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Fisher, Camille

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The Effects of Medical Marijuana on Crime Rates and Substance Abuse in California

Camille Fisher*

Department of Economics
2127 North Hall
University of California
Santa Barbara, CA 93106-9210

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ABSTRACT

With marijuana legislation repeatedly being seen on state ballots, research on marijuana's societal effects is in high demand. Using medical marijuana identification card data in California, this report observes the effects that medical marijuana has on crime and other drugs and alcohol. Medical marijuana has a small but statistically significant negative effect on total crime, larceny theft, property crime, and drunken arrests. There is a slight positive effect on drug and other mortality rates, but is negligible. Overall, there is some evidence of a substitution effect between medical marijuana and alcohol, but no evidence of a substitution effect between medical marijuana and other drugs.

*Corresponding author. Undergraduate Economics/Mathematics major at the University of California, Santa Barbara. Email: cfisher@umail.ucsb.edu. I would like to thank my advising professor, Dick Startz, Ph.D., for his help, comments, and suggestions.

1.0 INTRODUCTION

In November 1996, California became the first state to legalize the use of medical marijuana. Since then, a total of 23 states have passed medical marijuana laws (MMLs), along with 4 states and Washington D.C. legalizing the recreational use of marijuana. With marijuana legislation continuously being seen on state ballots, it is important to research and understand the effects it brings to society. To conduct our research, we will be looking specifically at the effect of medical marijuana use in California.

The goal of this paper is to observe the effects that medical marijuana has on crime rates and other drug and alcohol use. A specific question to be answered is whether or not marijuana can be a substitute, rather than a complement, for other illegal drugs and alcohol, resulting in a decrease in crime and drug and alcohol-induced deaths. To discover an answer, we will look at medical marijuana, crime, arrest, unemployment, and mortality rates in California counties from 2005-2014. The arrest and mortality rates will be used specifically to examine the possibility of marijuana being a substitute drug.

Today, there are approximately 572,762 medical marijuana patients in California, which is equivalent to 1.49% of California's population.[2] While recreational use of marijuana has not been legalized in California, it is estimated that 9% of Californians use marijuana.[3] If recreational marijuana use is legalized in California, it is possible that the percentage of marijuana users will increase. Given that California already has numerous marijuana farms and is predicted to provide 60-70% of the United States' crop if

[2] "Number of Legal Medical Marijuana Patients," *ProCon.org*, 2015, April 27, http://medicalmarijuana.procon.org/view.resource.php?resourceID=005889.

[3] Ingraham, Christopher. "Where Americans Smoke Marijuana the Most." *The Washington Post*, 2014, Aug. 5, https://www.washingtonpost.com/news/wonk/wp/2014/08/05/where-americans-smoke-marijuana-the-most.

legalized within the state, according to the *International Business Times*, it is pertinent to analyze the outcomes marijuana has on California's society today.[4]

In 2010, the number one cause of death among 25-64 year olds in California was drug overdose.[5] Many individuals have grown up with the notion that marijuana is a gateway drug to other illicit "hard" drugs. These other substances could include cocaine, heroin, methamphetamines, and prescription drugs, all of which can be extremely addicting and fatal. Since 1999, deaths from painkiller drug overdoses have increased 400% for women and 237% for men.[6] This causes us to think of potential solutions for fatal substance abuse. If medical marijuana can be offered as a substitute drug, will it decrease drug-poisoning deaths?

According to a survey implemented by the U.S. Department of Health and Human Services from 2005 to 2011, illegal drug use percentages were much higher in unemployed individuals than individuals with some sort of employment.[7] Specifically, it was shown that 18% of the unemployed were involved in illegal drug use, compared to 10% of part-time workers and 8% of full-time workers. This causes us to question whether or not there's a relationship between drug use and unemployment.

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[4] Warner, Joel. "California Marijuana Legalization 2016," *International Business Times*, 2015, Nov. 4, http://www.ibtimes.com/california-marijuana-legalization-2016-10-legalization-efforts-afoot-golden-state-2166983.

[5] "Drug Poisoning Deaths," *County Health Rankings*, 2015, http://www.countyhealthrankings.org/app/california/2015/measure/additional/138/description.

[6] "Injury Prevention & Control: Prescription Drug Overdose," *Centers for Disease Control and Prevention*, 2016, http://www.cdc.gov/drugoverdose/data/overdose.html.

[7] Badel, Alejandro, Brian Greaney, "Exploring the Link between Drug Use and Job Status in the U.S.," The Federal Reserve Bank of St. Louis, *The Regional Economist*, July 2013, https://www.stlouisfed.org/publications/regional-economist.

2.0 LITERATURE REVIEW

When California passed Proposition 215, referred to as the California Compassion Use Act, it allowed patients, along with their primary physicians, to possess and grow marijuana for medical use, once given a referral from a California-licensed doctor.[8] In 2004, California passed SB 420 to supplement Prop 215. The SB 420 specified the amount of marijuana each patient could possess and cultivate and created a voluntary, statewide, ID database through California health departments. This database is run by the California Department of Public Health and will be used to estimate marijuana use for this report. While both Prop 215 and SB420 protect patients and physicians from arrest in California, marijuana continues to be a federal crime, where there is no differentiation between medical and recreational marijuana use.

Currently, the Drug Enforcement Administration has marijuana listed as a Schedule I drug, defined as a drug with the highest potential for danger and abuse and is listed along with heroin, LSD, and ecstasy. Schedule I drugs are assumed worse in comparison to Schedule II drugs, which are recognized to be less abusive. Schedule II drugs include cocaine, methamphetamines, and other highly addictive prescriptions. According to the Office of National Drug Control Policy, the reason marijuana legalization is refused at the national level, is because marijuana use is believed to increase the use in other illicit drugs.[9] This brings us back to the question of whether or not marijuana can act as a substitute, rather than a "gateway", to other hard drugs.

[8] "Patients' Guide to Medical Marijuana Law in California," California NORML, *CaNORML*, 1 Nov. 2013, http://www.canorml.org/medical-marijuana/patients-guide-to-california-law.

[9] "Marijuana," *The White House*, 2015, https://www.whitehouse.gov/ondcp/marijuana.

While there has been little to no research done in the area of recreational marijuana, there have been many articles published on the effects of medical marijuana legalization.

In 2013, Anderson et al. (2013) published a paper that studied the effects of MMLs on traffic fatalities across the nation by using alcohol consumption as an instrument. The authors first used price data to observe the effects on the marijuana market after the MML took effect. They found that the supply of high-grade marijuana dramatically increased, while the lower quality cannabis was moderately impacted. Getting to the basis of their main goal, they used data on traffic fatalities within a 20-year period, across 14 states, to determine if marijuana was a substitute for alcohol. It was discovered that there was an 8-11% decrease in traffic fatalities within the first year of legalization with an even larger effect on traffic fatalities involving alcohol consumption.

The authors then used individual behavioral data to examine the probability of consuming alcohol in the past month, binge drinking, and the number of drinks consumed after the MML took place. They found that these probabilities drastically decreased after the legalization occurred. When looking at alcohol sales, it was also discovered that there was a decline of 5% on beer consumption in the age range of 18-29. The MMLs were then used as an instrument of beer consumption to establish the amount of traffic fatalities. It was deduced that for every 10% increase in beer sales per capita, alcohol related traffic fatalities increased by 24%. The article goes on to conclude that marijuana does have a substitution effect on alcohol, especially among young adults, which inherently declined traffic fatalities.

There is currently a working paper called "The Effect of Medical Marijuana Laws on Marijuana, Alcohol, and Hard Drug Use," where Hefei Wen studied these effects using geographic identifiers and by estimating a state-specific time trend model that included two-way fixed effects. It was discovered that the relative probability of marijuana use among individuals over 21 increased by 16%, the frequency of marijuana use increased by 12-17%, and marijuana abuse and dependency increased by 15-27%.

While there was an overall increase in marijuana use after MMLs went into effect, there was no strong evidence that showed marijuana use increased in youth. While the authors predicted that there could be a spillover effect of marijuana on other substances, there was no significant evidence that marijuana caused increases in alcohol and other drug use.

A more recent study done through the *Drug and Alcohol Review* examined medical marijuana as a substitute for alcohol, prescription drugs, and other illicit substances. The data was taken from a cross-sectional survey, completed online by 473 Canadian medical marijuana patients. The analysis found that 87% of patients substituted cannabis for one or more substances. This included an 80.3% substitution rate for prescription drugs, a 51.7% substitution rate for alcohol, and a 32.6% substitution rate for other illicit substances. These rates serve as evidence that marijuana can "play a harm reduction role in the context of use of these substances, and may have implications for abstinence-based substance use treatment approaches."[10] While these results show significant effects for marijuana substitution, there are an estimated 2.3 million users of cannabis in Canada alone, making it difficult to assume a survey of only medical

[10] Lucas, Philippe, et al., "Substituting cannabis for prescription drugs, alcohol and other substances among medical cannabis patients: The impact of contextual factors," *Drug and Alcohol Review,* 2015.

marijuana patients represents the entire population of all marijuana users.

An additional study was done through the University of Virginia in 2014 that examined how MMLs affect crime rates.[11] The author, Catherine Alford, decided to use difference-in-differences estimations where she controlled for state specific crime trends by collecting data across states over time from 1995-2012. It was discovered that after the implementation of MMLs, overall property crime and robbery rates increased. However, if the MMLs allowed for home cultivation, robbery rates actually decreased by about 10%. While these results show a positive relationship between MMLs and the previously mentioned crime rates, there was no statistically significant effect on violent crime rates.

However, a study done in 2012, by the Center on Juvenile and Criminal Justice, showed that after California passed the SB 1449 for the decriminalization of marijuana, youth crime rates were at an all-time low.[12] The SB 1449 allowed for a small possession of marijuana to count as an infraction, instead of a misdemeanor. Within a one-year period from 2010-2011, youth arrests declined by 16% for violent crime, 26% for homicide, and 50% for drug arrests. The author, Mike Males, concluded that the only significant explanations for a dramatic decline in juvenile crime rates would be the passing of SB 1449 and the improvement of socio-economic programs in California's poor neighborhoods.

In the previous reports examined, crime rates, drug and alcohol use, and traffic fatalities were all studied after the passing of MMLs among multiple states to discover any significant effects. While my proposed project would like to examine both crime

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[11] Alford, Catherine, "How Medical Marijuana Laws Affect Crime Rates," *University of Virginia,* Sept. 2014, http://people.virginia.edu/~cea9e/website_files/alford_mml_and_crime.pdf.

[12] Males, Mike, "California Youth Crime Plunges to All-Time Low," *Center on Juvenile and Criminal Justice,* October 2012.

rates and drug use affected by marijuana, it will look purely at California county data across a 10-year period and will not focus on age-specific crimes. The following report will also include an analysis of how the issuance of medical marijuana identification cards (MMICs) affects other drug and alcohol use, controlling for unemployment.

3.0 EMPIRICAL METHODS

The methodology used to answer the research questions above will be a series of multiple regressions with county and year fixed effects. To begin the analysis, we will determine how MMIC issuance affects crime rates. This regression will include unemployment as a right hand side variable to control for variations in the workforce. A regression will be run for every type of crime rate, as well as for total crime, in order to discover if marijuana has individual effects on different types of crime.

In addition to regressing crime rates on MMICs, drug and alcohol arrest rates will be regressed on MMICs to examine if there's a substitution effect between marijuana and other drugs and alcohol. Because arrest and crime rates do not depend solely on MMICs, we will also include unemployment rates as a right hand variable. After analyzing the number of MMICs on crime and arrest rates, drug, alcohol, and other mortality rates will be regressed on the number of MMICs issued per county. The point of this is to observe whether or not marijuana has a negative effect on drug and alcohol related deaths, implying that marijuana is a substitute for other drugs.

Because cross-sectional data will be used, there are unobservable events that could affect the analysis within that time period. For example, the Great Recession occurred from 2007-2009, which could have possibly increased crime rates. In order to

combat time trend errors in the model, I will add annual fixed effects. This will allow the model to absorb any overlooked effects dependent on time.

Because California counties are diverse and not all of them implement laws to the same extent, county fixed effects are also necessary for all regressions. By using these fixed effects, we will control for county-specific omitted variables that are time invariant. Relevant county-controlled variables may include the number of police stations or type of legislation implemented within a single county. All regressions in this report will contain both county and year fixed effects.

4.0 DATA

The main data set we will use is the number of MMICs issued each fiscal year per county. This data was collected by the California Department of Public Health when SB 420 was implemented in 2005. The count of MMICs is updated through September 2015, but we will only use the number of cards issued from 2005-2014 since all other data is given annually. The cards issued each year range from zero to 1475. Because each card is only valid for one year, we assume that these annual numbers include renewed cards.

There is a variation in these numbers between counties and time due to the fact that some patients may not have renewed their cards and every county implemented this system at different times. Because it is a voluntary identification system, any significant results would be under estimated. The MMIC data has been converted into number of MMICs issued per 100,000 people, as shown in 7.1.1 of the Appendix, in order for an easier interpretation between variables. It should be noted that some counties did not participate in some years and many others had zero medical marijuana cards issued at the

beginning of 2006. Sutter and Colusa counties still have not applied this system and thus have no observations. Because there is no data on medical marijuana cards issued, Sutter and Colusa counties were omitted from all data sets. Table 4.1 below offers summary statistics for the MMICs issued per 100,000.

In order to use unemployment as a right-hand side variable in the models, data from the California Employment Development Department was collected and offers per county unemployment rates from 1990-2014. This data will allow us to have a stronger model when examining the given research questions. Unemployment rates from 2005-2014 will be used in order to compare it to our MMIC data. Referring again to Table 4.1, we observe a mean unemployment rate of 9.8. All data sets contain 560 total observations from the 56 counties used within the 10-year period.

Table 4.1: Summary Statistics of MMICs, Unemployment, and Mortality Rates

Variable	Mean	Std. Deviation	Minimum	Maximum
MMICs per 100,000	53.2	95.3	0	779.8
Unemployment Rate	9.8	4.0	3.4	29.1
Alcohol-Induced Crude Rate	15.8	8.6	4.9	57.6
Drug-Induced Crude Rate	13.4	6.0	6.6	43.1
All Other Crude Rates	759.4	212.14	266.9	1328.6

The mortality data to be used in this report comes from the Centers of Disease Control and Prevention (CDC). The mortality (crude) rates are divided into three categories: Alcohol-Induced Causes, Drug-Induced Causes, and All Other Causes. These rates are given per 100,000, as shown in 7.1.3 of the Appendix. Estimated population sizes per year are also included in the data set. Like the MMIC data, the crude rates are

reported per county, per year from 2005-2014. Within this time period, these crude rates have ranged from 4.9 to 1328.6 per 100,000. Referring above to Table 4.1, the mean alcohol-induced, drug-induced, and other crude rates are 13.5, 15.8, and 759.4, respectively.

In addition to the mortality data, arrest rates will be examined to determine if medical marijuana is a substitute for other drugs and alcohol. The arrest data comes from the State of California Department of Justice's Criminal Justice Statistics Center (CJSC) and includes 76 arrest variables. Of these 76 variables, I will be using 7 of them in my data analysis. These variables include marijuana, drunk, felony drug offenses, narcotics, dangerous drugs, other drugs, and total arrests. Other drugs represent all misdemeanor drug arrests excluding marijuana. However, the marijuana variable used in our data is the sum of both misdemeanor and felony marijuana arrests. As stated by the CJSC, "A felony offense is defined as a crime which is punishable by death or by imprisonment in a state prison. A misdemeanor offense is a crime punishable by imprisonment in a county jail for up to one year."[13] Full variable definitions are given in Table 7.2.1 in the Appendix. All variables in the data set were given as number of arrests per county, per year again from 2005-2014. As presented in part 7.1.2 of the Appendix, I converted these numbers into arrests per 100,000 so the analysis of all variables could be more easily interpreted.

The CJSC has also provided crime data from 2005-2014 to be used in the regressions. Not to be confused with arrest data, the crime data set contains all individuals convicted of a crime, whereas arrests occur when a person is simply taken into custody for a crime. The crime data presented by the CJSC offers 66 variables, from

[13] Criminal Justice Statistics Center, *Report on Drug Arrests in California, From 1990 to 1999.* Dec. 2000, http://ag.ca.gov/cjsc/publications/misc/drugarrests/drugs2.pdf.

which I selected the 10 main types of crime, including, violent crime, burglary, larceny/theft, property crime, aggravated assault, motor vehicle theft, robbery, forcible rape, homicide, and total crime. Property crime is the sum of burglaries, larceny/thefts, and motor-vehicle thefts and violent crime is the sum of forcible rapes, homicides, and robberies. For full definitions of crime variables, refer to Table 7.2.2 in the Appendix.

The crime data set originally included city and county distinction, but I collapsed the data into strictly per county observations. Computed the same as the MMIC, crude, and arrest rates, the third calculation shown in 7.1.3 of the Appendix was used to convert the numbers into crimes per 100,000 people. Table 4.2 below offers summarized statistics of all data collected from the CJSC.

Table 4.2: Summary Statistics of Arrest and Crime Rates per 100,000

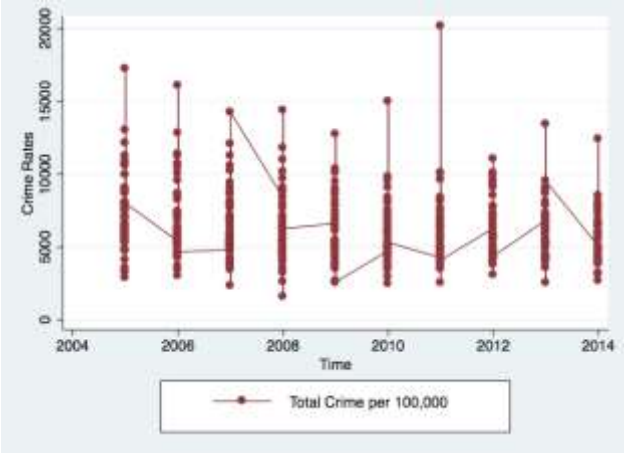
Variable	Mean	Std. Deviation	Minimum	Maximum
Marijuana Arrests	183.87	150.11	0	1324.5
Drunk Arrests	488.8	334.5	14.5	1958.6
Felony Drug Offenses	376.1	176.4	80.1	2118.4
Narcotics Arrests	91.1	65.6	0	717.3
Dangerous Drug Arrests	241.4	111.8	0	728.9
Other Drug Arrests	248.3	170.5	0	918.8
Total Arrests	1629.6	630.8	451.4	4760.8
Violent Crime	425.1	175.7	103.8	1201.9
Burglary	704.0	241.6	190.0	1800.2
Larceny-Theft	1621.5	711.9	211.2	7560.8
Property Crime	2679.9	1012.3	626.4	9450.9
Aggravated Assault	299.9	132.3	70.6	1041.7
Motor-Vehicle Theft	354.4	236.7	0	1339.5
Robbery	89.5	85.9	0	520.9
Forcible Rape	31.1	23.9	0	266.2
Homicide	4.6	6.1	0	82.8
Total Crime	6210.0	2265.16	1573.2	20162.0

5.0 ANALYSIS

To begin analyzing the effect of medical marijuana in California, all nine individual crime rates and total crime rates were regressed on MMIC rates (per 100,000 people) and unemployment rates with county and year fixed effects. It is necessary to

include county fixed effects in the model because there are unobservable factors that could affect crime rates. For example, high-income counties in California may have lower crime rates by being able to afford tighter security. It is also obligatory to include year fixed effects in the crime rates model. This type of fixed effect absorbs any event or time trend that could potentially adjust crime rates. Because the data ranges from 2005-2014, the housing market crash could have affected crime rates. Referring to Graph 5.1, it is indicated that crime rates don't necessarily have a linear time trend. Thus, the individual year dummy variables will be the best fit to combat the unobservable events that occur across time.

Graph 5.1: Total Crime Rates



By including county (δ_i) and year (α_t) fixed effects, the following model is obtained:

Equation 5.2:

$$Crime\ Rates_{it} = \beta_0 + \beta_1 * MMICs\ per\ 100{,}000_{it} + \beta_2 * unemployment\ rate_{it} + \delta_i + \alpha_t + \varepsilon_{it}$$

After applying Equation 5.2 to all crime variables, we observe significant effects of medical marijuana on total crime, larceny-theft, and overall property crime. Table 5.3 shows the estimates for the marginal effects on total crime.

Table 5.3: Total Crime

Variable	Estimate	Standard Error	t-statistic	95% Confidence Interval	
MMIC per 100,000	-1.51	0.48	-3.12	-2.46	-0.55
Unemployment	-30.73	40.57	-0.76	-110.50	49.04
Constant	7202.36	318.99	22.58	6575.24	7829.48

Here we see that for every additional medical marijuana card issued, total crime decreases by one and a half crimes. This appears to be a significantly large effect. However, looking at the average MMIC rate of 53 and the average total crime rate of 6,210, it is unlikely that medical marijuana could completely eradicate crime. The estimated results imply that if the mean of MMICs goes up to 54, crime rates will fall to an average of 6,208.5. This is only a decrease of 0.024% of total crime, which is a small, yet reasonable estimate. While this is a small effect on total crime, the 95% confidence level suggests the true estimate is between -2.46 and -0.55. Because these values are negative, it is acceptable to assume medical marijuana will not negatively impact society by increasing crime rates.

After observing that medical marijuana has a negative effect on total crime, it can also be seen that medical marijuana also has negative effects on larceny-theft and property crime, with estimates shown in tables 5.4 and 5.5.

Table 5.4: Larceny Theft

Variable	Estimate	Standard Error	t-statistic	95% Confidence Interval	
MMIC per 100,000	-0.56	0.15	-3.66	-0.86	-0.26
Unemployment	-10.44	12.84	-0.81	-35.68	14.8
Constant	1854.50	100.95	18.37	1656.03	2052.96

Table 5.5: Property Crime

Variable	Estimate	Standard Error	t-statistic	95% Confidence Interval	
MMIC per 100,000	-0.75	0.21	-3.52	-1.18	-0.33
Unemployment	-24.32	18.02	-1.35	-59.75	11.11
Constant	3217.15	141.67	22.71	2938.64	3495.68

Table 5.4 indicates that for every additional MMIC issued, larceny/theft declines by about half of a crime, while Table 5.5 suggests that for every additional MMIC issued, property crime decreases by ¾ a crime. Because property crime is defined as the sum of larceny/thefts, burglaries, and motor-vehicle thefts, the effect on larceny/theft is contained within the effect on overall property crime. As these estimates appear to be miniscule, they are both statistically significant at $\alpha = 0.05$ with t-statistics of -3.66 and -3.52, respectively.

Many individuals who argue against the legalization of marijuana claim that marijuana usage would increase crime, thereby negatively impacting society. By building a 95% confidence interval it is shown that the true estimates are negative and that 95% of the time, the estimate will fall between -1.18 and -0.33. Thus, medical marijuana will not increase overall property crimes, specifically larceny/thefts. This answers the common argument that marijuana use increases crime rates.

The other seven crime variables regressed on MMIC, using Equation 5.2, showed no significant effects of medical marijuana on crime. However, vehicle theft showed a statistically significant negative effect at the 90% confidence level. This can be explained by the above regression results on property crime, given that vehicle theft is included in the overall property crime rates by definition. All other crimes displayed zero effect from medical marijuana.

While we can comfortably say that medical marijuana does not increase crime rates, there needs to be an explanation for why it has a significantly negative effect on both total crime and property crime. One explanation is that allowing consumers to purchase legally decreases the amount of associated crime that comes with the illegal marijuana market. It is often true that individuals who enact in criminal activity participate in more than one crime. This means when individuals are purchasing marijuana illegally, they are more likely to commit other crimes. Thus, when additional MMICs are issued, individuals are purchasing marijuana legally and are less likely to be crime participants. This effect can be seen in the above regression results where additional MMICs lead to a slight fall in committed crimes.

A second explanation could be that there are substitution effects for marijuana and other drugs and alcohol. With evidence of marijuana reducing violent behavior, as explained further below, individuals are less likely to commit crimes. Because many crimes are committed while drunk or intoxicated, an increase in marijuana use with significant substitution effects on other drugs or alcohol could lead to a slight decrease in crime.

This brings us to the next two models, created to observe whether or not marijuana is a substitution drug for alcohol and/or other drugs. Equation 5.6 regresses every individual arrest rate on MMICs and unemployment rates, while Equation 5.7 regresses drug-induced, alcohol-induced, and all other mortality rates on MMICs and unemployment rates. These two equations will allow us to examine any substitution effects going on between marijuana and other drugs and alcohol. Both equations are again controlled for county and time fixed effects.

Equation 5.6:

$$Arrest\ Rates_{it} = \beta_0 + \beta_1 * MMICs\ per\ 100{,}000_{it} + \beta_2 * unemployment\ rate_{it} + \delta_i + \alpha_t + \varepsilon_{it}$$

Equation 5.7:

$$Mortality\ Rates_{it} = \beta_0 + \beta_1 * MMICs\ per\ 100{,}000_{it} + \beta_2 * unemployment\ rate_{it} + \delta_i + \alpha_t + \varepsilon_{it}$$

Looking at both arrest and crude rates gives us two opportunities to observe a substitution effect. After running regressions on all 7 arrest rates, I found that the number of drunk arrests per 100,000 people decreases by ¼ of an arrest for every medical marijuana card issued. This means that if there are 4 additional medical marijuana users, there will be one less drunk arrest, as shown in Table 5.8.

Table 5.8: Drunk Arrests

Variable	Estimate	Standard Error	t-statistic	95% Confidence Interval	
MMIC per 100,000	-0.244	0.078	-3.12	-0.39	-0.09
Unemployment	1.28	6.56	0.20	-11.62	14.19
Constant	449.49	51.61	8.71	348.02	550.96

While again, this is a very small effect, given that the average number of MMICs is only 53 per 100,000, it is significantly negative. We observe that the 95% confidence

interval falls within a negative interval, far enough below zero, giving evidence of a slight substitution effect between alcohol and marijuana. When performing a hypothesis test that the effect of MMICs in less than zero, we can reject the null that the effect is greater than or equal to zero at the 99.9% confidence level, as shown below:

$$H_0: \beta_1 \geq 0$$
$$H_1: \beta_1 < 0$$

t-statistic = -3.12 < -3.107 (critical value at 0.1% significance)

This means that 99.9% of the time medical marijuana has a negative effect on drunken arrests. While this indicates that there may be a substitution effect for alcohol, it is a small effect with a 1:4 substitution ratio. For this effect to decrease drunken arrest rates by 1%, MMICs would have to increase by about 20 per 100,00. This could be a possible scenario, given that the standard deviation of MMICs is 95.34. In the likelihood of this event, medical marijuana could be a significant substitute for alcohol.

As briefly mentioned earlier in this analysis, a substitution effect between marijuana and alcohol can justify why we see a decrease in crime. It has been observed by many studies that a large proportion of crimes are committed when an individual is intoxicated. According to the Huffington Post, the National Institute on Alcohol Abuse and Alcoholism "found that 25-30% of violent crimes are linked to alcohol use," and the journal of Addictive Behaviors performed a study that suggested "cannabis reduces likelihood of violence during intoxication," thus explaining why an increase in marijuana use can decrease crime rates.[14] By finding a slight substitution effect between marijuana and alcohol, we are able to explain some of the negative effect that marijuana has on

[14] Ferner, Matt, "Legalizing Medical Marijuana May Actually Reduce Crime, Study Says," *HuffPost Politics*, 27 March, 2014, http://www.huffingtonpost.com/2014/03/27/medical-marijuana-crime-study_n_5044397.html.

crime.

After regressing all other arrest rates, drunken arrests remains the only significant category affected by MMICs. So with the given data, there is no evidence that marijuana is a substitute for dangerous drugs, other drugs, felony drugs, nor narcotics. It is particularly surprising that we see no effect on narcotics, considering most medical marijuana patients specifically use cannabis as a substitute for narcotics. An explanation for this can be that some medical marijuana users do not use for medical reasons many of the MMIC holders in this particular data base may only use for recreational purposes.

To observe any further substitution effects, I used Equation 5.7 to regress alcohol-induced crude rates, drug-induced crude rates, and all other crude rates on MMICs and unemployment still controlling for county and year fixed effects. Unlike the arrest rate data, no substitution effects were found. Referring to the regression output in Table 5.9 for alcohol-induced deaths, MMICs actually had a statistically significant positive effect on alcohol related deaths.

Table 5.9: Alcohol-Induced Deaths

Variable	Estimate	Standard Error	t-statistic	95% Confidence Interval	
MMIC per 100,000	0.0068	0.0035	1.96	-0.000053	0.014
Unemployment	0.095	0.26	0.72	-0.425	0.615
Constant	12.60	1.83	6.88	8.99	16.20

The interpretation is that for every new medical marijuana user, the alcohol crude rate increases by 0.0068 deaths per 100,000. However, observing that zero is in the confidence interval and that the t-statistic is borderline significant, it is likely that there is no effect at all. While this is still a positive number, its suggested effect is so small, it becomes negligible. This can be determined by looking at the average crude rate for

alcohol related deaths, which is 15.8. There would have to be an additional 147 MMICs per 100,000 to increase this crude rate by 1 death per 100,000. This is a highly unlikely scenario, and could therefore be dismissed.

By applying this same model to drug-related deaths, we again get a statistically significant positive effect on the crude rate, shown in Table 5.10.

Table 5.10: Drug-Induced Deaths

Variable	Estimate	Standard Error	t-statistic	95% Confidence Interval	
MMIC per 100,000	0.0077	0.0039	2.00	0.0001	0.015
Unemployment	0.50	0.29	1.75	-0.06	1.07
Constant	10.58	2.12	4.99	6.40	14.76

While this would typically suggest that marijuana is a complement drug to other drugs, the effect is again, miniscule. With the average drug-induced crude rate of 13.4 deaths per 100,000, the number of medical marijuana cardholders would have to increase by 142 to cause 1 drug-related death. Similar to the effect on alcohol-induced mortality rates, this is a very unlikely event, and can be disregarded. While the drug and alcohol related deaths were affected slightly by medical marijuana, all other crude rates did not. There was no statistically significant effect when applying Equation 5.7 to all other crude rates.

6.0 CONCLUSION

After implementing all regressions, there is evidence to suggest that medical marijuana has a negative effect on crime rates, decreasing total crime by 1.5 per 100,000 for every additional MMIC issued. It is also found that medical marijuana has a significantly negative effect on both property crime and larceny/theft rates. While

medical marijuana could not completely alleviate crime all together because of the significantly higher crime rate average, there is no evidence that marijuana use would increase crime; thereby disproving the common argument that implementing marijuana legislation will increase crime rates.

Because I used a voluntary identification card database as a proxy for all medical marijuana users in California, many approximations may be under estimated. While there was some evidence of a substitution effect between alcohol and medical marijuana from the arrest data, the true effect could be much larger. This would justify why in previous studies, there has been stronger evidence of substitution effects. It was particularly interesting that there was no evidence of a substitution effect between marijuana and narcotics. Because the proxy for narcotics use was arrest rates, it is possible that the actual substitution effect could not be observed. Many users who substitute narcotics for medical marijuana are originally prescribed a legal amount of prescription-drugs, thus having no reason for an arrest to take place. It is also possible that many medical marijuana cardholders do not use for medical purposes and the actual medical users did not identify themselves in this database.

While this proxy is not definitive of all effects that marijuana has on society, it offers insight on the true impact that marijuana use can have on crime and substance use. An improvement of this study would be to use data from states that have passed recreational marijuana laws and comparing it to those who have not. However, at the moment we can use this analysis to better understand how the current marijuana laws affect California.

7.0 APPENDIX

7.1 VARIABLE CALCULATIONS

7.1.1 MMICs issued per 100,000 calculated as follows:

$$= \frac{Number\ of\ MMICs}{Population} \times\ 100{,}000$$

7.1.2 Crimes/Arrests per 100,000 calculated as follows:

$$= \frac{Number\ of\ Crimes/Arrests}{Population} \times\ 100{,}000$$

7.1.3 Crude rates calculated as follows:

$$= \frac{Number\ of\ Deaths}{Population} \times\ 100{,}000$$

7.2 VARIABLE DEFINITIONS

Table 7.2.1: Arrest Variable Definitions

Variable	Data Code	Definition
Marijuana Arrests	SCO13_sum + SCO34_sum	Sum of both misdemeanor and felony marijuana arrests.
Drunk Arrests	SCO43_sum	Total drunken arrests in which an individual drinks alcoholic beverages to the extent that one's mental faculties and physical coordination are substantially impaired.
Felony Drug Offenses	F_DRUGOFF	Sum of all felony drug arrests.
Narcotics Arrests	SCO12_sum	Felony drug arrest category including heroin, cocaine, etc.
Dangerous Drug Arrests	SCO14_sum	Felony drug arrest category including arbiturates, phencyclidine, methamphetamines, etc.
Other Drug Arrests	SCO15_sum	All misdemeanor drug arrests, not including marijuana. (Possession of paraphernalia, etc.)
Total Arrests		Sum of the above arrest categories.

* Definitions given by the CJSC publications

Table 7.2.2: Crime Variable Definitions

Variable	Data Code	Definition
Total Property	Property_sum	Sum of burglaries, larceny/thefts, and motor-vehicle thefts.
Burglary	Burglary_sum	Unlawful or forcible entry or attempted entry of a residence.
Larceny/Theft	LTtotal_sum	Completed or attempted theft of property or cash without personal contact.
Motor-Vehicle Theft	VehicleTheft_sum	The stealing or unauthorized taking of a motor vehicle, including attempted thefts.
Total Violent Crime	Violent_sum	Sum of aggravated assaults, robberies, forcible rapes, and homicides.
Aggravated Assault	AggAssault_sum	Attack or attempted attack with a weapon, regardless of whether or not an injury occurred and attack without a weapon then serious injury results.
Robbery	Robbery_sum	The completed or attempted theft, directly from a person, of property or cash by force or threat of force, with or without a weapon, and with or without injury.
Forcible Rape	ForRape_sum	The carnal knowledge of a female forcibly and against her will.
Homicide	Homicide_sum	Includes murder and non-negligent manslaughter, which is the willful killing of one human being by another.
Total Crime		Sum of total property crimes and total violent crimes.

* Definitions given by the Bureau of Justice Statistics

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