adolescent drug use initiation. The study concluded that because the results demonstrated that "the phenomenon used to motivate belief in [the gateway effect] is consistent with an alternative simple, plausible common-factor model" (Morral et al., 2002), the gateway effect is not required for explaining the relationship between marijuana usage and hard drug initiation.

III. Data & Empirical Strategy

As mentioned before, the data on the state-level prevalence of marijuana and NMPR usage came from the National Survey on Drug Use and Health (NSDUH). More specifically, the data came from state estimates of the 50 states and the District of Columbia that were derived from combining the results of the NSDUH in two consecutive years during the time span of 2002

to 2012. The NSDUH, planned and managed by the Substance Abuse and Mental Health Services Association (SAMHSA), measures prevalence and correlations between illicit drug uses in the US non-institutionalized civilian populated aged 12 years or older. Conducted by the Federal Government since 1971, the NSDUH went through several changes in 2002 that resulted in prevalence rates in 2002 being substantially higher than those for 2001 because of the increase in the weighted interview response rate. Thus, the 2002 NSDUH was established as a new baseline for the US, so surveys results from 2002 and onwards are not comparable with estimates for 2001 and prior years (SMAHSA 2003). Furthermore, SAMHSA determined that state-level sample sizes for the majority of states, those with annual sample sizes of approximately 900 persons, were too small to detect any trends from 1 year to the next. Hence, it combined data across 2 consecutive years to improve the precision of the estimates for small states. For simplicity, this current study associates the state-level data of usage of marijuana and non-medical usage of pain relievers with only the first year of the combined two years. For example, the state estimate of marijuana usage derived from the combination of 2011 and 2012 NSDUH is labeled with the year 2011. Hence, the time period of this study's data is considered to be from 2002 to 2011.

The main dependent variables of this study derived from NSDUH are the state-level prevalence of NMPR usage and state-level marijuana use. The NMPR usage is the percentage of respondents who reported that they used pain relievers for non-medical purposes at least once in the past year. The state-level prevalence of marijuana usage is the percentage of respondents who reported that they used marijuana at least once in the past 30 days.

A primary concern about the NSDUH data used in this current study is that it is only from the years 2002 to 2011. Fortunately, 9 out of 20 states, where medical marijuana is now

legal, passed medical marijuana laws that became effective during this time span so the NSDUH data may be enough to give statistically significant results. The greatest advantage of using NSDUH data is that it provides survey responses regarding both marijuana usage and NMPR usage, which is rare to find among national health surveys.

Another integral variable used in this study is the categorical variable MML, which stands for medical marijuana legalization. The MML variable is equal to 0 when a state in a given year does not have medical marijuana legalization laws in effect. The MML variable is equal to 1 when a state in a given year does have medical marijuana legalization laws in effect. In this study, a state is considered to have medical marijuana legalization laws in effect as long as its original bill was made effective anytime between 2002 and 2011. Although some states did make amendments and changes to their medical marijuana laws from 2002 to 2011, none of these essentially reversed the effect of the original bill of legalization so they will not impact the results of the study. Information on the years when state medical marijuana laws became effective was compiled from the website of the Marijuana Policy Project, an organization focused on legalizing medical and non-medical use of marijuana in the entire US. Table 1 displays the states that have legalized medical marijuana and the years in which the laws became effective. The states that had medical marijuana laws that became effective between 2002 and 2011 are referred to as the "9 MML States" in this study. The 9 MML States are particularly important because the categorical MML variable for these nine states switch from 0 to 1 during the time period focused in this study. Hence, the effect of MML on a state's prevalence of NMPR usage will be best illustrated in these nine states.

Other data collected for this current study is state gender percentage, race percentage, unemployment rate, median income in 2012 dollars, and event dropout rate of high school

students from 2002 to 2011. The state gender and race percentage was collected from the Center for Disease Control and Prevention (CDC) database, the unemployment rates came from the US Department of Labor database, the median income was gathered from the US Census Bureau, and the event dropout rates of high school students was collected from the US Department of Education database. The state high school event dropout rates for the years 2010 and 2011 are currently unavailable, so the data for these years were generated through STATA by using linear interpolation and extrapolation of dropout rates from years 2002 to 2009 on the years 2002 to 2011 for the missing dropout rates of years 2010 and 2011.

This study focuses on two state panel regression models:

$$MJ_{st} = \alpha + \beta_1 MML_{st} + \beta_2 race_{st} + \beta_3 gender_{st} + \beta_4 unemployment_{st} + \beta_5 income_{st} + \beta_6 education_{st} + \beta_7 stateFE + \beta_8 yearFE + \varepsilon_{st} \quad (1)$$

$$NMPR_{st} = \alpha + \beta_1 MML_{st} + \beta_2 race_{st} + \beta_3 gender_{st} + \beta_4 unemployment_{st} + \beta_5 income_{st} + \beta_6 education_{st} + \beta_7 stateFE + \beta_8 yearFE + \varepsilon_{st} \quad (2)$$

In these models MJ stands for marijuana usage, NMPR stands for non-medical usage of pain relievers, s stands for the state the respondent was living in at the time he or she took the survey, and t is the year the respondent took the survey. MML_{st} is a categorical variable that represents the legality of medical marijuana, $race_{st}$ is the proportion of a specific race population of a state in year t, $gender_{st}$ is the percentage of females in a state in year t, and $unemployment_{st}$, $income_{st}$, and $education_{st}$ are the state unemployment level, the state median income in 2012 dollars, and the high school event dropout rate of the state in year t, respectively. The $stateFE$ and $yearFE$ are categorical variables that represent the state fixed effect and year fixed effect, respectively. The ε_{st} is the error term.

The first regression model is used to determine the statistical association between MML and state-level prevalence of marijuana usage of individuals aged 12 to 25. In this model, the dependent variable is MJ_{st} and the independent variable is MML_{st}. The control variables are the variables on the right side of the model except the constant α and the error term ε_{st}. Control variables are included in the model in order to control the effects they may have on the dependent variable. The categorical variables $statef.e$ and $yearf.e$ are controlled because the dependent variable may change simply due to state-specific trends or trends over time, not the independent variable.

The second regression model is used to determine the statistical association between MML and state-level NMPR usage of individuals aged 12 to 25. In this regression model, the dependent variable is PR_{st} and the independent variable is MML_{st}. The control variables and categorical variables are identical to those of the first regression model.

IV. Results & Analysis

Figure 1 displays the average yearly percentage of state-level prevalence of marijuana usage by individuals aged 12 to 17 and 18 to 25 from 2002 to 2011. As illustrated in Figure 1, the state-level percentage average of marijuana used by individuals aged 18 to 25 is much greater than that of those aged 12 to 17. In fact, the difference between the US average marijuana usages of these two age groups is 10.33%, more than half of the average of marijuana usage by individuals aged 18 to 25, which is 17.84%. Figure 1 further demonstrates that there is an increasing trend in the US yearly percentage average of marijuana usage by 18 to 25-year-olds over the years from 2002 to 2011, as illustrated by the trend line with the positive slope, and that there is a slightly downward trend of marijuana usage by individuals aged 12 to 17, indicated by

the trend line with the slight negative slope. Although the MML of 9 states during the years 2002 to 2011 is most likely not the only cause of this increasing trend of marijuana usage by 18 to 25-year-olds, based on previous studies done on the effect on MML and marijuana usage, it would be safe to assume that MML of these 9 states is one of the key drivers of this increase in the percentage average of state-level marijuana usage across the US.

Figure 2 illustrates the average yearly percentage of state-level prevalence of NMPR usage by individuals aged 12 to 17 and 18 to 25 from 2002 to 2011. Much like the state-level prevalence of marijuana usage, the average of NMPR usage is higher for the older age group 18 to 25 than the age group 12 to 17. The difference between the average state-level NMPR usages of these two age groups is 5.09%, nearly half of the average of the state-level NMPR usage by individuals aged 18 to 25, which is 12.03%. Despite the NSDUH report that found pain reliever abuse by individuals older than 12 to have increased "more than fourfold between 1998 and 2008" (SAMHSA 2010), Figure 2 shows that there was a downward trend in the state-level NMPR usage in the age groups 12 to 17 and 18 to 25 between 2002 and 2011. Although there is a steady decreasing trend in the younger age group, there are some fluctuations in the age group of 18 to 25. If this downward trend were being driven by MML, it would suggest that the increased accessibility to marijuana through MML decreased the prevalence of NMPR usage, most likely because individuals decided to use marijuana instead of pain relievers in order to get "high."

Figure 3 illustrates the average percentage of state-level marijuana usage of the 9 MML States and that of all other states for the age groups 12 to 17. Figure 3 shows that the state-level marijuana usage by individuals aged 12 to 17 of the 9 MML States remained constant between 2002 to 2011, the time span in which the 9 MML States legalized medical marijuana. On the other hand, the average percentage of state-level marijuana usage of all other states except the 9

MML States shows a mostly decreasing trend between 2002 and 2011. Figure 3 has two implications. First, MML, which directly increases the accessibility of marijuana in a state, may have caused the state-level marijuana usage by 12 to 17-year-olds in the 9 MML States to be constant although marijuana usage in the other states generally decreased. Second, the 9 MML States had relatively higher state-level marijuana usage than other states during this time period. This is implied by the stark difference between the average yearly percentage of state-level marijuana usage of the 9 MML States and that of the other states.

Figure 4 illustrates the average percentage of state-level marijuana usage of the 21 MML States and that of all other states for the age groups 12 to 17. The 21 MML States are the states where medical marijuana was legal as of 2013 including California, Alaska, Oregon, Washington, Maine, Colorado, Hawaii, Nevada, Connecticut, Massachusetts, Illinois, New Hampshire, Arizona, Delaware, District of Columbia, Michigan, Montana, New Jersey, New Mexico, Rhode Island, and Vermont. Figure 4 shows very similar results to that of Figure 3: the state-level marijuana usage by individuals aged 12 to 17 of the 21 MML States remained constant while that of all other states showed a mostly decreasing trend between 2002 and 2011.

Figure 5 illustrates the average percentage of state-level marijuana usage of the 9 MML States and that of all other states for the age groups 18 to 25. It shows that the average state-level marijuana usage by individuals aged 18 to 25 of the 9 MML States is higher than that of the other states and is constant between 2002 and 2011. However, the state-level marijuana usage by this age group of the other states had a mostly increasing trend in this time period, despite the fluctuations over the years. Similar to Figure 3, Figure 5 demonstrates that the 9 MML States had relatively higher state-level marijuana usage than other states during this time period, which leads one to assume that the 9 MML States decided to legalize medical marijuana because there

was already a high usage of marijuana in these states. Moreover, Figure 5 shows that the state-level marijuana usage of the 9 MML States was constant in these nine states between 2002 and 2011, while the state-level prevalence of marijuana usage in other states mostly increased – though fluctuating – in this time period. This is a contrast to the trend illustrated in Figure 3, where the marijuana usage in the states except the 9 MML States mostly decreased.

Figure 6 displays the average percentage of state-level marijuana usage of the 21 MML States and that of all other states for the age groups 18 to 25. Figure 6 interestingly shows opposite results to that of Figure 5: the state-level marijuana usage by individuals aged 18 to 25 of the 21 MML States had an increasing trend while that of all other states showed a constant trend between 2002 and 2011.

Figure 7 displays the average of state-level prevalence of NMPR usage by individuals aged 12-17 from 2002 to 2011 of the 9 MML States and that of all states except the 9 MML States. Figure 7 shows that the average state-level prevalence of NMPR usage by 12 to 17-year-olds in the 9 MML States remained constant while it generally decreased in all the other states between 2002 and 2011. This could imply that the increased accessibility of marijuana through MML may be preventing the NMPR in these nine states from decreasing. The same implication can be made in Figure 8, which illustrates the average of state-level prevalence of NMPR usage by individuals aged 18 to 25 from 2002 to 2011 of the 9 MML States and that of all states except the 9 MML States. As in Figure 7, the average state-level prevalence of NMPR usage by 12 to 17-year-olds in the 9 MML States remained constant while it generally decreased in all the other states between 2002 and 2011. When comparing Figures 7 and 8, one can see that the older age group 18-25 had higher averages of state-level prevalence of NMPR usage in 9 MML States and all other states than the younger age group 12 to17. Furthermore, there was less difference in the

NMPR usage between the 9 MML States and all the other states amongst the observations made in the 18 to 25 age group than those made in the 12 to17 age group, which supports the SAMHSA's claim that older individuals are more likely to abuse pain relievers than youths.

While the figures are suggestive about causal relationships, one can explore deeper using multivariate relationships. Tables 2, 3, 4, and 5 organize the results of four different regressions on either the state-level marijuana usage or NMPR usage by individuals aged 12 to 17 or 18 to 25. The first regression is with random effects, the second regression is with random effects clustered around the states, the third regression is with fixed effects, and the fourth regression is with fixed effects clustered around the states. Random effects regressions were built with the assumption that time-invariant omitted variables related to the state are random and not related to any of the independent variables in the regression. Fixed effects regressions assumed that time-invariant omitted variables related to the state are systematically associated with the independent variables in the regression. Regressions with clustering were included in the study to make valid statistical inferences while assuming that the observations are not entirely independent and there may be intrastate correlation.

Table 2 displays the regression results on state-level marijuana usage by individuals aged 12 to 17. According to the results displayed on Table 2, there is a positive, statistically significant association between MML and state-level prevalence of marijuana usage in all four regressions. The effect of MML on the state-level marijuana usage by 12 to 17-year-olds is statistically significant in all four different regressions, though the effect is more statistically significant in the random effects regression (significant at the 1% level) than in the fixed effects regression (significant at the 10% level). The regressions (1) and (2) show that when a state legalizes medical marijuana, the state-level marijuana usage increases by 1.201 percentage points,

which is 16.1% of the average of marijuana usage by persons aged 12 to 17 who took the NSDUH from 2002 to 2012, 7.44%. Regressions (3) and (4) show that it increases by 0.456 percentage points, which is 6.2% of the average of marijuana usage by 12 to 17-year-olds who took the NSDUH from 2002 to 2011.

Other variables that have a statistically significant effect on state-level marijuana usage by 12 to 17-year-olds are median income and the percentage of females, American Indian or Alaska Native, and black population of a state. The median income appears to be statistically significant at the 1% level in regression type (1) and (2), although its coefficient is so small that it rounds to 0. The state percentage of females also has positive effects on the marijuana usage by 12 to 17-year-olds, according to all regression types; the effects are more statistically significant in the random effects regression (significant at 1% level) than the fixed effects regression (significant at 5% or 10% level). The effect of a state's female proportion on marijuana usage by youths seem unusually big – it is almost as big as the effect made by MML in the random effects regressions and even bigger in the fixed effects regressions – given that past studies conducted by SAMHSA has shown that males are more likely to be dependent on marijuana than females (SAMHSA 2010). It is more likely that this strong effect of female percentage on marijuana usage is due to factors that change the ratio of non-institutionalized females in a state, such as high incarceration of males, than the possibility that a state's female proportion causes in an increase of marijuana usage by youths aged 12 to 17. Another variable that has a statistically significant positive effect on marijuana usage by youths is a state's proportion of American Indian or Alaska Native (AIAN) population. This variable's effect is the same in regression (1) and (2), but it is more significant in the former (at the 1% level) than in the latter (at the 5% level). On the other hand, there is a variable that has a statistically significant negative effect on

the marijuana use of youths: a state's proportion of black individuals. Unlike the other variables that had statistically significant effects, the black variable has a negative effect on the marijuana use of youths; this negative effect is statistically significant at the 1% level when regressed with fixed or random effects.

Regression results of marijuana usage by individuals aged 18 to 25 (Table 3) are both similar and different to that of marijuana usage by 12 to 17-year-olds. According to the results displayed on Table 3, there is a positive, statistically significant association between MML and state-level prevalence of marijuana usage in random effects regressions. The effect of MML on the state-level marijuana usage by 18 to 25-year-olds is statistically significant in regressions (1) and (2) at the 1% level. The regression type (1) and (2) show that whenever a state legalizes medical marijuana, the state-level marijuana usage increases by 2.775 percentage points, which is 15.5% of the average of marijuana usage by persons aged 18 to 25 who took the NSDUH from 2002 to 2012, 17.89%. MML does not have a significant effect on marijuana usage in the fixed effects regressions.

Much like Table 2, Table 3 shows that median income, a state's proportion of females, AIAN, and black population. Just as it was the case for marijuana usage by persons aged 12 to 17, median income and a state's proportion of the female population have a positive, significant effect and a state's proportion of the black population had a negative, significant effect on the marijuana usage of individuals aged 18 to 25. However, similarities of Table 2 and 3 end there. For instance, the AIAN variable was statistically significant in regressions (1) and (2) in Table 2, but it is significant in regressions (1), (3), and (4) in Table 3. Plus, the AIAN variable positive effect on marijuana usage by 18 to 25-year-olds switches to a negative effect in fixed effects regressions. Moreover, while the black variable was significant in all four regressions in Table 2,

it is only significant in the random effects regressions in Table 3. Other variables that have significant effects on marijuana usage by 18 to 25-year-olds are unemployment rate and the proportion of the Hispanic population. Unemployment rate has a positive effect on marijuana usage and it is more significant in regression (2) (significant at 5% level) than in regression (1) (significant at 10% level). The Hispanic variable has a negative effect and is more significant in regression (3) (significant at 1% level) than in regression (4) (significant at 5% level).

By analyzing the regression results displayed in Table 2 and 3, it can be determined that there is a positive, significant effect of MML on marijuana usage by individuals aged 12 to 17 and 18 to 25. This means that one can safely assume that if a state legalizes medical marijuana, its state-level marijuana usage will increase as a direct result of the legalization law.

Table 4 displays the regression results on state-level NMPR usage by persons aged 12 to 17. According to the results displayed on Table 4, there is a positive, statistically significant association between MML and state-level non-medial pain reliever usage in random effects regressions. The effect of MML on pain reliever abuse by 12 to 17-year-olds is statistically significant in random effects regressions at the 5% level. The regression type (1) and (2) show that whenever a state legalizes medical marijuana, the NMPR usage increases by 0.437 percentage points; this is 6.4% of the average of pain reliever abuse by persons aged 12 to 17 who took the NSDUH from 2002 to 2012, 6.85%. The MML variable is not significant in the fixed effects regressions.

Other variables that have significant effects on pain reliever abuse by 12 to 17-year-olds are median income and a state's proportion of the female, Hispanic, and Asian or Pacific Islander (API) population. The median income and proportion of API population have negative, significant effects on state-level NMPR usage in all four regressions. The effect of median

income is more significant in random effects regression (significant at 1% level) than in the fixed effects regressions (significant at 10% and 5% level). The effect of API population proportion is generally more significant in fixed effects regressions (significant at the 1% level) than in random effects regressions (significant at the 1% and 5% level). A state's female population proportion also has negative, significant effects on pain reliever abuse, but it is significant only in the random effects regression at the 5% level. The Hispanic population proportion is the only variable other than MML that has a positive, significant effect on the NMPR usage by 12 to 17-year-olds; this variable is significant in the fixed effects regressions at the 5% significance level.

Table 5 displays the regression results on state-level NMPR usage by persons aged 18 to 25. According to the results displayed on Table 5, there is a positive, statistically significant association between MML and state-level non-medial pain reliever usage in both random effects and fixed effects regressions. The effect of MML on pain reliever abuse by 18 to 25-year-olds is statistically significant in random effects regressions at the 1% level and is statistically significant in fixed effects regressions at the 10% and 5% level. The regression type (1) and (2) show that whenever a state legalizes medical marijuana, the NMPR usage increases by 0.953 percentage points, which is 8.0% of the average of pain reliever abuse by persons aged 18 to 25 who took the NSDUH from 2002 to 2011, 11.98%.

Other variables that have statistically significant effects on pain reliever abuse by individuals aged 18 to 25 are a state's proportion of female, Hispanic, API, and black population. Although the former three variables also have significant effects on pain reliever abuse by the younger age group, the type of effect and types of regressions in which these effects are significant are quite different in Table 5 from those in Table 4. For instance, whereas the female population proportion had a negative, significant effect in the random effects regressions in

Table 4, it has a positive, significant effect in the fixed effects regressions in Table 5. Moreover, while the API population proportion has negative, significant effects in both regressions (1) and (2) in Table 4, its effect is negative and significant in only regression (2) in Table 5. Furthermore, the API population proportion has a negative, significant effect on pain reliever abuse in only random effects regressions in Table 5, whereas its effect is negative and significant in all four regressions in Table 4. Finally, the black population proportion is not significant in any regression in Table 4, but it is negative and significant in random effects regressions in Table 5.

In order to determine the robustness of the reported relationship between MML and pain reliever abuse, a variety of alternative specifications needed to be implemented in the regressions. In this study, further regressions were built to ensure that the reported relationship was not being driven solely by a state, particularly one of the 9 MML States, of which the MML variable changes from 0 to 1 between 2002 and 2011. The change in MML variable in these nine states is what the regression results are based on in the fixed effects regressions, so it is important to assess whether the reported result was being driven by a particular 9 MML State.

Tables 6 and 7 display the results of ten different fixed effects regressions on state-level NMPR usage by individuals aged 12 to 17 and 18 to 25, respectively. Regression (1) is the fixed effects regressions that included all the states and regressions (2) to (10) each excluded one 9 MML State. In Table 6, the MML variable has a positive, significant effect in regression (10), which excluded Vermont. The MML variable is not significant in all the other regressions in Table 6. On the other hand, in Table 7 the MML variable has a positive, significant effect in the regressions (1) to (5) and (8) to (10). The positive coefficients of the MML variable in Table 7 range from 0.685 to 0.89.

Tables 8 and 9 display the results of ten different random effects regressions on state-level NMPR usage by individuals aged 12 to 17 and 18 to 25, respectively. In Table 8, the MML variable has a positive, significant effect in all ten regressions; the coefficients of the MML variables range from 0.304 to 0.559. Again, in Table 9 the MML variable has a positive, significant effect in all ten regressions; the coefficients of the MML variable in Table 9 range from 0.875 to 1.077.

V. Discussion & Limitations

This study provides an overview of the US medical marijuana laws and national trends in marijuana usage and prescription pain reliever abuse based on data from the National Survey of Drug Use and Health (NSDUH) conducted from 2002 to 2011. The results show that there is generally a modest, positive association between MML and marijuana use and MML and state-level prevalence of NMPR usage by individuals aged 12 to 17 and 18 to 25. The results also show that the NMPR use and marijuana use by individuals aged 18 to 25 increase more than those by individuals aged 12 to 17 when a state legalizes medical marijuana.

The main implication of this study is that the increased accessibility of marijuana through MML could encourage more marijuana use and prescription pain reliever abuse among individuals aged 12 to 25. As there is already prior literature that explains why MML may not have a concrete causal relationship with marijuana use, this study will attempt to explain why MML may not be what is causing this increase in NMPR use.

It is difficult to determine whether the increase in pain reliever abuse is a direct result of MML because the results of this study could have been skewed due to omitted variable bias, meaning that some variable that is correlated with the passage of medical marijuana laws and

state-level NMPR use was not controlled for in the regression models. Such a variable could be perceived risk of all kinds of illicit drug use. According to past research done by SAMHSA, a factor that commonly influences individuals to partake in illicit drug use is their perceived legal and physical risk of the substance (SAMHSA 2010). Unfortunately, the NSDUH does not have questions regarding perceptions of risk in all kinds of illicit drug use, although it does include questions regarding perceived risk of specifically marijuana, cigarettes, and alcohol. If the data on state-level perception of risk in all illicit drug use were available, one could compare the trend of this perceived risk in the 9 MML States with that in all the other states. If the linear trend of perceived risk in illicit drug in the 9 MML States was negative and had a steeper slope than that of the other states, one could assume that it is the changing perception of all illicit drug use of being less risky that is causing both MML and the increase in NMPR use.

There are several limitations to this current study. First, there is limited access to the NSDUH data on marijuana and NMPR use. Although NSDUH had been annually conducted since 1971, due to major changes in the survey design, survey results from 2002 to 2011 are not comparable with those from years before 2002. This restricts the time scope of this current study and hence restricts the number of states that have a MML variable that changes from 0 to 1 in the regressions. Second, because SAMHSA did not allow access to individual-level data regarding drug use in order to protect the privacy of NSDUH participants, this study was unable to control for individual-level variables. Every individual's decision to initiate drug use is affected by personal circumstances and experiences, so using state-level control variables to determine the likelihood an individual would use marijuana or abuse pain relievers may not truly capture all the relevant variables. Finally, a state's decision to pass MML laws is not determined randomly. There are state-specific traits and trends that are correlated with the state's legalization of

medical marijuana, so it is difficult to argue that the legalization itself – and not the state-specific traits that lead to MML – is driving the increase in pain reliever abuse. In order to improve this study, one could build regression models using individual-level data, including individual-level control variables that most likely influence an individual's decision to initiate drug use.

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Figure 1

Average yearly percentage of state-level prevalence of marijuana usage by individuals aged 12-17 and 18-25 in the US from 2002 to 2011

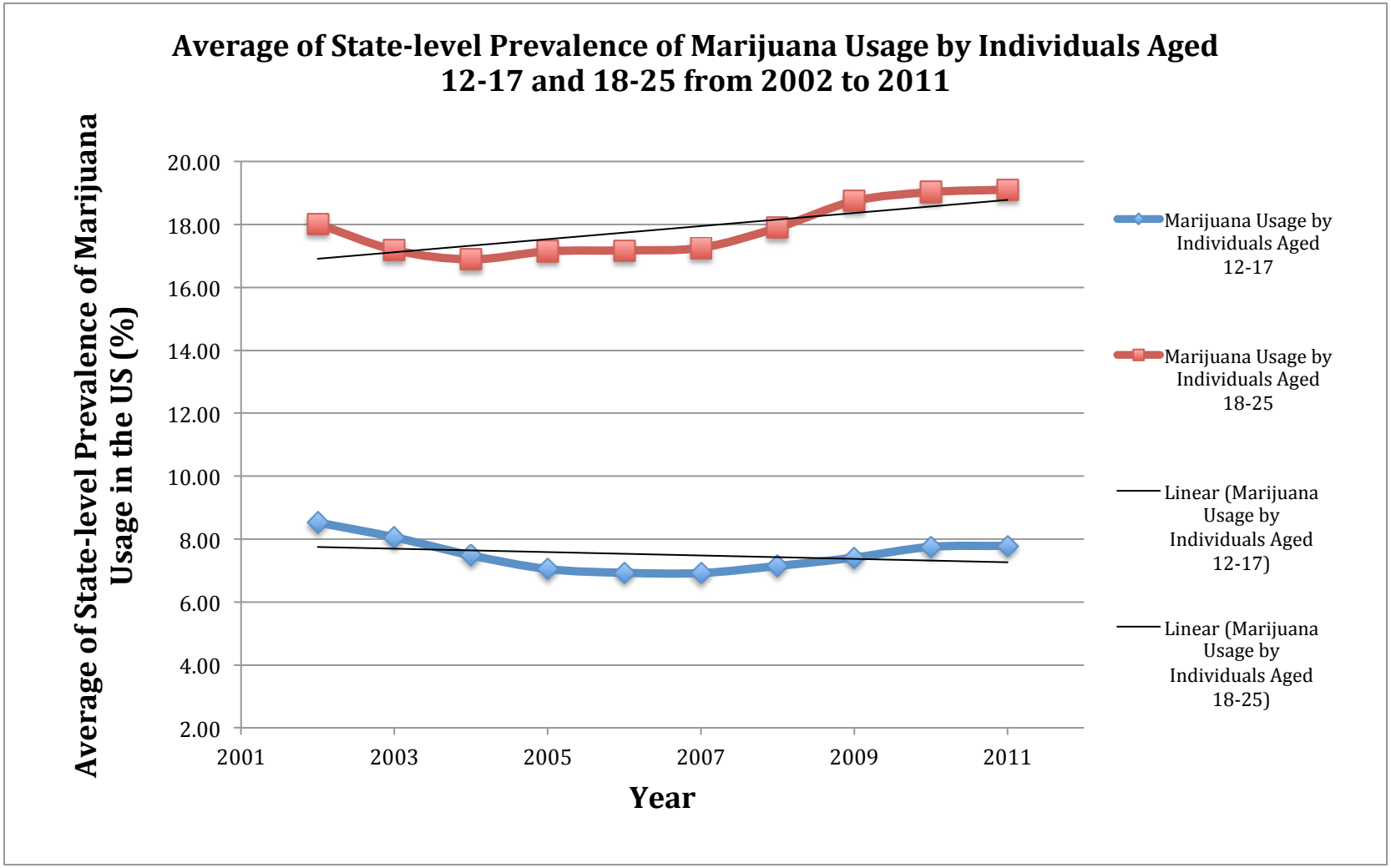


Figure 2

Average yearly percentage of state-level prevalence of non-medical pain reliever usage by individuals aged 12-17 and 18-25 in the US from 2002 to 2011

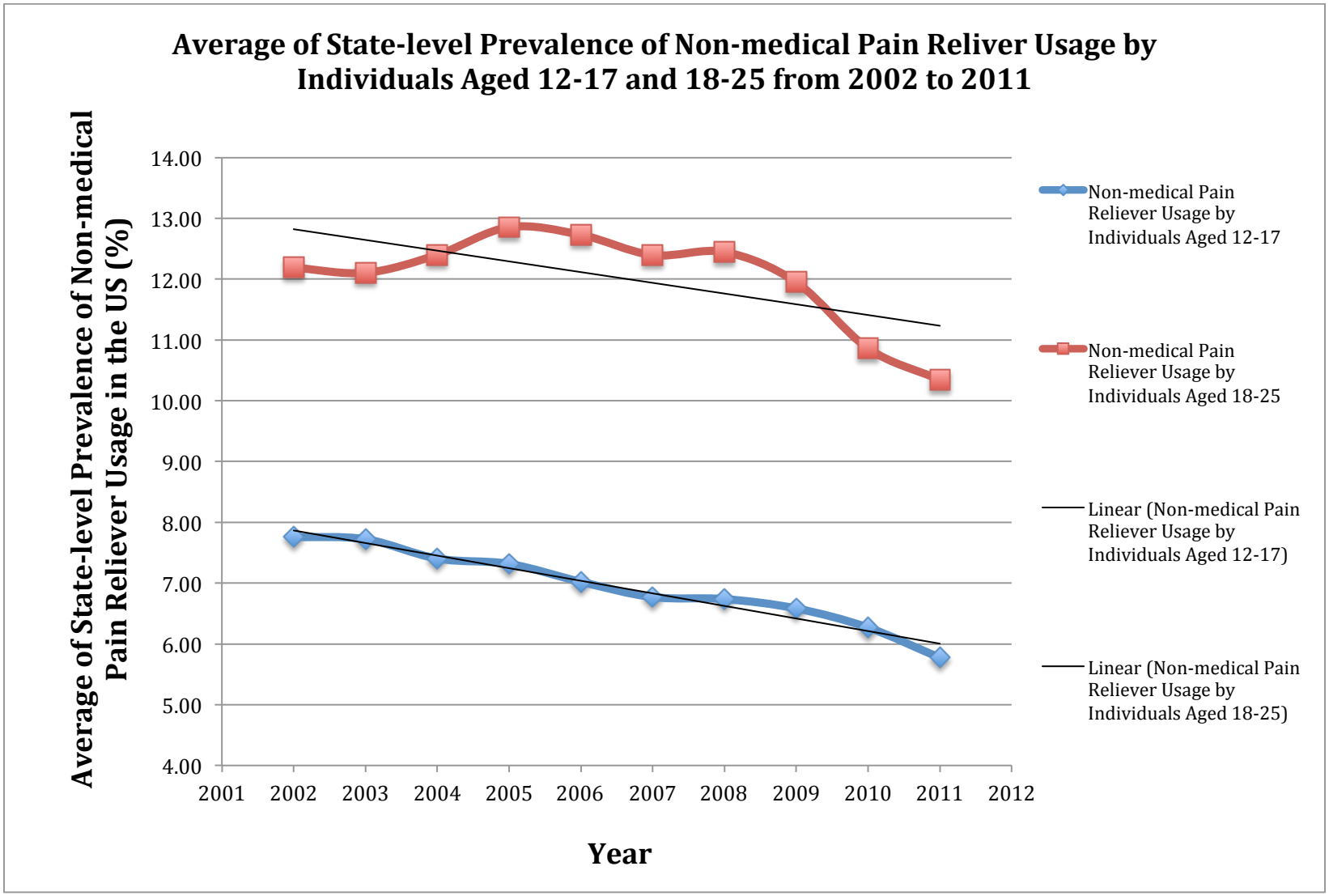
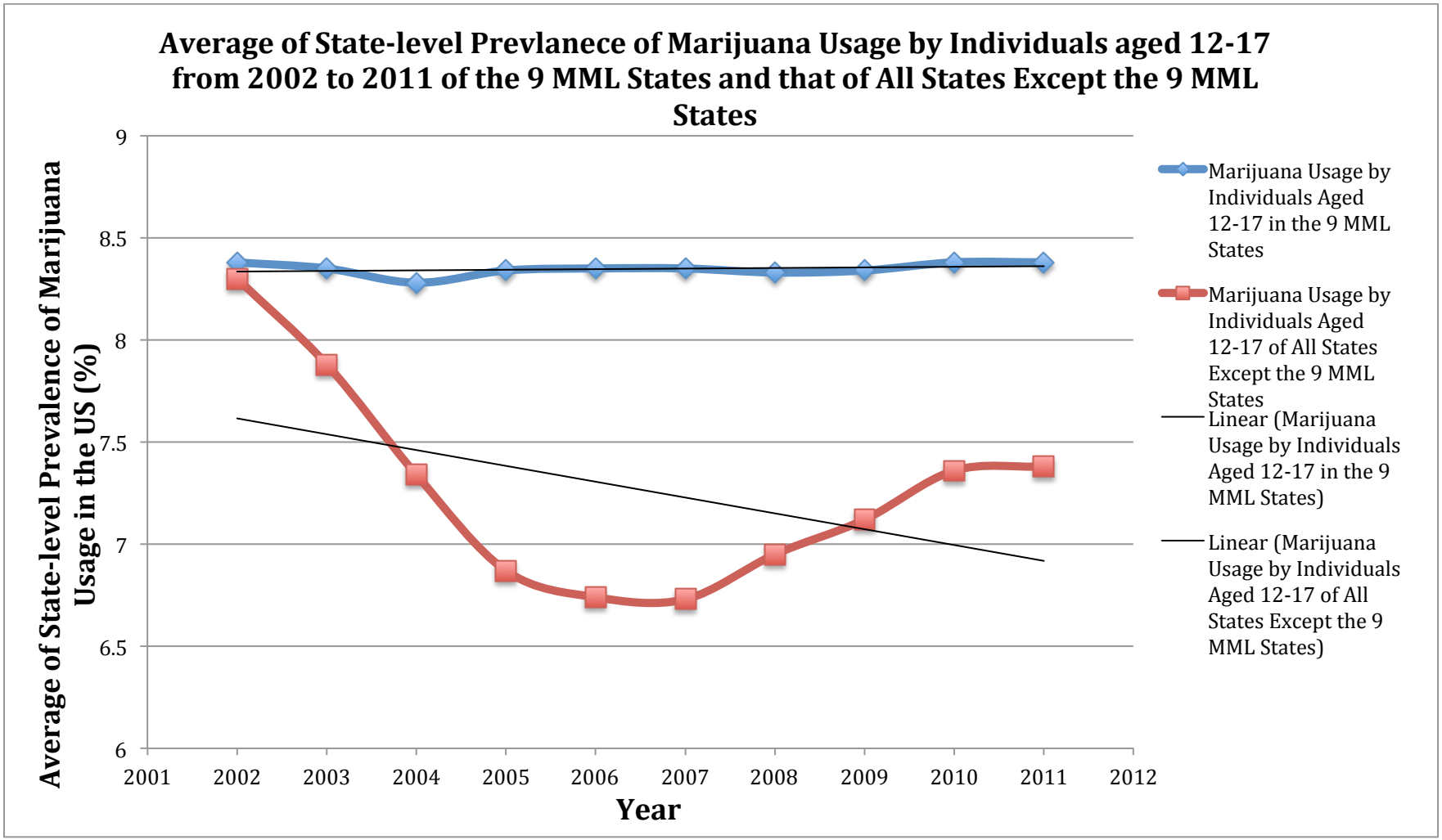


Figure 3

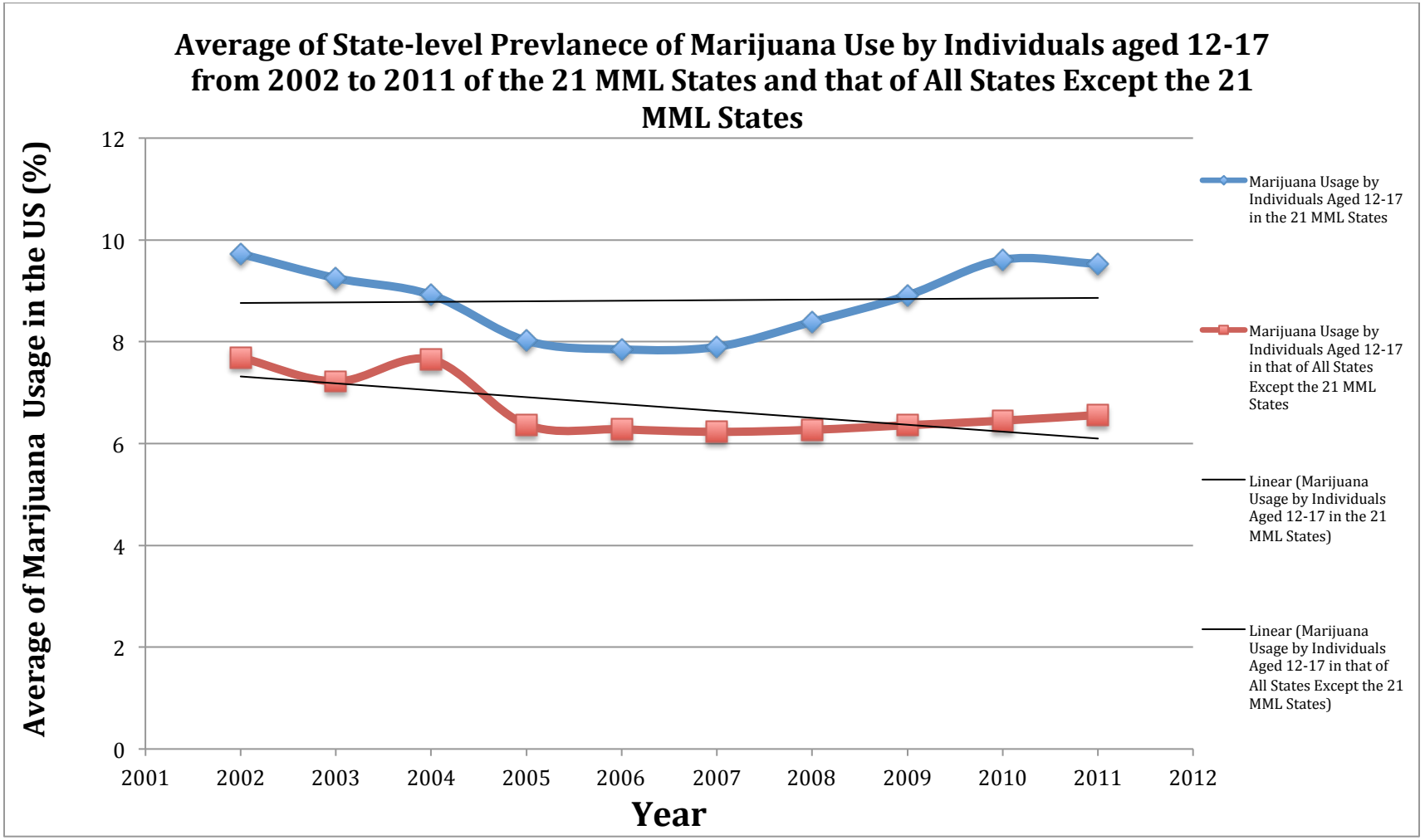
Average yearly percentage of state-level prevalence of marijuana usage by individuals aged 12-17 of the 9 MML States from 2002 to 2011 and that of all states except the 9 MML States



**NOTE: The 9 MML States refer to the states that had medical marijuana laws go into effect between 2002 and 2011. They are Arizona, Delaware, District of Columbia, Michigan, Montana, New Jersey, New Mexico, Rhode Island, and Vermont.*

Figure 4

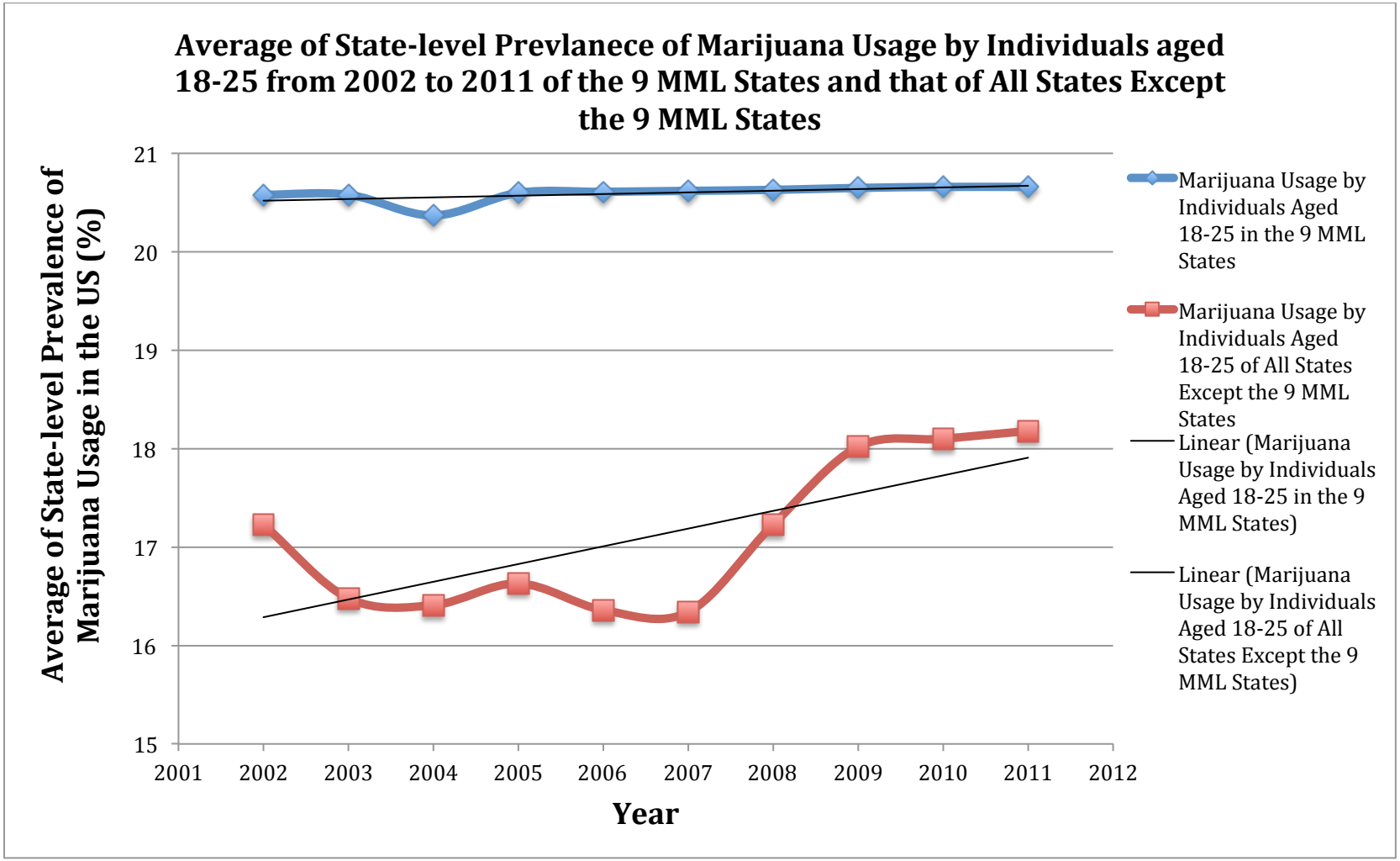
Average yearly percentage of state-level prevalence of marijuana usage by individuals aged 12-17 of the 21 MML States from 2002 to 2011 and that of all states except the 21 MML States



**NOTE: The 21 MML States refer to the states where medical marijuana is legal as of 2013. They are California, Alaska, Oregon, Washington, Maine, Colorado, Hawaii, Nevada, Connecticut, Massachusetts, Illinois, New Hampshire, Arizona, Delaware, District of Columbia, Michigan, Montana, New Jersey, New Mexico, Rhode Island, and Vermont.*

Figure 5

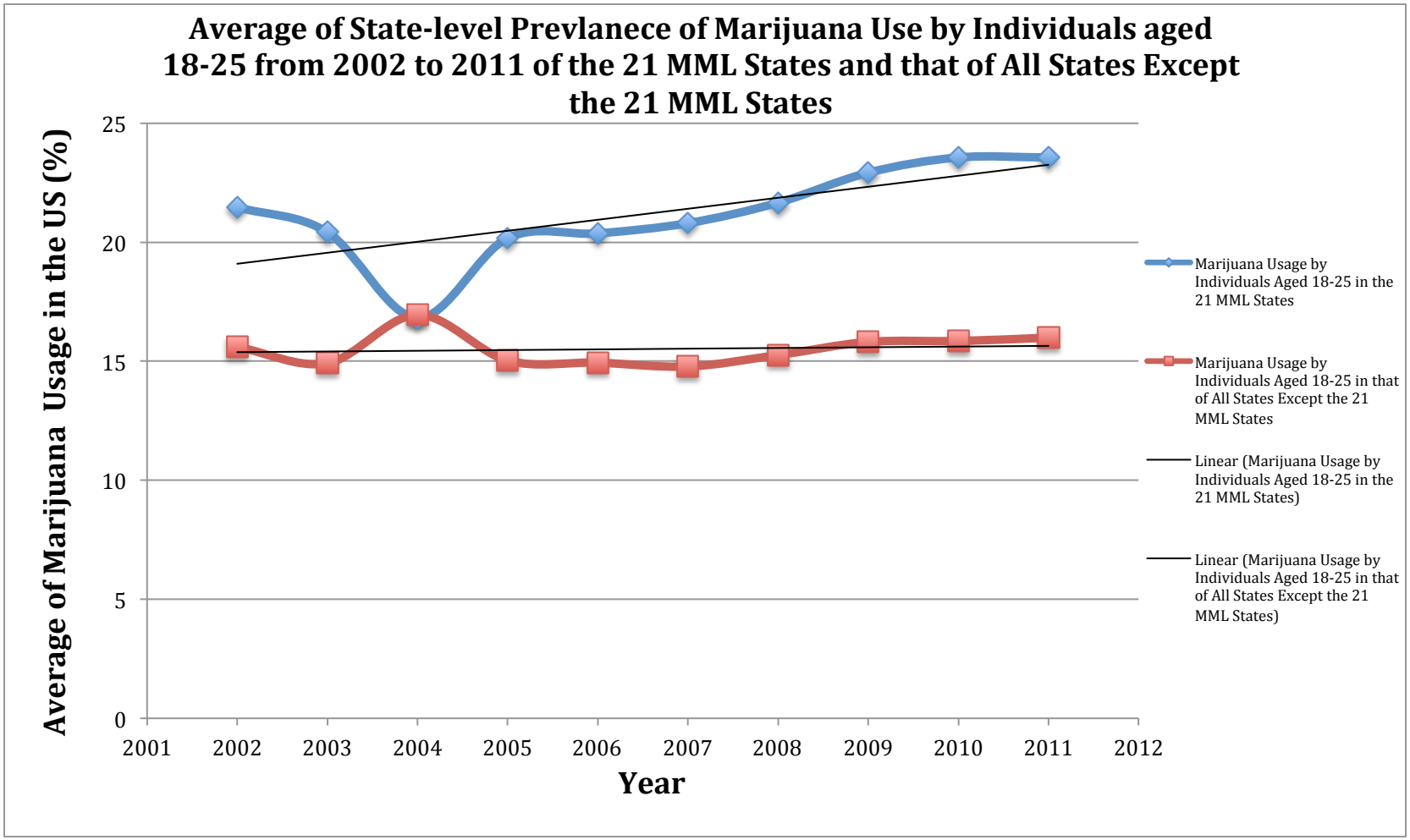
Average yearly percentage of state-level prevalence of marijuana usage by individuals aged 18-25 of the 9 MML States from 2002 to 2011 and that of all states except the 9 MML States



***NOTE: The 9 MML States refer to the states that had medical marijuana laws go into effect between 2002 and 2011. They are Arizona, Delaware, District of Columbia, Michigan, Montana, New Jersey, New Mexico, Rhode Island, and Vermont.*

Figure 6

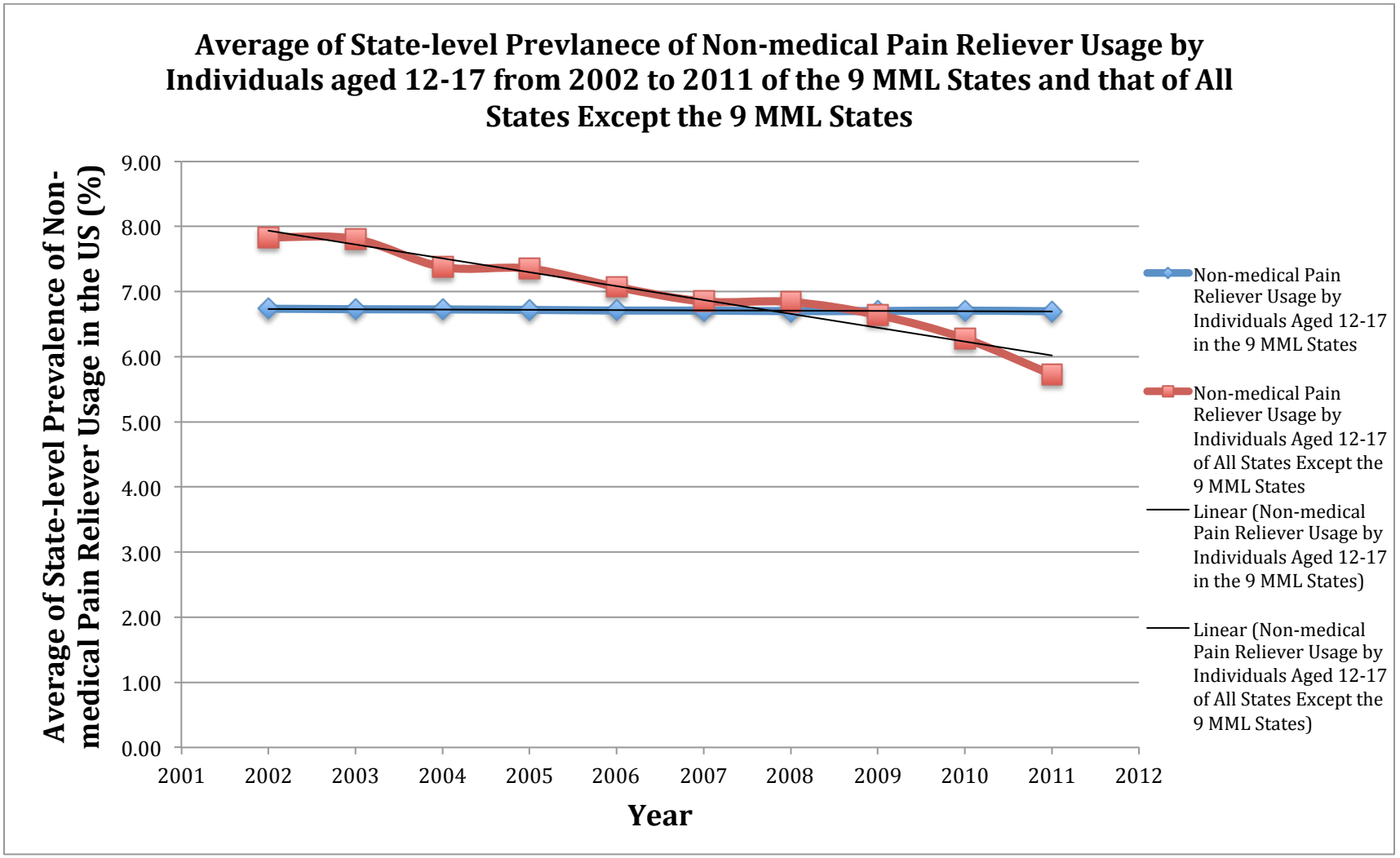
Average yearly percentage of state-level prevalence of marijuana usage by individuals aged 18-25 of the 21 MML States from 2002 to 2011 and that of all states except the 21 MML States



**NOTE: The 21 MML States refer to the states where medical marijuana is legal as of 2013. They are California, Alaska, Oregon, Washington, Maine, Colorado, Hawaii, Nevada, Connecticut, Massachusetts, Illinois, New Hampshire, Arizona, Delaware, District of Columbia, Michigan, Montana, New Jersey, New Mexico, Rhode Island, and Vermont.*

Figure 7

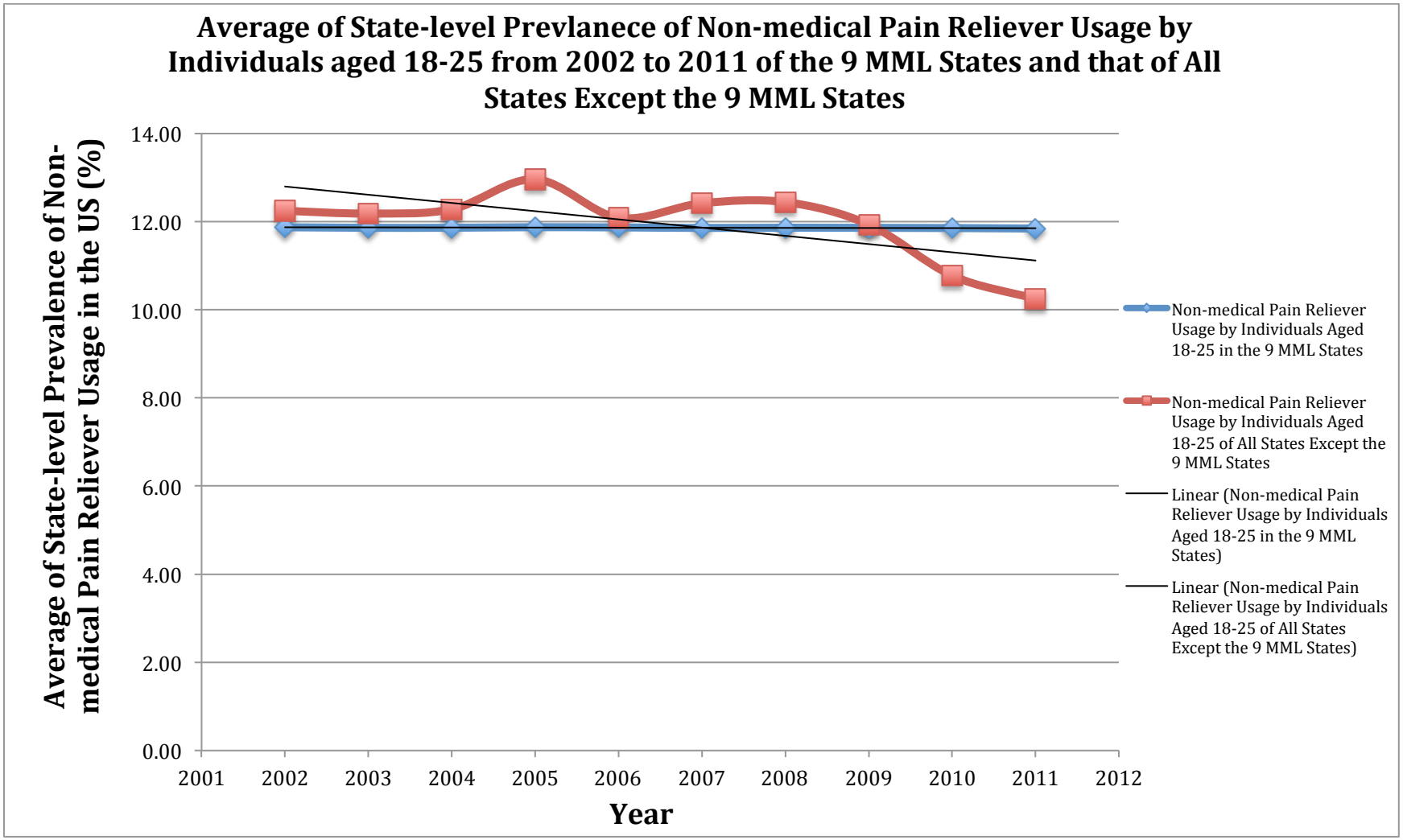
Yearly percentage average of state-level prevalence of non-medical pain reliever usage by individuals aged 12-17 of the 9 MML States from 2002 to 2011 and that of all states except the 9 MML States



**NOTE: The 9 MML States refer to the states that had medical marijuana laws that went into effect between 2002 and 2011. They are Arizona, Delaware, District of Columbia, Michigan, Montana, New Jersey, New Mexico, Rhode Island, and Vermont.*

Figure 8

Yearly percentage average of state-level prevalence of non-medical pain reliever usage by individuals aged 18-25 of the 9 MML States from 2002 to 2011 and that of all states except the 9 MML States



**NOTE: The 9 MML States refer to the states that had medical marijuana laws that went into effect between 2002 and 2011. They are Arizona, Delaware, District of Columbia, Michigan, Montana, New Jersey, New Mexico, Rhode Island, and Vermont.*

Table 1

States with medical marijuana laws and the years when they became effective

State	Year of MML
California	1996
Alaska	1998
Oregon	1998
Washington	1998
Maine	1999
Colorado	2000
Hawaii	2000
Nevada	2000
Montana*	2004
Vermont*	2004
Rhode Island*	2006
New Mexico*	2007
Michigan*	2008
Arizona*	2010
District of Columbia*	2010
New Jersey*	2011
Delaware*	2012
Connecticut	2012
Massachusetts	2012
Illinois	2013
New Hampshire	2013

*States that had medical marijuana laws that became effective between 2002 and 2011

Table 2

Determinants of state-level marijuana usage by individuals aged 12 to 17

Regression Type	(1) Random Effects	(2) Random Effects Clustered Around State	(3) Fixed Effects	(4) Fixed Effects Clustered Around State
MML	1.201***	1.201***	0.456*	0.456*
	(0.216)	(0.203)	(0.266)	(0.268)
Unemployment Rate	0.072	0.072	0.021	0.021
	(0.054)	(0.050)	(0.064)	(0.048)
Median Income	0.000***	0.000**	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Female	1.172***	1.172***	1.630**	1.630*
	(0.215)	(0.247)	(0.732)	(0.872)
Hispanic	-0.001	-0.001	-0.033	-0.033
	(0.012)	(0.009)	(0.135)	(0.161)
American Indian or Alaska Native	0.131***	0.131**	-1.118	-1.118
	(0.044)	(0.054)	(0.889)	(0.801)
Asian or Pacific Islander	-0.000	-0.000	0.265	0.265
	(0.014)	(0.007)	(0.256)	(0.260)
Black	-0.066***	-0.066***	-0.310***	-0.310***
	(0.013)	(0.013)	(0.097)	(0.092)
Dropout	-0.010	-0.010	-0.015	-0.015
	(0.029)	(0.026)	(0.031)	(0.035)
Constant	-52.824***	-52.824***	-69.805*	-69.805
	(10.911)	(12.531)	(37.375)	(44.563)
Observations	510	510	510	510

*** p<0.01, ** p<0.05, * p<0.1
Standard error in parenthesis

Table 3

Determinants of state-level marijuana usage by individuals aged 18 to 25

Regression Type	(1) Random Effects	(2) Random Effects Clustered Around State	(3) Fixed Effects	(4) Fixed Effects Clustered Around State
MML	2.775***	2.775***	0.913	0.913
	(0.567)	(0.743)	(0.654)	(0.898)
Unemployment Rate	0.269*	0.269**	0.197	0.197
	(0.138)	(0.125)	(0.156)	(0.131)
Median Income	0.000***	0.000***	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Female	3.501***	3.501***	3.914**	3.914*
	(0.619)	(0.749)	(1.799)	(2.028)
Hispanic	-0.047	-0.047	-1.009***	-1.009**
	(0.035)	(0.030)	(0.332)	(0.381)
American Indian or Alaska Native	0.287**	0.287	-4.280*	-4.280*
	(0.129)	(0.175)	(2.186)	(2.153)
Asian or Pacific Islander	-0.021	-0.021	0.425	0.425
	(0.041)	(0.024)	(0.630)	(0.589)
Black	-0.142***	-0.142***	0.167	0.167
	(0.038)	(0.050)	(0.237)	(0.180)
Dropout	0.008	0.008	-0.073	-0.073
	(0.073)	(0.085)	(0.075)	(0.071)
Constant	-166.989***	-166.989***	-170.586*	-170.586
	(31.453)	(37.791)	(91.851)	(103.363)
Observations	510	510	510	510

*** p<0.01, ** p<0.05, * p<0.1

Standard error in parenthesis

Table 4

Determinants of state-level non-medical pain reliever usage by individuals aged 12 to 17

Regression Type	(1) Random Effects	(2) Random Effects Clustered Around State	(3) Fixed Effects	(4) Fixed Effects Clustered Around State
MML	0.437**	0.437**	0.282	0.282
	(0.173)	(0.212)	(0.214)	(0.216)
Unemployment Rate	0.012	0.012	-0.029	-0.029
	(0.043)	(0.041)	(0.051)	(0.049)
Median Income	-0.000***	-0.000***	-0.000*	-0.000**
	(0.000)	(0.000)	(0.000)	(0.000)
Female	-0.353**	-0.353**	-0.325	-0.325
	(0.178)	(0.151)	(0.590)	(0.503)
Hispanic	0.004	0.004	0.241**	0.241**
	(0.010)	(0.009)	(0.109)	(0.108)
American Indian or Alaska Natives	-0.008	-0.008	-0.890	-0.890
	(0.037)	(0.044)	(0.717)	(0.628)
Asian or Pacific Islander	-0.023**	-0.023***	-0.559***	-0.559***
	(0.012)	(0.005)	(0.207)	(0.185)
Black	-0.009	-0.009	-0.033	-0.033
	(0.011)	(0.010)	(0.078)	(0.043)
Dropout	0.023	0.023	0.010	0.010
	(0.023)	(0.029)	(0.025)	(0.030)
Constant	28.150***	28.150***	28.079	28.079
	(9.048)	(7.526)	(30.131)	(25.786)
Observations	510	510	510	510

*** p<0.01, ** p<0.05, * p<0.1

Standard error in parenthesis

Table 5

Determinants of state-level non-medical pain reliever usage by individuals aged 18 to 25

Regression Type	(1) Random Effects	(2) Random Effects Clustered Around States	(3) Fixed Effects	(4) Fixed Effects Clustered Around States
MML	0.953***	0.953***	0.724*	0.724**
	(0.322)	(0.270)	(0.384)	(0.342)
Unemployment Rate	0.089	0.089	-0.016	-0.016
	(0.078)	(0.065)	(0.092)	(0.081)
Median Income	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Female	0.553	0.553	2.262**	2.262**
	(0.361)	(0.338)	(1.058)	(0.943)
Hispanic	-0.031	-0.031**	-0.213	-0.213
	(0.020)	(0.015)	(0.195)	(0.184)
American Islander or Alaska Native	-0.051	-0.051	0.712	0.712
	(0.076)	(0.097)	(1.285)	(0.821)
Asian or Pacific Islander	-0.054**	-0.054***	0.086	0.086
	(0.024)	(0.008)	(0.370)	(0.388)
Black	-0.071***	-0.071***	-0.039	-0.039
	(0.022)	(0.024)	(0.139)	(0.074)
Dropout	0.002	0.002	-0.002	-0.002
	(0.041)	(0.046)	(0.044)	(0.053)
Constant	-14.172	-14.172	-101.585*	-101.585**
	(18.354)	(16.960)	(54.000)	(47.740)
Observations	510	510	510	510

*** p<0.01, ** p<0.05, * p<0.1

Standard error in parenthesis

Table 6

Determinants of non-medical pain reliever usage by individuals aged 12 to 17 excluding one out of the 9 MML States with fixed effects

Regression Types	(1) All States	(2) Excluding AZ	(3) Excluding DE	(4) Excluding DC	(5) Excluding MI	(6) Excluding MO	(7) Excluding NJ	(8) Excluding NM	(9) Excluding RI	(10) Excluding VT
MML	0.282	0.263	0.247	0.269	0.283	0.211	0.190	0.171	0.342	0.419*
	(0.214)	(0.222)	(0.224)	(0.218)	(0.214)	(0.231)	(0.229)	(0.231)	(0.234)	(0.227)
Unemployment Rate	-0.029	-0.029	-0.029	-0.044	-0.030	-0.026	-0.025	-0.007	-0.019	-0.025
	(0.051)	(0.052)	(0.052)	(0.051)	(0.051)	(-0.026)	(-0.025)	(-0.007)	(-0.019)	(-0.025)
Median Income	-0.000*	-0.000*	-0.000*	-0.000*	-0.000*	-0.000*	-0.000	-0.000*	-0.000*	-0.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Female	-0.325	-0.327	-0.311	-0.382	-0.365	-0.341	-0.275	-0.184	-0.407	-0.287
	(0.590)	(0.596)	(0.603)	(0.584)	(0.589)	(0.594)	(0.595)	(0.597)	(0.603)	(0.595)
Hispanic	0.241**	0.241**	0.239**	0.252**	0.244**	0.239**	0.227**	0.191*	0.255**	0.197*
	(0.109)	(0.110)	(0.110)	(0.108)	(0.109)	(0.110)	(0.110)	(0.113)	(0.111)	(0.112)
American Indian or Alaska Native	-0.890	-0.895	-0.901	-0.960	-0.893	-0.971	-1.011	-0.266	-0.876	-0.911
	(0.717)	(0.764)	(0.727)	(0.707)	(0.714)	(0.724)	(0.730)	(0.791)	(0.724)	(0.720)
Asian or Pacific Islander	-0.559***	-0.561***	-0.559***	-0.585***	-0.566***	-0.559***	-0.605***	-0.460**	-0.578***	-0.549***
	(0.207)	(0.208)	(0.208)	(0.206)	(0.207)	(0.207)	(0.220)	(0.214)	(0.209)	(0.207)
Black	-0.033	-0.035	-0.035	0.089	-0.037	-0.038	-0.031	-0.029	-0.025	-0.014
	(0.078)	(0.079)	(0.080)	(0.170)	(0.078)	(0.078)	(0.078)	(0.078)	(0.079)	(0.079)
Dropout	0.010	0.010	0.011	0.008	0.009	0.012	0.008	0.003	0.010	0.006
	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)
Constant	28.079	28.248	27.497	30.027	30.271	28.995	25.861	19.766	32.000	26.302
	(30.131)	(30.433)	(30.836)	(29.737)	(30.057)	(30.316)	(30.352)	(30.543)	(30.752)	(30.359)
Observations	510	500	500	500	500	500	500	500	500	500

*** p<0.01, ** p<0.05, * p<0.1

Standard error in parenthesis

^NOTE: The 9 MML States refer to the states that had medical marijuana laws that went into effect between 2002 and 2011. They are Arizona, Delaware, District of Columbia, Michigan, Montana, New Jersey, New Mexico, Rhode Island, and Vermont.

Table 7

Determinants of non-medical pain reliever usage by individuals aged 18 to 25 excluding one out of the 9 MML States with fixed effects

Regression Types	(1) All States	(2) Excluding AZ	(3) Excluding DE	(4) Excluding DC	(5) Excluding MI	(6) Excluding MO	(7) Excluding NJ	(8) Excluding NM	(9) Excluding RI	(10) Excluding VT
MML	0.724*	0.745*	0.736*	0.685*	0.725*	0.567	0.488	0.719*	0.782*	0.890**
	(0.384)	(0.398)	(0.399)	(0.393)	(0.386)	(0.414)	(0.410)	(0.417)	(0.416)	(0.408)
Unemployment Rate	-0.016	-0.014	-0.018	-0.033	-0.016	-0.025	-0.006	-0.010	0.019	-0.014
	(0.092)	(0.093)	(0.092)	(0.092)	(0.093)	(0.093)	(0.092)	(0.095)	(0.094)	(0.093)
Median Income	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Female	2.262**	2.296**	2.369**	2.219**	2.206**	2.410**	2.490**	2.483**	1.952*	2.302**
	(1.058)	(1.070)	(1.075)	(1.053)	(1.065)	(1.064)	(1.063)	(1.077)	(1.073)	(1.071)
Hispanic	-0.213	-0.218	-0.218	-0.211	-0.207	-0.201	-0.253	-0.267	-0.170	-0.250
	(0.195)	(0.197)	(0.196)	(0.196)	(0.196)	(0.197)	(0.196)	(0.203)	(0.197)	(0.202)
American Indian or Alaska Native	0.712	0.779	0.795	0.644	0.713	0.769	0.285	1.218	0.673	0.726
	(1.285)	(1.371)	(1.294)	(1.276)	(1.291)	(1.295)	(1.304)	(1.428)	(1.288)	(1.297)
Asian or Pacific Islander	0.086	0.082	0.099	0.083	0.090	0.094	-0.130	0.175	0.022	0.096
	(0.370)	(0.374)	(0.371)	(0.372)	(0.375)	(0.371)	(0.393)	(0.386)	(0.372)	(0.373)
Black	-0.039	-0.037	-0.042	0.030	-0.038	-0.054	-0.020	-0.024	-0.026	-0.020
	(0.139)	(0.141)	(0.142)	(0.307)	(0.141)	(0.141)	(0.140)	(0.141)	(0.141)	(0.142)
Dropout	-0.002	-0.004	0.004	-0.001	-0.002	-0.001	-0.011	-0.016	-0.002	-0.006
	(0.044)	(0.045)	(0.045)	(0.044)	(0.045)	(0.044)	(0.045)	(0.045)	(0.044)	(0.045)
Constant	-101.585*	-103.632*	-107.097*	-99.832*	-98.716*	-108.879**	-112.341**	-113.819**	-86.337	-103.592*
	(54.000)	(54.600)	(54.931)	(53.667)	(54.333)	(54.272)	(54.222)	(55.102)	(54.711)	(54.693)
Observations	510	500	500	500	500	500	500	500	500	500

*** p<0.01, ** p<0.05, * p<0.1

Standard error in parenthesis

^NOTE: The 9 MML States refer to the states that had medical marijuana laws that went into effect between 2002 and 2011. They are Arizona, Delaware, District of Columbia, Michigan, Montana, New Jersey, New Mexico, Rhode Island, and Vermont.

Table 8

Determinants of non-medical pain reliever usage by individuals aged 12 to 17 excluding one out of the 9 MML States with random effects

Regression Types	(1) All States	(2) Excluding AZ	(3) Excluding DE	(4) Excluding DC	(5) Excluding MI	(6) Excluding MO	(7) Excluding NJ	(8) Excluding NM	(9) Excluding RI	(10) Excluding VT
MML	0.437**	0.451**	0.419**	0.482***	0.439**	0.415**	0.414**	0.304*	0.484***	0.559***
	(0.173)	(0.178)	(0.178)	(0.176)	(0.173)	(0.184)	(0.180)	(0.183)	(0.182)	(0.183)
Unemployment Rate	0.012	0.012	0.017	0.001	0.011	0.013	0.015	0.044	0.020	0.008
	(0.043)	(0.043)	(0.043)	(0.042)	(0.043)	(0.043)	(0.043)	(0.044)	(0.044)	(0.043)
Median Income	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Female	-0.353**	-0.363**	-0.364**	-0.311*	-0.359**	-0.355**	-0.339*	-0.456**	-0.324*	-0.344*
	(0.178)	(0.177)	(0.179)	(0.175)	(0.179)	(0.180)	(0.181)	(0.190)	(0.188)	(0.180)
Hispanic	0.004	0.001	0.004	0.005	0.005	0.004	0.005	-0.004	0.004	0.003
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.012)	(0.010)	(0.010)
American Indian or Alaska Native	-0.008	-0.011	-0.008	0.003	-0.009	-0.008	-0.007	-0.023	-0.007	-0.011
	(0.037)	(0.037)	(0.037)	(0.036)	(0.037)	(0.038)	(0.037)	(0.041)	(0.037)	(0.037)
Asian or Pacific Islander	-0.023**	-0.023**	-0.023**	-0.023**	-0.023**	-0.023**	-0.023**	-0.021*	-0.024**	-0.025**
	(0.012)	(0.012)	(0.012)	(0.011)	(0.012)	(0.012)	(0.012)	(0.011)	(0.012)	(0.012)
Black	-0.009	-0.008	-0.010	0.002	-0.010	-0.010	-0.010	-0.007	-0.011	-0.009
	(0.011)	(0.011)	(0.011)	(0.012)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Dropout	0.023	0.020	0.024	0.027	0.023	0.026	0.023	0.011	0.025	0.020
	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)
Constant	28.150***	28.687***	28.758***	25.865***	28.557***	28.285***	27.375***	33.155***	26.630***	27.760***
	(9.048)	(8.991)	(9.069)	(8.905)	(9.101)	(9.156)	(9.220)	(9.597)	(9.542)	(9.152)
Observations	510	500	500	500	500	500	500	500	500	500

*** p<0.01, ** p<0.05, * p<0.1

Standard error in parenthesis

^NOTE: The 9 MML States refer to the states that had medical marijuana laws that went into effect between 2002 and 2011. They are Arizona, Delaware, District of Columbia, Michigan, Montana, New Jersey, New Mexico, Rhode Island, and Vermont.

Table 9

Determinants of non-medical pain reliever usage by individuals aged 18 to 25 excluding one out of the 9 MML States with random effects

Regression Types	(1) All States	(2) Excluding AZ	(3) Excluding DE	(4) Excluding DC	(5) Excluding MI	(6) Excluding MO	(7) Excluding NJ	(8) Excluding NM	(9) Excluding RI	(10) Excluding VT
MML	0.953***	1.007***	0.964***	1.018***	0.949***	0.875**	0.858**	1.027***	1.004***	1.077***
	(0.322)	(0.332)	(0.328)	(0.329)	(0.324)	(0.343)	(0.334)	(0.346)	(0.338)	(0.342)
Unemployment Rate	0.089	0.090	0.100	0.074	0.086	0.085	0.090	0.076	0.118	0.087
	(0.078)	(0.079)	(0.078)	(0.077)	(0.079)	(0.080)	(0.079)	(0.082)	(0.079)	(0.080)
Median Income	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Female	0.553	0.551	0.513	0.625*	0.558	0.570	0.584	0.608	0.405	0.559
	(0.361)	(0.364)	(0.356)	(0.354)	(0.366)	(0.366)	(0.368)	(0.393)	(0.380)	(0.367)
Hispanic	-0.031	-0.037*	-0.031	-0.030	-0.031	-0.031	-0.030	-0.027	-0.033	-0.032
	(0.020)	(0.021)	(0.020)	(0.020)	(0.021)	(0.021)	(0.021)	(0.025)	(0.021)	(0.021)
American Indian or Alaska Native	-0.051	-0.056	-0.055	-0.032	-0.050	-0.045	-0.047	-0.038	-0.061	-0.053
	(0.076)	(0.076)	(0.074)	(0.074)	(0.077)	(0.078)	(0.077)	(0.086)	(0.076)	(0.077)
Asian or Pacific Islander	-0.054**	-0.054**	-0.053**	-0.053**	-0.054**	-0.052**	-0.054**	-0.055**	-0.055**	-0.055**
	(0.024)	(0.024)	(0.023)	(0.023)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)
Black	-0.071***	-0.069***	-0.073***	-0.052**	-0.069***	-0.073***	-0.072***	-0.071***	-0.065***	-0.071***
	(0.022)	(0.023)	(0.022)	(0.024)	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)
Dropout	0.002	-0.005	0.005	0.010	0.000	0.001	-0.001	-0.007	0.002	-0.002
	(0.041)	(0.041)	(0.041)	(0.041)	(0.041)	(0.041)	(0.041)	(0.042)	(0.041)	(0.041)
Constant	-14.172	-14.177	-12.034	-18.191	-14.475	-14.891	-16.115	-16.836	-6.890	-14.396
	(18.354)	(18.492)	(18.059)	(18.044)	(18.595)	(18.580)	(18.710)	(19.919)	(19.294)	(18.609)
Observations	510	500	500	500	500	500	500	500	500	500

*** p<0.01, ** p<0.05, * p<0.1

Standard error in parenthesis

^NOTE: The 9 MML States refer to the states that had medical marijuana laws that went into effect between 2002 and 2011. They are Arizona, Delaware, District of Columbia, Michigan, Montana, New Jersey, New Mexico, Rhode Island, and Vermont.