The Legalization of Marijuana and the Opioid Crisis: Hero or Heroin?

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Abstract

In the past 15 years many states have legalized medical and recreational marijuana, and the ramifications of these policies are hotly debated. This work looks to reconcile the effects of marijuana on the opioid crisis. Using a difference in differences model I find that legalizing marijuana leads to a 2-percentage point decrease in the rate of admittance for opioid addiction. This leads to the conclusion that marijuana legalization decreases, or at least does not increase, the rate of opioid addiction. Additionally, this paper performs a sub-analysis for African Americans, finding that legalizing cannabis does not have a significant reduction in admittance for this population. Although, medical marijuana sees a 3-percentage point drop in opioid admittance rates for the black subsample.

Introduction

From 1996-2016 twenty-five states have decided to allow medical marijuana, and of those, eight have legalized it for recreational use. This trend of increasing marijuana acceptance in the United States has sped up recently. As of this paper's writing, a total of 10 states have legalized recreational cannabis, and 33 have legalized medical marijuana[i]. Below is a map depicting the varying stages of legalization in the U.S.

Figure 1[ii]:

The increasing number of states allowing medical and legal marijuana in the United States is undeniable, and as the laws surrounding the drug have change, the debate on its effects have as well. One of the foremost discussions involves cannabis's role in narcotic usage. Specifically does marijuana increase or decrease the number of opioid[1] addicts? This question has become particularly salient recently because of the opioid crisis. According to the NIH, there has been a substantial increase in deaths related to heroin and similar drugs over the past decade; going from below 17,000 in 1999 to over 70,000 in 2017[iii]. Therefore, if marijuana plays a role in opioid usage then it is important to understand its effect.

There are two leading theories concerning the effect that marijuana legalization will have on hard drug use. Some people believe that marijuana acts as a gateway drug. Specifically, that it causes its users to desire narcotics when they otherwise wouldn't. This theory was popularized by D.A.R.E in the 1980's and was specifically linking marijuana's use to heroin addiction[iv]. If this causal link is true, it is important for policy makers to know the danger of marijuana legalization. Although, there is a contrary hypothesis to gateway drug theory, that marijuana acts as a substitute for hard drugs.

This hypothesis states that people would rather forgo narcotics, like heroin, in favor of marijuana. People effectively substitute their use of opioids for cannabis. This could stem from marijuana acting as an alternative way to get high or kill pain. Regarding the latter reason, the NIH[v] states that over 80% of heroin users started with prescription opioids, and that 29% of people who use prescription opioids misuse them. Since prescription opioid use often starts with

[1] Opioids are defined as drugs with qualities similar to opium such as heroin or prescription opioids like Fetanyl, OxyCoton, Hydrocodone, Codeine, Morphine, and others.

the drugs being given by doctors as a pain killer, the latter portion of the substitution hypothesis could be important in battling this drug crisis. Now that the opposing theories about marijuana's effect on opioid use have been discussed, this paper would like inspect other literature seeking to better understand the opioid-cannabis interaction.

Chu (2013)[vi] found that a state medicalizing marijuana decreased heroin and prescription opioid use by up to 20%. Chu's paper used arrest records and rehabilitation admissions as the identifying variables. The strongest findings of medicalization's effect on heroin use (20% decrease previously discussed) came from the admissions data. Although not as large, the arrest records did see a 15% decrease in possession arrests for heroin.

These findings were corroborated by Powell (2016)[vii], which examined deaths by overdose as a function of dispensary density in medically legal areas. This work found that overdose deaths from heroin and opioids decreased significantly when the population had easy access to medical marijuana. Although, when laws became more restrictive on dispensary presence, the effect declined. This implies that access to legal cannabis heavily influences the results, and there is a significant negative correlation between opioid overdoses and cannabis usage.

Both Chu's and Powell's papers are informative on how medical marijuana effects hard drug use, and both pieces tell the same story. Medical cannabis works as a substitute for opioids. Although, these two works, and the literature in general, share a common gap that this paper aims to fill. Does the legalizing marijuana have the same effect previously found for medicalization?

This work will attempt to fill this void by examining the effects of both medical and recreational marijuana simultaneously. This should allow for a more complete picture of cannabis's effect on hard drug usage. Following Chu's work, this paper will utilize a difference in differences model. This strategy for causal inference operates on the assumption that the only major change between groups during times of policy change is the effect of that legislative change itself. In other words, in the absence of treatment the difference in trends in each group should be the identical. Therefore, by looking at the difference in differences during changes in the law this paper should give a causal estimate of marijuana policy's effect on opioid rehab admissions.

Using this methodology, I find that a state legalizing both medical and recreational marijuana caused a significant decrease of 2 percentage-points, a 9% drop in total, in heroin and prescription opioid rehab admissions. Additionally, for African Americans medical marijuana sees a 3% drop in opioid admissions, but legal shows no significant difference. These findings corroborate other work on the link between marijuana access and hard drug usage.

Data

This paper uses the Treatment Episode Data Set: Admissions, which records individuals going to rehabilitation centers in the US. The TEDS-A data used by this paper spans all 50 states over 16 years and contains over 32 million observations, of which 9 million are for opioid admittance. The observational unit is an admittance for any drug addiction. Every center that takes federal or state funding is required to report details on their admissions and on the traits of those admitted. There could be a potential problem using this data since presumably not all

rehabilitation facilities take government funding. Although most do, since this reporting is one of the few requirements to get that funding. Otherwise businesses would be leaving easily obtainable money on the table. Although, some places may not be recording admissions because of privacy or other concerns. Since these centers don't take government money, they would have to make up for that loss in revenue by charging more. So, only individuals who can afford extra-expensive rehabilitation centers should be omitted from the sample. This is a small subset of all people going to rehab, so its exclusion should not disrupt the overall observed trend. Now that the sample selection has been covered, it is important to note that this data does not record the actual amount of drug abuse, but instead the number of people going to rehab.

This paper will use the rehabilitation attendance for substance abuse as a sort of proxy for the number of people who use a substance. In theory, the number of people who are getting help for their drug problem should move with the number of people that are addicted. This pattern was seen in Chu's work when he blended admission and arrest records to show that both datasets give the same result. Logically, when more people use drugs, more will need to go to rehab. Although, there could be a problem, if for some reason the number of people going to rehab faces outside bias not present in the number of substance addicts. One worry is that this could happen because people choose to go to rehab, so the propensity to attend could be influenced by outside cultural factors that have changed since Chu's paper. Although, this is only a problem if there is a difference in people's desire to go to rehab when marijuana laws change. Otherwise that change would be picked up in the controls and be negated. Therefore, the trend should not change, since there is no reason a change in judicial law should cause a shift in willingness to go to rehab. The states that wanted marijuana, except Maine, all did it by

proposition. Additionally, every state that legalized marijuana already had legal medical marijuana. This means that people already approved of cannabis before the laws changed. So, there shouldn't be a major cultural factor at play. Additionally, an increase in perceptions of marijuana should not affect the view of other substances.

Opioids and cannabis have very different societal perceptions, so a change in the view of one should not strongly affect the other. The arguments about legalizing marijuana revolve around three main points, it is nearly impossible to OD on, it can be an effective pain reducer, and it calms people who may otherwise experience emotional distress (like PTSD). The overall reasoning for cannabis usage is that marijuana is not highly addictive and can be used without the consequences seen by hard drugs.

The addictive and dangerous nature of opioids is widely known. The crisis with prescription opioids has seen a dramatic increase in awareness because of the large amount of media coverage opioids have seen. In the last decade and half coverage of the opium epidemic has included everything from public health campaigns, to tv shows, to books, to news. All this coverage has talked about the problems facing opioid users, like dependence and over-dosing. Therefore, the dangers of this drug are widely known, meanwhile marijuana has seen increasingly positive coverage in the past decade.

The difference in rhetoric surrounding the two drugs confirms that the arguments and views about the safety and use of cannabis vs. opioids are entirely different. So, while people may view marijuana more favorably after legalization, there is no reason to assume that they would also look at opium more positively, making them less willing to go to rehab.

Since rehabilitation attendance should not be influenced by outside factors at the time of legalization, there should be no violation of the causal assumption. Additionally, since the number of drug addicts should move with the number of people attending rehab as discussed in Chu's work, the rehabilitation attendance data should perform as a valid proxy. Therefore, the results of this paper should not have an efficacy issue when measuring the effect of marijuana laws on opioid rehab admittance and should function as a usable proxy for drug addiction rates.

Now that there is some background on the data and sample, it is important to look at the variables this paper will use. This work looks at individual admission to rehab for drug use by state and year. The response is an admittance for opioid addiction, and it uses controls for race, sex, and age. Below in Table 1 are summary statistics for the data.

Table 1: Descriptive Statistics

variable	mean	min	max
sex	.3224124	0: Male	1: Female
white	.6376673	0: Non-white	1: White
black	.2173009	0: Non-Black	1: Black
opium	.2828533	0: Non-opioid	1: Opioid
N	32068339		

Summary statistics for the controls and response variable excluding age

The table above shows the descriptive statistics for 3 control variables and the response. There are several important notes to make. First is that most of the sample is white, around 64%. This means that for the race control the vast majority falls into just that category. The second largest racial group in the sample is black, which comprises about 22% of the observations. There are 7 other smaller racial groups recorded by TEDS-A, but they are not shown because their percentage is small. Although, no group has under 130,000 admissions. Since there are so many

different groups, with two very large ones, and each could react differently to marijuana legislation, it is important to control for them. The next major variable to look at is sex. This is coded as a 0 for men and a 1 for women. This means most of the sample is comprised of men, with only approximately 32% of the observations being women. So, the sample is heavily male, but that is not surprising as substance users are a heavily male demographic according to the NIH[viii]. Additionally, according to the same source, men are more likely than women to use marijuana. Therefore, the two sexes may react non-identically to legalization and need to be controlled for. Finally, Table 1 shows that about 28% of the users admitted to rehab are there for opium addiction. This is a substantive portion of the sample, so it should offer enough variation to be used as a response. Table 1 demonstrates that the sample is largely white and black men, with roughly a quarter being admitted for opioid use. Although, there is one control variable left to look at, the ages of attendees.

Table 2: Age Statistics

Age Range	Frequency	Percent
12-14	19,806	.06
15-17	440,921	1.37
18-20	1,860,447	5.80
21-24	2,159,797	6.73
25-29	3,923,437	12.23
30-34	4,638,346	14.46
35-39	4,172,587	13.01
40-44	3,968,472	12.38
45-49	3,923,441	12.23
50-54	3,265,369	10.18
55-64	2,169,232	6.76
65 and older	1,526,482	4.76
Total	32068339	100

Summary breakdown for age

Table 2 shows the breakdown for age in the data. The frequency of observations is much more uniform across groups than the other variables, like race or sex. Although, there is a visible grouping in Table 2. The plurality of admittances is in the 30-34 range, but the sample is largely aged 21 – 64. Since there are so many different groups, and each may exhibit a different reaction from marijuana legalization. The difference in response could be due to perceptions of the drug or other unobservable factors, so it is important to control for every age.

Model and Results

To identify the effect of marijuana law, this work looks at 50 states and compares the three stages of marijuana legalization: illegal, medical, and recreational. To allow for a causal inference with this data, the paper will use a difference in difference model. This means that the only effect the model displays comes from the difference between the stages of marijuana laws. Therefore, the models display a meaningful estimate of the impact of medical and recreational

marijuana laws. Although, for this analysis to be accurate it does have one main necessary assumption, that the only major causal difference in the rate of heroin admittance at the time of law changes stemmed from the laws themselves. Implicitly this means the comparison groups, which are the states with medical and illegal marijuana laws, also have similar trends to legal states before the treatment period. Otherwise a major change may not be due to treatment. It is worth noting this assumption is not saying that the magnitude of drug use is identical across locations, but that drug usage follows a similar pattern. To check for common trends, it is important to look at the compositions of the sample. Since there are fifty states, and 28 have medicalized cannabis and the other half haven't, both groups have a large and comparable sample size. Also, each sample contains a range of geographic and cultural diversity: west coast, midwest, east coast, and the south. Finally, the last comparison groups are the states that have legalized recreational marijuana. These states sample from the east coast, west coast, and midwest. So, there should be enough diversity in the sample location and culture to meet the similar trends criteria. To further investigate the veracity of the main assumption for this work, a pre-trends plot is given on the next page.

Figure 2:

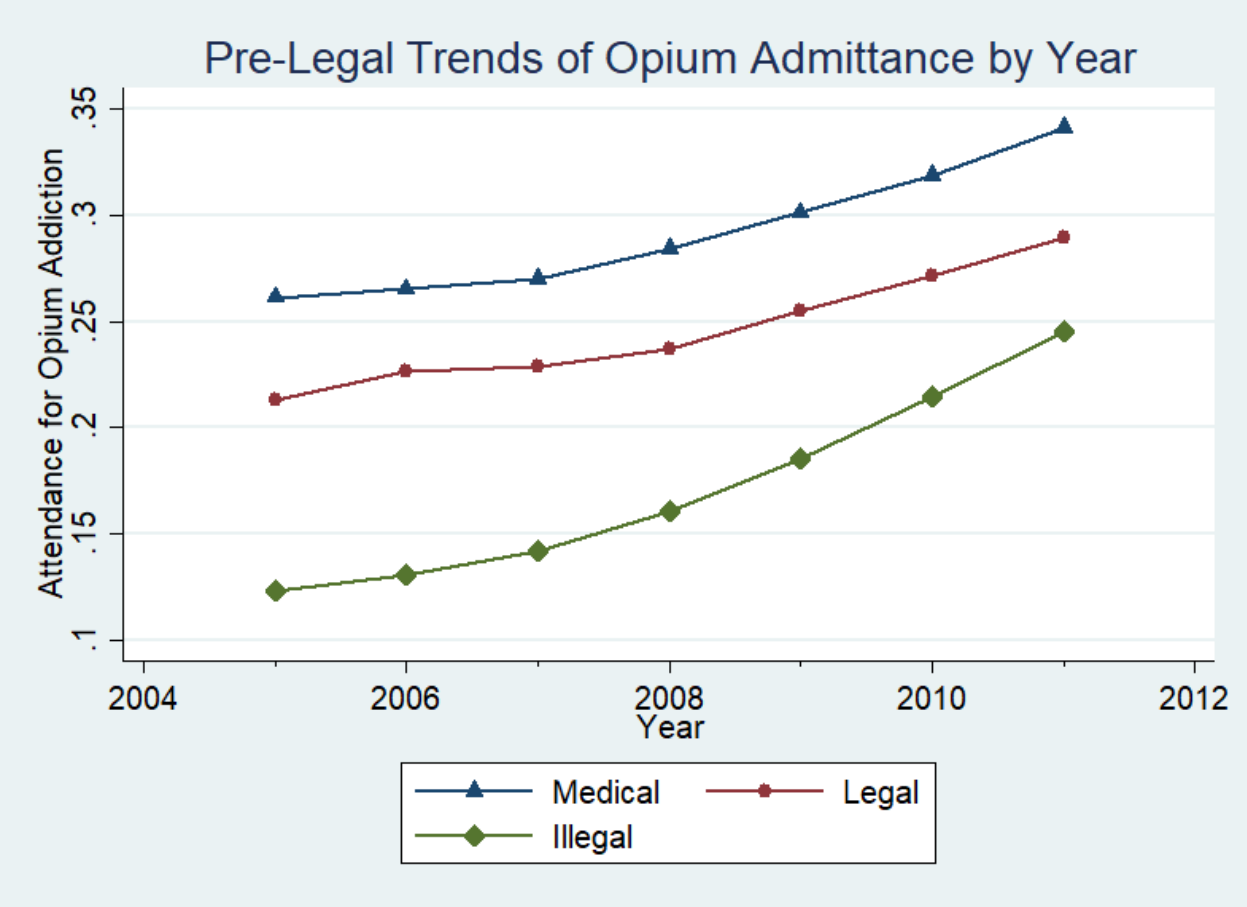

Figure 2 goes from 2005 to 2011, as the first states did not legalize until 2012. There are three major trends to look at on this plot, the illegal, medical, and legal. It is important to note that the legal states are a subset of the medical ones, so their trends being similar is not surprising. Although, all the states seem to follow an increasing trend overtime, with the illegal states moving more drastically upwards but still matching a similar pattern. So, the graph implies that the common trends assumption necessary for the difference in difference model is met, and now it is important to get into the specifics of the estimation strategy.

This paper uses one main model to look at how opioid use changes in response to marijuana laws. It contains several controls that were included in the TEDS-A data. Below is the regression equation used in this paper.

$$opioids = \beta_0 + \beta_1[medical] + \beta_2[legal] + \sum_{i=3}^{19} \beta_i\,[year] + \sum_{i=20}^{69} \beta_i\,[state] + \sum_{i=70}^{81} \beta_i\,[age] + \sum_{i=82}^{91} \beta_i\,[race] + \beta_{92}[sex]$$

The important estimators are the medical and legal variables. They give the effect of what happens to the proportion of opioid admittance at the times of their respective law changes. The variables for state, year, age and sex are all controls for their respective names. This model looks like a simple regression, although it is a difference in difference model with the collinear variables removed. Since state is a control variable, and a constant across each location, and legal is all years in a state when it has become legal, the interaction term of state and legal would be perfectly collinear. Therefore, that term has been omitted, and the causal effect can be read directly from the legal and medical variables. The coefficient for medical marijuana means that a change medical legislature leads to a $\beta_{medical}$ change in the proportion of opioid admittance. Building on this, all states that have legalized marijuana have previously had medical. So, in the model the legal variable means that a state changing to legal cannabis causes a β_{legal} change above and beyond the $\beta_{medical}$ change that is already present. On the next page are the results from the differences regression model.

Table 3: Differences Model

	(1) No Controls	(2) Year and State	(3) All Controls
legal	-0.00538***	-0.0231***	-0.0215***
	(0.000421)	(0.000479)	(0.000479)
medical	0.0583***	0.000352	-0.00178***
	(0.000178)	(0.000357)	(0.000351)
r2	0.00372	0.106	0.140
N	32068339	32068339	31591467

A single star is $p < .0012$, two stars is $p < .0006$, and three stars is $p < .00012$. These values were chosen to conform to the conservative Bonferroni adjustment for sample and model size.

This paper ran three nested models, each with differing levels of controls. Regarding the legalization of marijuana, each model demonstrates similar results. All regressions find the effect of legalization significant at the Bonferroni adjusted p-level of .00012. Each coefficient is negative, and when controls are added it increases in magnitude by 4-5 times, to a value around -.02. In perspective, legalization leads to a 2-percentage point decrease, or a drop of nearly 9%, in attendance for opioid addiction beyond that of medicalization. This strong result across all the models is likely due to the substitution effect previously discussed. Although, the results for medical marijuana are less uniform.

The medicalization of cannabis also sees a decrease in heroin usage. Although, this is not realized until all controls are included. The first regression has a large positive coefficient and is significant, but without the other controls it seems to be picking up other variation. In the model with the year and state effects included, both the p-value and coefficient see a large decrease. Medicalization becomes insignificant at the lowest Bonferroni adjusted value. Finally, and most importantly, the full model has a significant and negative coefficient. Aligning with

previous literature, it shows a decrease in heroin admittance. Since this model controls for the most outside variation by having the most controls (each of which are significant although not displayed), it gives the most accurate representation of medical marijuana's effect. Additionally, this coefficient is found to be highly significant with a p-value less than the Bonferroni adjusted level of .00012. To help better visualize the resulting drop in opioid admittance around the time of legalization the plot below is given below.

Figure 3:

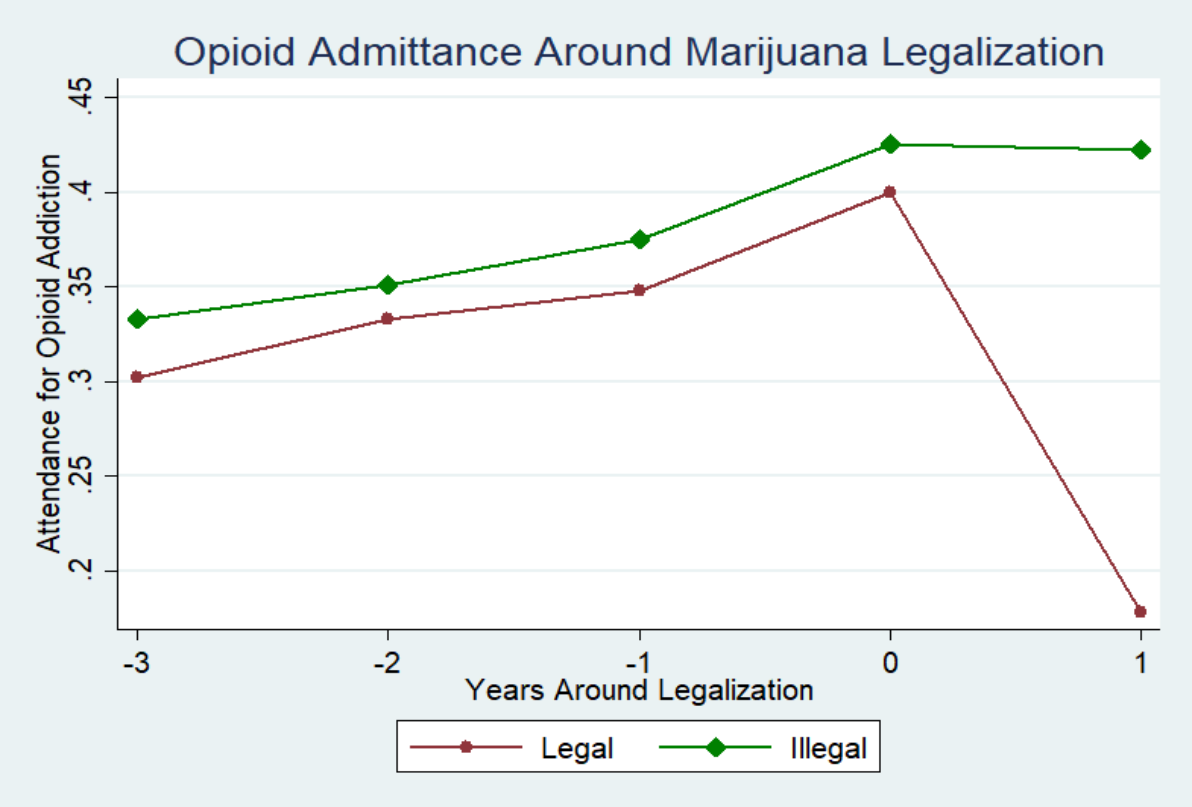

Figure 3 was constructed by averaging periods. The red line for legal states indicates the mean proportion of opioid admittance around the year that a state legalized marijuana. The green line was made by taking the average year a state legalized as 0, then it displays the mean

proportion of opioid admissions where Cannabis is illegal at each time. The reason there is only one year shown in the post period is that the average time in which a state went legal was 2015, so there is only one year of data after that to use for the plot. With an understanding of figure 3's construction the next step is interpretation.

The graph shows a large drop after a state has legalized. The admittance rate goes from nearly .4 to .2. In the other time periods, the legal and illegal track each other closely, making the stark change occurring at year 1 all that more drastic. Granted, this graph only looks at one major predictor, but it nonetheless aligns with the finding from the differences model. Although, this paper has one question left to look at.

Are these findings the same for African Americans? The black group in the sample comprises about a quarter of admissions. This group may react differently to marijuana legislation than does the overall sample. To test for this, the model used on all groups is run a second time, but now only on the black sample. The result is displayed below.

Table 4: Differences Model Subsample Analysis

	(1) No Controls	(2) Year and State	(3) All Controls
legal	-0.0547***	-0.00218	-0.00198
	(0.00122)	(0.00137)	(0.00137)
medical	0.0516***	-0.0293***	-0.0295***
	(0.000388)	(0.000724)	(0.000723)
r2	0.00289	0.110	0.112
N	6774995	6774995	6773853

A single star is p < .0012, two stars is p < .0006, and three stars is p < .00012. These values were chosen to conform to the conservative Bonferroni adjustment for sample and model size.

Table 4 shows a similar, but non-identical pattern to the overall sample. In each regression the medical variable is highly significant. Additionally, the coefficient for medicalization starts positive, but as controls are added it reverses sign. The magnitude of the medical coefficient in the full model indicates a decrease of 2.93 percentage points, which nearly 30 times larger in magnitude than for the overall group. This result is likely due to differences stemming from cultural factors and location-based factors which will be further discussed later. Although, medical marijuana does not see the only difference between the overall and reduced model.

Full legalization of marijuana has a less significant impact on admissions for opioid dependence in the black subsample. In the first model, legal is highly significant and has a coefficient of -.0547. Although, because states have medical and then legal cannabis, the change from having illegal to legal marijuana has a true value of -.0031, which is negligible. This regression is unspecified, so the other two models should be more accurate. In both models with controls, legal becomes insignificant and the coefficient decreases in magnitude. This may be that the admission reducing effect of marijuana legislature is mostly realized in the medical change. This is likely happening because the overall group sees a significant total decrease from illegal to legal of about 2.3%, and the black model shows an opioid admission drop of roughly 2.9%. These are close in magnitude, with the African American sample showing a sharper reaction to marijuana legislature. The effect of allowing easier access to cannabis tells the same story in both the overall and subsample models, but the paths there are different. These results will be further explored in their contexts.

Analysis

This paper's findings align with the substitution hypothesis, as well as the findings of other literature, that legalizing marijuana decreases rehab attendance for opium addiction. Specifically, legalizing marijuana causes a roughly 9% drop in heroin and prescription opioid admittance above and beyond the effect of medical. Additionally, the black population sees a roughly 14% drop in opioid rehab admittance when a state medicalizes cannabis. Now, it is important to note that this does not mean there is a 9% decrease in overall opioid addiction, but it does mean a drop of over 500,000 people coming for rehab each year. Although, there is no reason to assume that when a state legalizes, another factor unrelated to marijuana happens simultaneously changing people's propensity to attend. So, there should not be anything making people less likely to seek treatment other than a decrease in necessity. Therefore, when a state legalizes cannabis it can reasoned that the number of people addicted to opioids drops. Unfortunately, because of the unobservable nature of illegal drug usage, the actual size of the drop depends on the relationship with the proportion of users that go to rehab. This means that it can be somewhat confidently stated that legalizing marijuana leads to a drop in opioid addiction, just not by how much.

This work finds that opium admittance to rehab decreases in response to marijuana policy, now it is time to revisit why this may be the case. Going back to the hypothesis and previous work, it seems likely that the drop is due to the substitution effect. When wanting to use drugs, people may use marijuana instead of heroin or other opioids. Cannabis can give a high, is easy to get, and is not chemically addictive. All favorable qualities when making a choice on what to take. So, it acts as a preferable alternative. Additionally, when seeking pain relief for both

chronic and short-term conditions marijuana has several desirable qualities over opioids. Cannabis can effectively reduce pain and is not highly addictive. Meanwhile, the time needed to develop a dependence on opioids is small, so people may instead substitute marijuana. These may explain why easing marijuana legislature may decrease opioid rehabilitation admittance, but not why there is a difference in the type of legislation causing the effect in the subsample.

One explanation for the difference may stem from cannabis acting as a substitute earlier because without good insurance, marijuana may be cheaper than prescription opioids. This is applicable for the black subsample analysis because that group is more likely than whites, who make up most of the overall sample, to be uninsured. So, the black group may be substituting more during the medical period, because it is cheaper for them to get a license and use medical cannabis instead of prescription painkillers. This could partially cause the admission reducing effect at the medical stage rather than legal. There is another reason why marijuana policy may be causing an admittance reduction differently in both groups, obtainability.

In previous work, Powell found that increased access to marijuana significantly amplifies the hypothesized substitutive effect, and differing levels of obtainability may affect the two groups differently. The black subsample is more likely to come from urban areas, which have a higher population density and are generally more liberal. This could cause medical marijuana to be obtained with less work for that racial group, than ones not centered in cities. Which might make medical marijuana have a larger effect than full legalization. Meanwhile, the total group is largely white and other races. These populations may not be as centered in densely populated areas, and therefore have less access to medical dispensaries. Legalizing marijuana should increase obtainability everywhere, but significantly more so in less urban places. So, this

mechanism is likely contributing to the 9% change in rehab attendance in the overall sample. Although this work has helped to fill a gap in the literature, there is still space to expand on the causal link between marijuana and opium addiction.

The recent nature of legalization and functioning marijuana markets mean that better data will become available in a few years. The data used for this only goes up to 2016, so there are not as many fully legal states in the sample as would be preferable. More years of study in more states would help to get a better representation of marijuana's effects. Additionally, since it is believed that much of marijuana's ability to lower opioid admittance rates is due to access, it may be useful to look at when states set up functioning cannabis markets. There is often a delay period between when the substance becomes legal and when it is legal to be sold. The latter may be a more refined way to identify the mechanisms at play. This work was unable to use this data because most functional markets did not start until the end of 2016 or later. In summation, this paper has found that legalizing marijuana decreases opioid admittance, and certainly does not increase the rate of opioid abuse, but there is still more work that can be done.

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