

THE EFFECT ON MEDICAL MARIJUANA LAWS ON
OCCUPATIONAL RELATED FATALITIES

by

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This thesis examines the question of whether the legalization of medical marijuana has a positive or negative effect on the incidence of occupational fatalities. It hypothesizes that marijuana and alcohol are economic substitutes and that states that have passed medical marijuana laws will experience fewer occupational fatalities because marijuana use impairs reflexes and cognitive ability less dramatically than alcohol use, which is highly correlated with workplace injury fatalities. The research shows that there are large, statistically significant reductions in occupational fatalities for the age group of 25 to 44 year olds, an age demographic set by the Bureau of Labor Statistics, in states in which medical marijuana laws have been passed in comparison to states that have no such legislation. Additionally, the research shows that the occupational fatality event under the title “transportation accidents” experience statistically significant reductions in fatalities as well. Greater research is needed in this field to infer causation between marijuana legalization and increased workplace safety, but this thesis provides further evidence of alcohol and marijuana being substitute goods, leading to reductions in workplace fatalities.

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Introduction

Each year in the United States there are thousands of occupational related fatalities reported to the Bureau of Labor Statistics (BLS). These reported fatalities are caused for a multitude of reasons. Fatal work-related injuries are reported as roadway incidents, slips, trips, and falls, and even homicides. Despite the different types of occupational fatalities, one thing has been consistent since 1992 when the Census of Fatal Occupational Injuries (CFOI) began to publish their data: transportation related fatalities have always accounted for the highest percentage of work-related fatalities. Accounting for roughly 40 percent of all work-related fatalities in 2017, year in and year out transportation accidents disproportionately account for the highest percentage of occupational fatalities. Transportation accidents occur in many fields of work, and it plagues workers more than any other type of injury. In 2017, when combined with the “construction and extraction” occupation group, the two groups accounted for 47 percent of worker deaths in 2017. On average, the occupational field of construction and extraction accounts for one of the highest fatality rates each year, as this type of work often carries a greater level of risk with it than other types of occupations.

Since 1992, when the CFOI began to publicly publish their data, regulations surrounding marijuana have changed immensely. In 1992 no state in the United States had legalized the medical use of marijuana, and now, to date, 33 states have legalized medical marijuana in some capacity. The changes in laws regarding the use of marijuana, and the availability of marijuana, could have a significant impact on the number of occupational fatalities that occur in a given year, and in the field of work

with which these fatalities occur in. Particularly, medical marijuana legalization could lead to large reductions in the number of fatal transportation accidents that occurred in the workplace as much research has shown marijuana to be a safer substance than alcohol in terms of the operating of a motor vehicle.

Project and Research Question

Is there a correlation or relationship between the legalization of medical marijuana and the incidence of workplace related fatalities? Specifically, will there be a reduction of occupational related fatalities in states that have legalized the medical use of marijuana in comparison to states that have not? Additionally, I hypothesize that we will see a significant reduction in work-related fatalities in the occupational fatality event titled “transportation accidents” in states where medical marijuana has been legalized in comparison to where it has not.

Literature Review

There has been great deal of research on the impact of drug and substance use in the workplace, and in particular, how this relates to occupational related injuries and fatalities. In a study published by the RAND Corporation in 2009 titled, *The Effects of Substance Use on Workplace Injuries*, a history of substance use on workplace injuries is provided, and a myriad of studies are analyzed that provide evidence that support the association between substance use and workplace injuries. The RAND study concludes that while there is much evidence supporting the notion that substance use correlates with workplace injuries, it is more likely that individuals who are engaging in substance use and abuse have underlying personal characteristics that make them more prone to injure themselves in their place of work, a concept known as “deviance proneness” (RAND, 2009). At the same time, many studies that the RAND study analyzed found evidence of a strong correlation between workplace injuries and fatalities and drug and alcohol use. In a study published in 2003, for example, the relationship between self-reported drinking and workplace related injuries for farmers in the state of Colorado between 1993 and 1995 was examined. The study found that individuals who reported drinking alcohol three or more times per week had an increased risk of injury of 70 percent in comparison with individuals who abstained from drinking alcohol (Stallones and Xiang, 2003). In a study published in 2005 regarding high school students in Texas, it was found that the likelihood of a student having an occupational related injury increased from an odds ratio of 1.56 for individuals who reported light alcohol use in the last month, to an odds ratio of 10.55 for individuals who reported heavy alcohol use (Shipp et al., 2005). A study from 1994 provided evidence of a positive relationship

between an individual self-reporting that they consumed five or more drinks per day over the course of the past year and reporting an on-the-job injury (Dawson, 1994). Many studies have found a positive relationship between alcohol use and abuse and occupational related injuries, suggesting that a decrease in alcohol consumption could be associated with a lower risk of an occupational injury.

For this project, the relationship between the inception of Medical Marijuana Laws (MMLs) and their effect on occupational related fatalities will be examined, not occupational injuries as a whole. It is my contention, that with easier access to marijuana individuals will substitute alcohol for marijuana, leading to a reduction in occupational fatalities as whole, and within the fatality type labeled “transportation accidents”. Alcohol plays an integral role in the incidence of occupational related fatalities for two reasons important to this thesis. The first reason is that there is a strong correlation between alcohol use and motor vehicle use leading to disastrous results. A study conducted in 2013 found that the first full year of the legalization of medical marijuana is associated with an eight to eleven percent decrease in traffic fatalities (Anderson, Hansen and Rees, 2013), providing strong evidence that alcohol and marijuana are economic substitutes. This is of note because since 1992 (furthest one can go back in data on Bureau of Labor Statistics), roughly 50 percent of all occupational fatalities in the United States have been caused by some form of a transportation accident. If alcohol and marijuana are indeed substitutes you would expect the percentage of transportation related accidents to fall in states where medical marijuana was legalized in relation states where medical marijuana was not legalized based on the

findings of this 2013 study. The second reason alcohol plays an important role in my exploration is that as stated prior, many studies have found a strong correlation between alcohol use and abuse, and on-the-job injuries and fatalities. If individuals begin to substitute alcohol use for marijuana use as a result of lowering the cost of acquiring marijuana through legalization it is possible occupational fatalities could be reduced as a whole.

Mark Anderson and colleagues analyzed a similar topic to my thesis in a recent 2018 study. Upon analyzing occupational fatality data from the BLS, they concluded that men aged between 25 and 44 years old, an age grouping set by the BLS, were associated with a 19.5% reduction in the number of occupational related fatalities (Anderson et al., 2018). That is, in states where the use of medical marijuana was legalized, there was almost a 20% reduction in the occupational fatality rate for individuals aged between 25 and 44. This study was unable to find significant correlations with the other age groups set by the BLS. This study is strongly correlated to my thesis; however, I would like to take this study in a different direction. Anderson's study only looked at age demographics, while the data sets provided by the BLS also account for the type of accident and what industry the accident took place in. I contend that the MMLs will not only continue to have an effect on the age group of 25 to 44 years olds, but we will also see reductions in occupational fatalities in regard to "transportation accidents" as a whole.

Background

History of Marijuana in the United States

Marijuana was first introduced into the United States in the early 1600s where the plant was used in the production of hemp. (Marijuana is a mixture of shredded flowers and leaves that come from the hemp plant). In the year 1619 the Virginia Assembly passed legislation that required the production of hemp from all farmers. Hemp was used in the production of ropes, sails, and clothing among various other items. Domestic production of hemp flourished in the United States until after the Civil War when products such as cotton began to replace it. This decline in hemp production was also associated with an increase in the number of imports coming into the United States at the time. However, in the mid to late 19th century marijuana began to be used as an ingredient in many medicinal products and was sold in public pharmacies nationwide. From the years 1850 to 1942 marijuana was recognized as an official medicinal drug by the *United States Pharmacopoeia* (Anderson, Hansen, and Rees, 2013), a drug that is associated with having healing properties.

By the early 1900s the perception of marijuana in the United States began to change drastically. Following the Mexican Revolution of 1910, resulting in the immigration of a large number of Mexicans into the United States, the United States was first introduced to the recreational use of marijuana. This quickly resulted in a stigma towards marijuana that was associated with immigrants. In 1907 the Poison Act was passed in California, and it was later amended in 1913. This act aimed to limit the

recreational use of the drug. By 1937 the Marijuana Tax Act was passed by Congress, essentially criminalizing the use of marijuana. By 1970, marijuana was classified as a Schedule 1 drug, a drug defined as either having a high risk for abuse or having no accepted medical use.

The year 1996 marked a notable change in the perception of marijuana in the United States. Proposition 215, also known as the Compassionate Use Act, allowed for the sale of medical marijuana in the state of California. This law removed criminal penalties for using, possessing, and cultivating medical marijuana in the state of California, while it was still illegal under federal law (Anderson, Hansen, and Rees, 2013). Since the legalization of medical marijuana in California in 1996, 33 states have legalized the use of marijuana in some capacity, while it is still considered a Schedule 1 drug by the Federal Government.

Occupational Fatalities

An occupational fatality is defined as an employee death while at work. Since 2011, there have been at least 4,500 reported occupational fatalities each year, with a high of 5,190 fatalities occurring in 2016. This data takes into account fatalities that have occurred in all sectors of work. In 2017, our most recently published data from the BLS, several important statistics were found.

- Transportation accidents remained the most frequent fatal event in 2017 with 2,077 (40 percent) occupational fatalities.
- The transportation and material moving occupational group and the construction and extraction occupational group accounted for 47 percent

of worker deaths in 2017.

- Unintentional overdoses due to nonmedical use of drugs or alcohol while at work increased 25 percent from 217 in 2016 to 272 in 2017. This was the fifth consecutive year in which unintentional workplace overdose deaths have increased by at least 25 percent.

Since 1992, the first year the Census of Fatal Occupational Injuries (CFOI) began publishing data, transportation accidents have accounted for the most frequent fatal event in each year nationwide. Also, the two occupational groups mentioned above, transportation and material, and construction and extraction, consistently account for the most occupational fatalities between occupational groups. Lastly, we are seeing a substantial increase in the number of unintentional overdoses due to nonmedical use of drugs alcohol and alcohol. (This may very well be due to the current opioid epidemic facing the United States). If alcohol and marijuana are to be substitutes, the high at-risk groups should see a decrease in fatality rate upon medical marijuana becoming legal in comparison to states in which it is not legal.

Substitutes and Complements

There is much debate and conflicting data as to whether or not alcohol and marijuana are complements or substitutes. In terms of economics, complementary goods are goods defined by the price of one good falling, and the demand of another good increasing. In other words, it is difficult to have one good without the other. A primary example of this is a printer and printer ink. If the price of a printer goes up, the demand for the complementary good, printer ink, is going to go down. A substitute good is the

opposite. Here if the price of one good goes up the demand for the substitute good is also going to increase. An example of this would be the sodas Coke and Pepsi. If the price of Coke goes up in comparison to the price of Pepsi, the demand for Pepsi will increase as individuals are willing to substitute Coke with Pepsi as they will save money. Coke and Pepsi are a classic example of economic substitutes as the majority of people cannot taste the difference between the two sodas. Therefore, if the price of one of the sodas increases, the demand for the other soda will increase as well, as they are essentially the same product.

Alcohol and Marijuana As Complements

The legalization of marijuana, in any capacity, allows for easier acquisition of the drug (as there are less restrictions in place), thus decreasing the cost of marijuana. With this reduction in the cost to acquire marijuana we can study the effect this has on both marijuana and alcohol consumption, one of the main aims of this paper. A key question for marijuana and alcohol in regard to this paper are the two goods complementary goods or are they substitute goods? That is, with the legalization of marijuana are individuals going to consume more alcohol than before (complementary goods) or will we see a reduction of alcohol use (substitute goods)?

The answer to this question is unclear to economists. In a study published in 2004 assessing the impact of stricter alcohol regulation on college campuses it was found that greater alcohol regulations, increasing the price of alcohol, and in turn decreasing alcohol use, was associated with a decrease in the use of marijuana, suggesting that marijuana and alcohol are complementary goods (Williams et al., 2004).

In other words, this study concluded that college students tend to consume the two drugs together, as opposed to using them separately. A 1998 study published in the *Journal of Health Economics* set out to assess the impact of two laws passed by Congress that aimed to reduce alcohol consumption in individuals not of legal drinking age (the Federal Uniform Drinking Age Act and Congress increased the Federal excise tax on beer and wine for the first time in 40 years). This study also concluded that marijuana and alcohol were economic complements, and even found that, “increases in the federal tax on beer will generate a larger reduction in the unconditional demand for marijuana than for alcohol in percentage terms” (Pacula, 1998). Another study set out to analyze how changes in prices of cigarettes, alcohol and marijuana impacted the demand for marijuana as a whole. Using data from the National Household Surveys on Drug Abuse, and using in-place marijuana legislation as a proxy variable for the price of marijuana, it was concluded that marijuana, alcohol, and tobacco are economic complements, “so that increasing the price of any one of the goods will decrease the demand for marijuana” (Farrelly et al, 1999). In a more recent study done in 2011, as additional evidence of alcohol and marijuana being economic complements, Yoruk and Yoruk used a regression discontinuity design to, “estimate the impact of the minimum legal drinking age laws on alcohol consumption, smoking, and marijuana use among young adults” (Yoruk and Yoruk, 2011). They were able to determine from their research, using data from the National Longitudinal Survey of Youth from 1997 (NLSY97) that under certain specifications, at the age of 21 (the Federal minimum drinking age since 1984) not only is there a sharp increase in alcohol consumed, but also an increase in the amount of marijuana consumed, further suggesting that the two

goods are complements.

Alcohol and Marijuana As Substitutes

While there is plenty of evidence to support alcohol and marijuana are economic complements, economists have found the opposite to be true in a multitude of studies. In one of the first studies published of its kind in 1997, data obtained from the “Monitoring the Future” survey taken by high school seniors to assess the impact of higher legal drinking ages found alcohol and marijuana to be economic substitutes (Chaloupka and Laixuthai, 1997). Using the “Monitoring the Future” survey data from 1982 to 1989 to estimate youth drinking and heavy drinking as functions of alcohol price, minimum legal drinking ages, and the price of marijuana Chaloupka and Laixuthai found, “youths residing in states where marijuana is decriminalized consume alcohol less frequently and are less likely to engage in heavy drinking than those states where marijuana criminalized. This suggests that, at least for high school seniors, alcohol and marijuana are substitutes” (Chaloupka and Laixuthai, 1997). In a similar study published in 2001, John DiNardo and Thomas Lemieux conducted research on the impact of the minimum drinking age and the prevalence of alcohol and marijuana use in high school seniors. They found that the increased minimum drinking age did slightly decrease the amount of alcohol consumed, but the unintended consequence of this was an increase in the amount of marijuana the students consumed, providing evidence that marijuana and alcohol are substitutes (DiNardo and Lemieux, 2001). In a more recent study authored in 2012 by Benjamin Crost and Santiago Guerrero, the minimum legal drinking age was used as a discontinuity for their data. Their study found that upon

turning 21 years old, the consumption of marijuana sharply decreases, while the consumption of alcohol increases, again providing evidence that alcohol and marijuana are substitutes (Croston and Guerrero, 2012). In a previously mentioned study concerned with medical marijuana laws, traffic fatalities, and alcohol consumption it was found that the passing of MMLs was associated with sharp decreases in the price of marijuana, and also significant reductions in the amount of alcohol consumed (Anderson, Hansen, and Rees, 2013). This study very clearly showed that reductions in the price of marijuana significantly reduced alcohol consumption, providing more evidence that alcohol and marijuana are economic substitutes.

There are even economic studies that have set out to determine whether or not marijuana and alcohol are substitutes or complements and have found inconclusive evidence in either direction. Croston and Rees applied the same research design as the Yoruk and Yoruk study mentioned earlier, except they made an adjustment. The Yoruk and Yoruk study only analyzed participants from the NLSY97 that had previously used marijuana. When accounting for participants that both have and have not used marijuana prior to the survey Croston and Rees found no evidence that marijuana and alcohol were substitutes, nor complements, suggesting that changing the price of one of the goods does not change the demand for the other good. In other words, they found a minimal relationship between alcohol and marijuana. It is evident that there is no clear answer as to whether or not alcohol and marijuana are substitutes or complements. It is a goal of this paper however, to add to the existing literature of the goods being economic substitutes.

Evidence Marijuana is Safer Substance than Alcohol

In order for the hypothesis of enactment of MMLs leading to a reduction in occupational fatalities as a result of substituting marijuana for alcohol to be plausible marijuana must be safer, or at least possess less disastrous effects than alcohol. In terms of operating a motor vehicle, being under the influence of either marijuana or alcohol unambiguously impairs one's ability to drive. However, drunk drivers are involved in 25% more motor vehicle fatalities than drivers under the influence of marijuana (Sewell et al, 2009). Marijuana users tend to exhibit far greater caution and safety while driving than that of drivers under the influence of alcohol. These behavioral differences greatly contribute to marijuana users being in less fatal motor accidents than individuals under the influence of alcohol. In another study analyzing alcohol and marijuana use among over 1023 trauma patients, it was found that the vehicular crash victims were found under the influence of alcohol far more than victims were found under the influence of marijuana (Soderstrom et al, 1988). The Anderson, Hansen, and Rees study provides evidence that alcohol and marijuana are economic substitutes. The article also suggests that marijuana is a safer substance alternative in terms of driving under the influence. The eight to eleven percent reduction in traffic fatalities the year after MMLs were enacted is further evidence that marijuana is a safer alternative to alcohol in terms of operating a vehicle. This is important to my inquiry. The legalization of medical marijuana is not responsible for "magically" reducing the number of traffic fatalities that occurred in treatment states. It does however provide further evidence that when people have easier access to marijuana, as is the case after MMLs are enacted, there is the potential that the roads become safer. This is why I have hypothesized that states in

which MMLs are in place will see a reduction in the number of occupational fatalities caused by transportation accidents.

Methodology

Data for this project was obtained from the Bureau of Labor Statistics. As mentioned prior, each year since 1992 the BLS has published state data on every reported occupational related fatality. This provides state and year workplace fatality statistics for the last 25 years (2017 is the most current data set able to be obtained). If one takes these 25 years and multiplies it by 51 (all 50 states and the District of Columbia) 1,275 observations are available for analysis. This panel data, defined as data containing observations from multiple phenomena and multiple time periods, was provided by the Census of Fatal Occupational Injuries which is administered by the BLS. This data is divided into multiple demographics including age, gender, and race. The data is also separated into the occupation in which the fatality occurred, and the type of fatality that occurred. For the purposes of this research age, occupation, and type of fatality will be analyzed. Of note, the BLS also provides data on occupational injuries, however due to under reporting of injury issues, fatalities provide of more concrete data set for analysis. Previous studies similar to mine, including Anderson et. al 2018, use a multivariate Poisson regression analysis. This regression estimates the association between an indicator variable for whether or not medical marijuana is legalized in the particular state, and the number or workplace fatalities in a given state and year. (An indicator variable, also known as a dummy variable, takes a value of zero in the control groups and a value of one in the treatment groups. For this project, the control groups are states where medical marijuana use is not legalized, and treatment groups are where it is legalized). Controlling for state fixed effects allows for seeing differences in the control and treatment groups, regardless on the number of fatalities

that occurred in a state in a given year or time period. Additionally, year fixed effects will allow for comparison across all 25 years available for study, regardless of the number of occupational fatalities in a given year. The outcome of this regression analysis is called the “treatment effect”, or in terms of this study the difference in fatality rates among treatment and control states accounting for variability across states and years.

Regression

Regression analysis, at its core, is a way to show or predict a relationship between two or more variables. The Poisson regression more specifically is used for modeling the number of times an event occurs in an interval of time, such as the number of occupational fatalities in a given state over the course of a year. For this project however, a linear regression approach will be used. The linear regression approach allows for more interpretable outcome coefficients and the fixed effects will have better statistical properties. The most basic equation for a regression is represented by the following:

$$\mathbf{Y} = \mathbf{a} + \mathbf{bX}$$

where **X** is the explanatory variable and **Y** is the dependent variable, meaning that it depends on the outcome of **X**. The symbol **b** represents the slope of the line, and **a** is the y-intercept, also known as where **b** is equal to zero. For the purposes of my research however, I will be using a different type of regression known as a “Difference-in-Differences” regression which estimates the difference in values of control groups and groups that were treated. A basic equation for a “Difference-in-Difference” is

represented by the following:

$$(y_t^A - y_t^B) - (y_c^A - y_c^B),$$

where **A** and **B** represent after and before treatment was put into effect, and **t** and **c** represent the treatment and control groups. Essentially all this equation is doing is taking the difference in mean outputs in the treatment group before and after treatment went into effect, and then subtracting that number from the difference in mean outputs in the control group before and after treatment went into effect. In terms of this research, the difference in difference will be the change in occupational fatalities in treatment states before and after marijuana legalization subtracted from the change in occupational fatalities in control states before and after marijuana legalization. This “Difference-in-Difference” equation will take on the form of a regression for this research, and can be represented by the following:

$$y = \beta_0 + \beta_1 * \text{MML_indicator}_i + \beta_2 * \text{after_legal}_t + \beta_3 * \text{MML_after_legal}_{it} + \epsilon_{it}$$

where β_0 is the y-intercept, β_1 is the coefficient multiplied by an indicator variable for whether or not medical marijuana has been legalized in a particular state, β_2 is the coefficient multiplied by an indicator variable for whether or not medical marijuana has been legalized in a particular year, and β_3 is the coefficient multiplied by an interaction term that takes a value of 1 only when both the first two indicator variables are satisfied (when marijuana has been legalized in a state, and the year of study is same or after the date of legalization). The coefficient of importance is β_3 , as β_3 is equal to the difference in difference. In other words, β_3 represents the differential effect across the treatment and control groups. Estimating the different regression coefficients, β_3 , for the varying age groups and transportation accidents as a whole, is the goal of this thesis.

As stated prior, the research design also includes state fixed effects and year fixed effects. Fixed effects allow us to control for unobservable difference in the data. By including fixed effects, we can come closer to finding the true treatment effect as we are controlling for the average differences across both the 51 states in this research, and the 25 years of data provided by the BLS. Within the regression fixed effects will be represented by indicator variables that essentially fix or hold constant the effects across different states and years that we cannot directly observe. The fixed effects control for the unobserved variation with the model, such as people in California may have a greater preference for marijuana than people in South Dakota. With this variation controlled for we are better able to identify the relationship between occupational fatalities and medical marijuana legalization. Fixed effects expression in regression for this research appears as the following:

$$y = \beta_0 + \beta_1 * \text{MML_indicator}_i + \beta_2 * \text{after_legal}_t + \beta_3 * \text{MML_after_legal}_{it} + \text{StateFixedEffects}_t + \text{YearFixedEffects}_t + \epsilon_{it}$$

Results

Analysis by Age Group

Each of the following four age groups were set by the Bureau of Labor Statistics. The age groups include 16 to 24 year olds, 25 to 44 year olds, 45 to 64 year olds, and 65 year olds and over. Eight separate regressions were computed to analyze the treatment effect of marijuana legalization on occupational related fatalities, with each age demographic accounting for two of the regressions. The first regression in each age demographic was an attempt to match the data found by the Andersen et. al. 2018 paper. At the time that the Anderson paper was published, only 20 states had operational medical marijuana facilities, while at the time of this research 29 states have operational medical marijuana facilities. These 29 states will be used as data in the second set of regressions for each age group. I will call these “Anderson data” and “Post-Anderson data”. The first goal of this paper was to attempt to match the findings of the Anderson paper, and then to analyze the differences with more states legalizing marijuana since the paper’s publication. For each regression, outputs were calculated for the treatment effect across age groups, and the treatment effect across age groups conditional on a state having legalized marijuana for at least five years. This indicator variable, titled `post_five_plus`, took a value of one if a state had legalized marijuana five years, and kept this value for the years leading up until 2017 (last year of available data). The reason for this additional value is that Anderson paper found significant reductions in the rate of occupational fatalities five years after medical marijuana legislation was passed, in addition to a treatment effect upon legalization. Each

regression used an “age demographic” variable to signify which age group warranted analysis in each regression, along with state and year fixed effects as mentioned prior. Lastly, the treatment indicator variable was regressed on the natural log of the number of deaths, not just the number of deaths. Natural log of deaths was used for two reasons. The first is that by taking the natural log of the number of deaths, we are able to reduce the influence of outliers in the data. For example, if a state had an extremely high number of occupational fatalities in a certain year, taking the natural log reduces the impact of this outlier. Second, taking the natural log allows economists to look at regression coefficients as percentage values, making reporting of data easier.

16 to 24 Year Old Age Demographic

Using Anderson data, the association between legalizing medical marijuana and occupational fatalities was negative. There was a 12.9% reduction in occupational fatalities, with an additional 1.5% reduction five years after marijuana had been legalized, however, these numbers are not statistically significant at the traditional level of 5%. These findings are consistent with the work of Anderson who also found a negative association with marijuana legalization, but without statistical significance.

Using Post-Anderson data, a similar result occurred, as there was again a negative association between medical marijuana legalization and occupational fatalities. The findings suggest there was a 14.4% reduction in occupational fatalities, with an additional 2.6% reduction five years after legalization, but the results were not statistically significant.

25 to 44 Year Old Age Demographic

Using Anderson data, the association between legalization and fatalities was again negative. There was a 16.3% reduction in occupational fatalities, and this was statistically significant at the 5% level, providing greater likelihood of a relationship between legalization and fatalities. This finding was consistent with the findings of the Anderson paper, as they found a 19.5% reduction in fatalities for this age group using different model specifications. There was an additional 12.2% percent reduction five years after legalization came into effect, but this result was not statistically significant. Figure 1 illustrates this reduction.

Using Post-Anderson data, we see large reductions in both the number of occupational fatalities, and number of occupational fatalities five years after legalization. The regression shows that legalization was associated with a 12.4% reduction in occupational fatalities, and an additional 14.9% reduction five years after legalization came into effect. Both of these outputs were statistically significant at the 5% level, suggesting that for this age group, marijuana legalization leads to sharp decreases in the number of occupational fatalities, especially five years after the law has been in effect Figure 2 illustrates this reduction.

45 to 64 Year old and 65 and Over Age Demographic

These age demographics exhibited both positive and negative associations with marijuana legalization and occupational fatalities. However, none of the four regression outputs achieved any level of statistical significance, and as such does not warrant further analysis. These findings were consistent with the Anderson paper.

Transportation Accidents

Looking at the treatment effect associated with medical marijuana legalization and occupational fatalities that resulted from a transportation accident extends the study of the Anderson paper. The “Difference and Difference” design for the regressions using transportation data were the same as that for regressions using data by age group, except there no age demographic variable was needed. The BLS does not supply information on the number of transportation accidents that occur by age group, but rather by the state as a whole for each year. Again, state and year fixed effects were used to control for unobserved difference across states and years.

Using data available from each year and each state from 1992, a negative association was found between fatalities that resulted from a transportation accident and the legalization of medical marijuana. Upon the legalization of marijuana there was a 7.7% reduction in the number of occupational fatalities caused by a transportation accident, statistically significant at the 5% level, and an additional 14.4% reduction in the number of occupational fatalities caused by a transportation accident five years after marijuana had been legalized, significant at the 1% level. These findings provide evidence that marijuana legalization leads to a reduction in the number of occupational fatalities as a result of a transportation accident, consistent with the Anderson, Hansen, and Rees findings stated prior. Figure 3 provides significance levels and number of observations for these findings. Figure 4 illustrates this reduction graphically.

Discussion

Under Federal law, marijuana is currently classified as a Schedule 1 drug which is a drug defined as either having a high risk for abuse or having no accepted medical use. As the conversation in the United States regarding marijuana use shifts from a taboo subject to a mainstream debate about legalization, it is important to acknowledge that the properties associated with marijuana are not conducive to increased workplace safety. Decreased hand-eye coordination, impaired cognitive function and memory processing abilities are just a few of the risks associated with the use of marijuana that decrease safety in the workplace, especially when operating a motor vehicle or heavy machinery. In fact, research shows that marijuana use increases the likelihood of an individual being involved in a motor vehicle accident (Asbrige and Cartright, 2012), which upon marijuana legalization, could increase the number of occupational injuries and fatalities each year.

The legalization of marijuana increases the consumption of marijuana as the cost of acquiring the drug is now lower. In theory, lower cost and easier access to marijuana could either make workplaces safer or more dangerous places. On one hand, as stated in the previous paragraph, many of the effects of marijuana use are not conducive to workplace safety. However, there are other effects of legalizing marijuana aside from increased marijuana consumption that could improve workplace safety. Existing literature referenced prior in this study suggests that alcohol use and workplace injuries have a positive association -- i.e. the more one drinks, the greater the likelihood of an injury or fatality on the job. There is also a great deal of literature that supports the

notion that alcohol and marijuana are economic substitutes, meaning that as the cost of marijuana goes down, the consumption of alcohol also decreases. The combination of the inherent risk of alcohol use on workplace safety and the substitutional effect between alcohol and marijuana, could, in theory, result in improved workplace safety through the legalization of marijuana, through a reduction in the consumption of alcohol. While marijuana does impair reaction speeds and cognitive ability, these results appear to be significantly less disastrous than the effects of alcohol, suggesting that as individuals substitute alcohol use with marijuana use, workplace safety could increase upon legalization in a state.

Using a “Difference and Difference” regression design, estimating the difference in the natural log of deaths on an indicator variable that took a value of one when both a state had legalized marijuana, and the year of study came after legalization, statistically significant reductions were found in both the age demographic of 25 to 44 year olds, and in “transportation accidents” as a whole. A primary goal of this paper was to match the findings of the Anderson study which found a statistically significant 19.5% reduction in occupational fatality rate in the age demographic of 25 to 44 years old individuals. The findings of my inquiry support the Anderson finding, as it was found that there was a 16.3% reduction in occupational fatalities for this age demographic, statistically significant at the 5% level. The Anderson study used more controls in their regression analysis than my study, including accounting for unemployment rate and state demographics, which might account for the difference in fatality reduction percentages. However, both inquiries found large reductions in the number of

occupational fatalities in this age demographic. The age demographics of 16 to 24-year olds and 45-year olds and older, had both positive and negative association with occupational fatalities on medical marijuana, but were not statistically significant, consistent with the findings of the Anderson paper.

To build on the findings of the Anderson paper, this study then looked at the impact of medical marijuana legalization on “transportation accidents” as a whole. “Transportation accidents” is a grouping set by the BLS accounting for the number of fatalities in a given state in a given year that resulted from some form of a transportation accident. It was found that there is a 7.7% reduction in the number of occupational fatalities as a result of a transportation accident, statistically significant at the 5% level, upon legalization, in states where MMLs had been passed compared to states where there is no such legislation in place. There was an additional 14.4% reduction in the number of occupational fatalities as a result of a transportation accident five years after an MML had been in place, statistically significant at the 1% level.

There are many factors that could contribute to reductions in the number of fatalities found in this study. A main contributor is that it appears that individuals aged 25 to 44 more readily substitute marijuana for alcohol upon legalization of the drug. This substitution in turn appears to reduce the number of occupational fatalities, but it is unclear why we see this negative association. It is my contention that the substitution of alcohol for marijuana improves workplace safety through the harmful effects associated with alcohol use in and out of the workplace, especially in terms of operating a motor

vehicle. This substitution could in part explain the strong negative association between fatalities caused by “transportation accidents” and medical marijuana legalization. At this point in time there is no definite answer as to why there is improved workplace safety upon medical marijuana legalization in the age demographic of 25 to 44 years old, and in the realm of transportation accidents. However, this study shows that there are negative associations between the two, providing more evidence that alcohol and marijuana are economic substitutes, and suggests that greater reform in legislation regarding legalization could improve workplace safety.

List of Figures

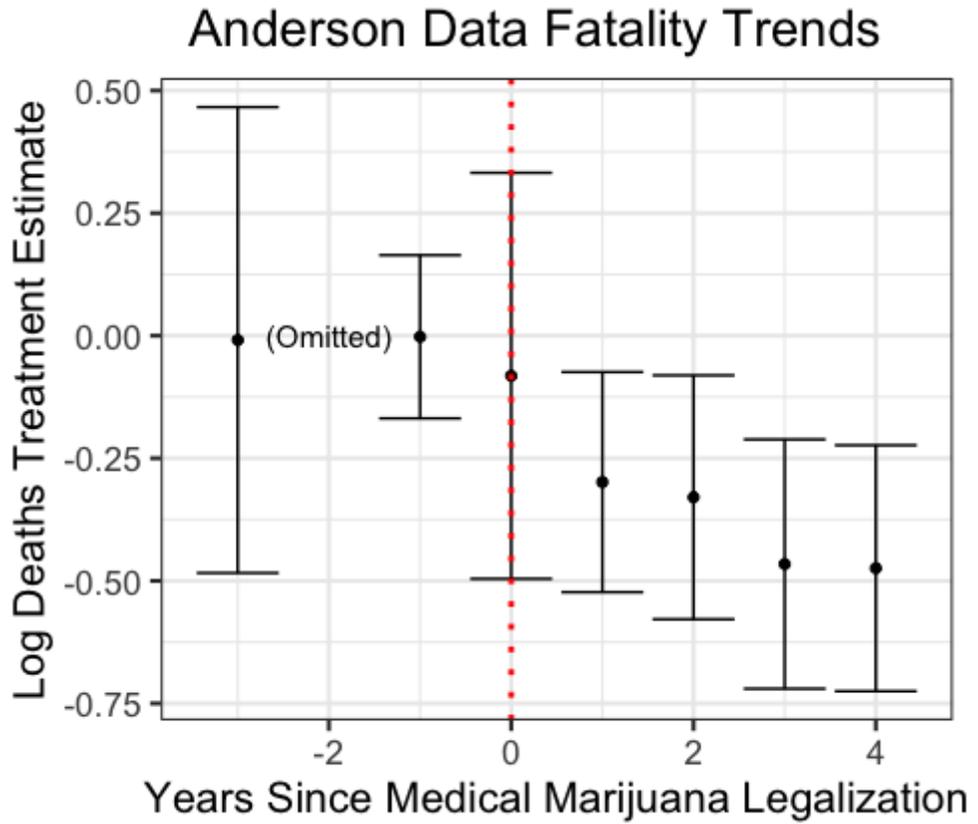


Figure 1: Occupational Fatality Trends Among 25-44 Year Olds for “Anderson” Data

This graph shows the difference in difference treatment estimate found after MMLs went into effect. The years leading up to Year 0 (dashed red line) appear to be hovering around the Log Deaths Treatment Estimate of 0.0, with a slight reduction in the treatment year. Then after the first full year of marijuana legalization the figure shows a reduction to a treatment estimate that hovers around 0.25, and then falls even lower in Year 5, coincident with the reductions described in Results.

Post-Anderson Data Fatality Trends

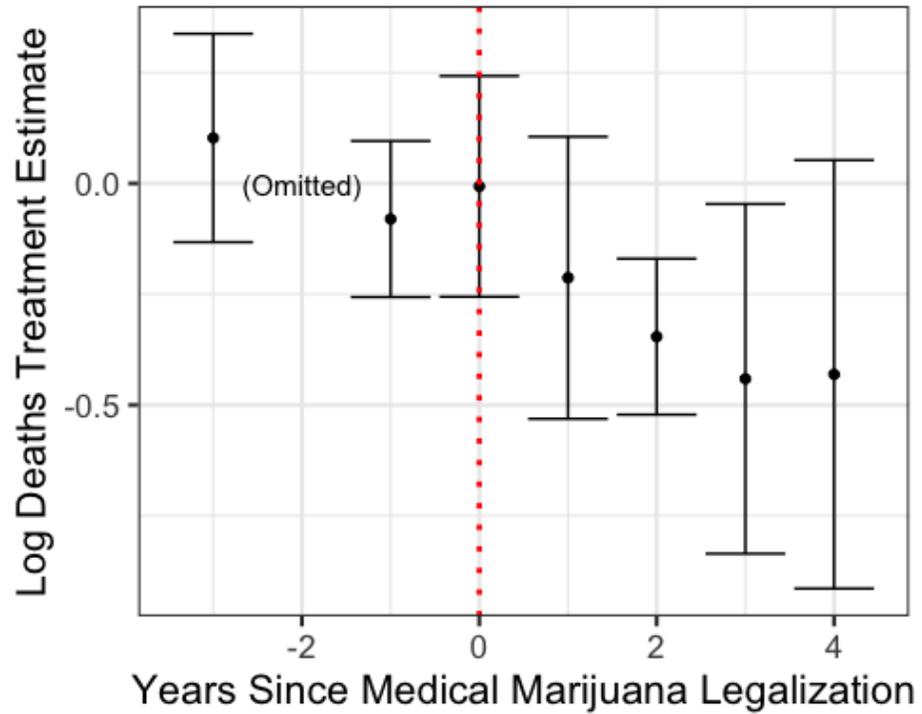


Figure 2: Occupational Fatality Trends Among 25-44 Year Olds for “Post-Anderson” Data

This graph shows the difference in difference treatment estimate found after MMLs went into effect. The years leading up to Year 0 (dashed red line) appear to be hovering around the Log Deaths Treatment Estimate of 0.0. Then after the first full year of marijuana legalization the figure shows a reduction to a treatment estimate that hovers around 0.25, and then falls even lower in Year 4.

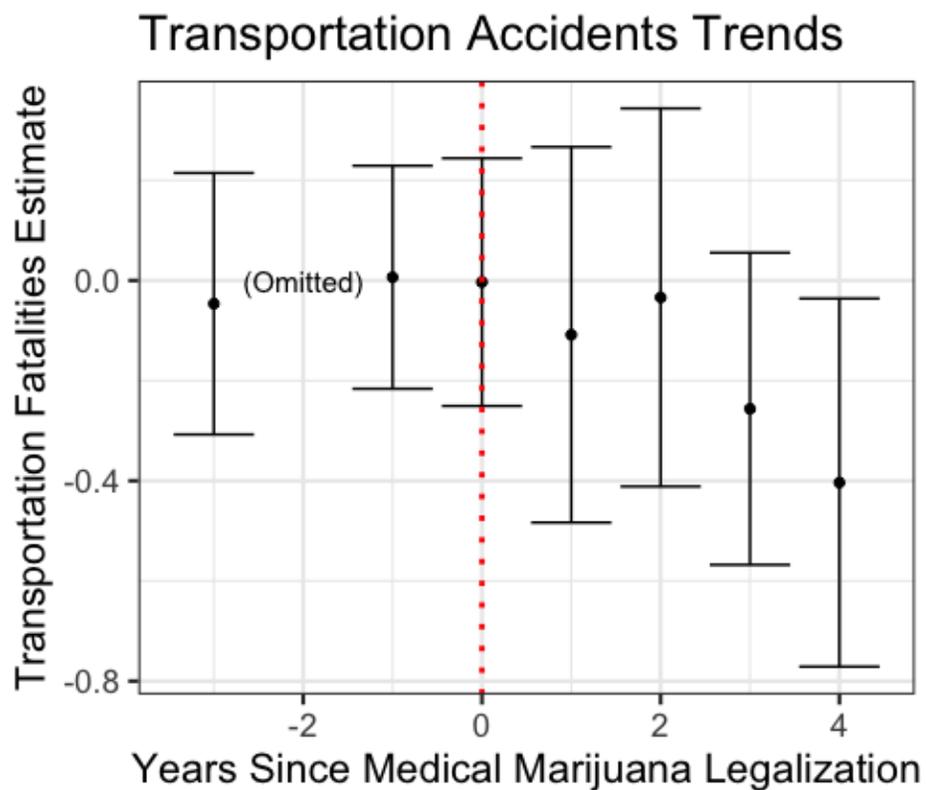


Figure 3: Occupational Fatality Trends For “Transportation Accidents”

Here the treatment effect due to MML enactment in regard to “transportation accidents” is analyzed. The graph shows that there was a reduction the year after MMLs went in effect with a slight increase in transportation related fatalities in Year 2, followed by sharp reductions in transportation fatalities in Years 3 and 4.

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