Educational Attainment in the Presence of Legalized Recreational Marijuana*

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Abstract

While the effects of teenage marijuana use are the subject of intense study, how the rollout of legalized marijuana has affected teenagers is much less well known. This study examines the relationship between educational attainment and the presence of local recreational marijuana dispensaries using school and dispensary data from the Colorado Departments of Education, Revenue, and Public Health and Environment. I find a positive association between the opening of a recreational dispensary within five miles of the school and four-year graduation rates, as well as college admissions test scores. I also find that the consumption of alcohol and consumption of marijuana are negatively associated with the opening of a dispensary within five miles.

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1. Introduction

In 2012 Amendment 64 was passed in Colorado which legalized recreational marijuana (Kelty, 2013). Over the next year the legislature set up a regulatory framework led by the Colorado Department of Revenue, which was already in charge of regulating medical marijuana. In late 2013 the CDR's Marijuana Enforcement Division started taking applications to convert existing medical marijuana dispensaries to recreational dispensaries, and on January 1, 2014 recreational sales began.

Concerns about how this rollout would affect teenage marijuana use were present even before Amendment 64 passed. This issue was a large part of the argument against it, and the tax revenue generated is explicitly earmarked for education funding. There are also minimum distance requirements between dispensaries and schools, for example the 1000 feet minimum distance by the city of Denver (Licensing Requirements-Retail Marijuana Stores, 2020). However, the effect of dispensaries being closely located to schools is unknown.

In this study I use school-level data and location data for dispensaries to estimate the effect the opening of recreational marijuana dispensaries has on graduation rates. Using school-level data from the Colorado Department of Education, I estimated the impact on graduation rates of public high schools of opening at least one retail marijuana dispensary within five miles of the school. Using a panel event study framework, I found that the opening of a recreational marijuana dispensary within five miles of a school is associated with a 4.3 percentage point increase in the four-year graduation rate after four years.

This was accompanied by no change in the dropout rate; thus, the increased four-year graduation rate is coming from students who would have otherwise graduated in more than four years graduating sooner. These results seem to be driven by schools with an above

median number of dispensaries (seven) within five miles. These results are also heterogenous across racial groups, with white students showing no change in graduation rates and non-white students showing a statistically significant increase.

I used this same strategy to estimate the effects of recreational shops on college admissions tests, specifically the ACT and SAT. I find that the opening of a recreational dispensary within five miles of a school is associated with a .035 standard deviation increase after three years, with this effect rising to .065 standard deviations at four years after treatment. These results are also seemingly driven by schools with an above median number of dispensaries within five miles. This increase in test scores is seen in both reading and math tests.

To attempt to find a mechanism for these results, I used a difference-in-differences strategy to look at the effect of opening at least one recreational dispensary on what percentage of students used alcohol in the last thirty days, what percentage used marijuana in the last thirty days, what percentage say marijuana is easy to get, and what percentage say marijuana is wrong for someone their age to use. I find that in 2017 treated schools are associated with a 4 percentage point lower rate of alcohol consumption, and a 5 percentage point lower rate of marijuana consumption.

2. Literature Review

There is evidence that marijuana use negatively affects short term and medium-term cognition (Schweinsburg et al., 2007). However, this is only part of the equation. How the implementation of legal recreational marijuana increases or decreases teen access, the

consumption of other mind-altering drugs, and how it affects attitudes towards marijuana use are all important factors as well.

The relationship between alcohol and marijuana use is an important aspect of marijuana legalization, as it carries important implications for everything from driving under the influence to overall levels of alcohol consumption. There is evidence that alcohol and marijuana are substitute goods (Crost and Guerrero, 2011). This suggests that legalizing recreational marijuana, and the assumed increase in marijuana consumption, will not lead to an increase in alcohol consumption. This directly affects issues such as the prevalence of drinking and driving. Anderson, Hanson, and Rees found that in states that legalized medical marijuana the rate of traffic fatalities decreased by 8-11 percent, with an even greater drop in accidents that involve alcohol (Anderson, Hanson, and Rees, 2013).

The literature directly looking at how legalizing marijuana affects education outcomes is small but growing. There is evidence that legalizing medical marijuana decreases high school graduation rates but does not increase consumption of marijuana by high school students (Rintala, 2020). There is also a study which shows that access to legal recreational marijuana in the Netherlands decreases grades for college students (Marie and Zölitz, 2017). Using previous research which showed that math skills are more affected by marijuana use (Pacula, Ringel, and Ross, 2003), they showed that grades in math-heavy courses were disproportionally affected. This is a solid indication that legal access to marijuana increased consumption among those college students.

One other possible reason for these effects could be time use. If students are more likely to slack off on schoolwork to use marijuana, then that could cause these negative outcomes. There is evidence that shows a negative association with time spent on education related

activities by college students in states which have passed medical marijuana laws (Chu and Gershenson, 2018). However, they also found no evidence of this effect on high-school students.

Overall, the literature provides strong evidence that teen marijuana use would decrease academic performance. However, there is still much work to be done investigating if legalization increases teen marijuana use, how it affects alcohol consumption, and possible peer effects. My paper contributes to this literature by looking directly at education outcomes, alcohol and marijuana consumption, and attitudes surrounding marijuana for high-school students.

3. Data

The data for school outcomes, demographics, and funding comes from the Colorado Department of Education[1]. Graduation rates, college admissions test scores, and demographics are all measured at the school level and funding per pupil is observed at the district level. This data starts with the 2010-2011 school year and ends with the 2018-2019 school year. This data is collected annually for all public and charter schools in the state of Colorado and published online on the Colorado Department of Education website. College admissions test scores and standard deviations were collected from the National Center for Education Statistics[2] and CollegeBoard[3], who make the SAT.

The sample of schools includes public and charter high schools in Colorado that operated during the entirety of the 2010-2011 through 2018-2019 time period. Online schools, schools

[1] I would like to thank Kathryn Wright at the Colorado Department of Education for her help with this data set.
[2] Specifically, the 2016 and 2018 digests (Snyder, de Bray, Dillow, 2018) (Snyder, de Bray, Dillow, 2019).
[3] Specifically, the 2019 yearly report (CollegeBoard, 2019).

with less than 25 students in most years, a special education school, and two tech schools were dropped from the sample. Once this list of schools was generated, I then calculated latitude and longitude values for each of them using the Google Geolocation API[4].

The lists of marijuana dispensaries are from the Colorado Department of Revenue Marijuana Enforcement Division. Lists for the years 2014-2018 that contain recreational dispensaries with active licenses and full physical addresses were used to calculate latitude and longitude values using the Google Geolocation API. Lists that contain active medical licenses with full physical addresses are available for 2010 and 2013-2018 and were used to calculate latitude and longitude using the Google Geolocation API. However, there are no 2011 and 2012 lists with full physical addresses available. To get as accurate a list as possible the 2010 and 2013 lists were merged onto the 2011 and 2012 lists by licensee name and county. In cases where a licensee is listed as having both a medical and a recreational license, it is assumed they are purely a recreational shop[5].

These latitude and longitude values were used to calculate the number of medical and recreational shops within five miles of each school[6]. Dummy variables were then generated using these values. For each year dummy variables for no medical dispensaries, one or two, and at least three dispensaries are generated[7]. The procedure for recreational dispensaries was slightly different. There were four indicators chosen: no dispensaries within five miles, at

[4] The code to do this was written by Christos Samaras and published on his blog: myengineeringworld.net.
[5] I do this as the restrictions to buy medical marijuana are more onerous, and I assume that the recreational effect would dominate the medical one.
[6] To come to this number, I ran a difference-in-differences regression to find how far the effects of dispensaries go. A full discussion of this regression and how I used it are available in the appendix.
[7] The median number of medical dispensaries within five miles of each school in my sample was zero, so three was arbitrarily chosen as the cutoff.

least one dispensary, one to six dispensaries, and at least seven dispensaries[8]. In addition, schools were assigned treatment status based on their 2014 and 2015 numbers.

This was done to prevent endogenous variation in the treatment variable. With Colorado's legalization being tied for first in the nation there was not much known about the best places to open a recreational shop, and significant regulatory barriers existed as municipalities allowed shops to open at different times. This creates a situation with exogenous variation, but over time as these municipality restrictions eased and the market stabilized there is more potential for shops to react to both each other and the schools.

For schools which had shops open in January 2014, they are counted as being treated for the 2013-2014 school year, as half that year was treated, as well as the 2014-2015 school year. The 2015 numbers are then used to calculate the 2015-2016 school year, and a school's 2016-2017 through 2018-2019 status is whatever it was for the 2015-2016 year.

The final piece of data used is the Healthy Kids Colorado Survey from the Colorado Department of Public Health and Environment[9]. This survey is conducted on odd-numbered years starting with 2013. For this study, the relevant years are 2013, 2015, and 2017. This survey asks many questions about various topics such as drug use, sexual activity, and overall health. The relevant questions for this study are if the student surveyed used alcohol in the last thirty days, marijuana in the last thirty days, if marijuana is easy to get, and if it is wrong for people the same age as the student to use marijuana.

[8] The median number of dispensaries in the treated sample is seven, so that number was chosen as the cutoff.

[9] I would like to thank Ashley Brooks -Russell, Christine Mulitauopele, and Jacqueline Gardner for their help in acquiring the Healthy Kids Colorado Survey data. I would also like to thank the Colorado Department of Health and Public Environment, the Colorado Department of Human Services, the Colorado Department of Public Safety, the Colorado Department of Public Education, and the Colorado School of Public Health at the University of Colorado Anschutz Medical Campus for conducting the survey.

This survey is conducted by sampling middle and high schools in the state of Colorado, though I only use the high school data. After a school is sampled then classrooms within that school are sampled. During this process schools, classrooms, and students may opt out of the survey. After the survey data is collected it is then weighted by the Colorado Department of Health and Public Environment, which I use. I aggregated the results to the school level for my analysis. A table of summary statistics for this data is available in Table 1.

4. Empirical Technique

I begin my analysis with a panel event study[10] framework to estimate the relationship between graduation and college admissions test scores and the presence of recreational marijuana dispensaries using OLS.

$$Y_{idt} = \alpha + \sum_{l=2}^{L} \beta_l^1 (Lag\ l)_{idt} + \sum_{e=1}^{E} \beta_e^2 (Lead\ e)_{idt} + \theta_t + \mu_i + \gamma X_{idt} + \varepsilon_{idt}$$

Where Y is the outcome variable for school *i* in district *d* in year *t*, β_l^1 and β_e^2 are the lag and lead coefficients for school *i* in district *d* in year *t*, θ_t is the year fixed effect, μ_i is the school fixed effect, X_{idt} is a vector of control variables that vary over time, and ε_{idt} is the error term. The controls include the natural log of student population, percent of students who qualify for free and reduced lunch programs, student-teacher ratio, district-level per pupil funding, percent of students who are white, and dummy variables for the presence of medical dispensaries.

[10] I relied extensively on (Clark and Schythe, 2020) for this analysis.

This strategy controls for several potential issues. While schools and dispensary owners did not control who got the initial waves of licenses or where they could operate, it is impossible to assume that this distribution is truly random. The year and school fixed effects control for year-specific shocks and aspects of the school which stay fixed over time. Next, the panel event study framework, like the difference in differences framework, controls for the fact that treatment and control groups were not randomly selected and could have different starting values for the outcome variables. The panel event framework has the added benefit of giving insight into the main assumption that needs to be made for this to causally identify the effect, the parallel trends assumption.

The second part of my empirical strategy is, using OLS, difference-in-differences to study the relationship between the presence of retail marijuana dispensaries and how many students use alcohol and marijuana, how easy it is for students to get marijuana, and if students think it is wrong for people their age to use marijuana. I am forced to use difference-in-differences rather than a panel event study because there are not enough years to data to do an event study.

$$Y_{idt} = \alpha + \beta_1 PRM_{idt} + \theta_t + \mu_i + \gamma X_{idt} + \varepsilon_{idt}$$

In this equation β_1 is the coefficient of interest, and PRM is a dummy variable which equals zero if there is no recreational marijuana presence, and one if there is for school *i* in district *d* in year *t*. This strategy controls for the same issues that the panel event study does but does not afford us the ability to test if the parallel trends assumption holds.

5. Results

The preferred specification is the panel event study where the treatment group is any school with at least one dispensary within five miles and the control group is any school that does not have a dispensary within five miles. The results of this specification looking at four-year graduation rates and college admissions test scores are presented in Figures 1 and 2. In Figure 1 there is no significant pre-trend, but there is a post-treatment trend that peaks four years after treatment with a value of 4.3 percentage points. Figure 2 is the same story, no significant pre-trend and a post-treatment trend which peaks at .0652[11] standard deviations four years after treatment. This .0652 works out to a 12.7 point difference on the SAT in 2017, which is a very modest gain in real terms.

To get a better idea of what this 4.3 percentage point increase in graduation rates means in real terms, we need to also look at the dropout rate. The results for this panel event study are presented in Figure 3. The results here show no effect of dispensary openings on dropout rates. This means that the increase in the four-year graduation rate is coming from students who would otherwise graduate in more than four years but would still graduate in the counterfactual where no dispensary was opened. While a good benefit for those students, it is not quite the same impact that decreasing the dropout rate by 4.3 percentage points would be.

However, there are still plenty of questions as to what or who is driving these results. One possibility is the intensity of the treatment. To investigate this, I ran panel event studies using the below-median and above-median indicator variables. The results of these are available in Figures 1a, 1b, 2a, and 2b[12]. What we find is that for both four-year graduation rates and

[11] A full table of results for these regressions are presented in Table 2.
[12] The full table of results is presented in Table 2, along with the main results.

college admissions tests that the results are driven by schools with an above-median number of dispensaries within five miles. For both regressions of the below-median variable there are no pre- or post-trends. The above-median college admissions test study shows a similar trend to Figure 2, but with an even higher peak in year four of .0906 standard deviations or 17.7 points. The above-median graduation rate study is similar, in that has the same overall pattern as Figure 1 with a higher peak at 6.6 percentage points, though it also has a small pre-trend.

Another aspect to consider is heterogenous effects. For graduation rates I ran the panel event study of four-year graduation rates for white students on the indicator for at least one dispensary within five miles. I did the same with non-white students. The results are presented in Figures 1c and 1d. I find that there is no significant pre- or post-trend for white students, but that non-white students have the same story as Figure 1. The association in four-year graduation rates peaks at 4.4 percentage points four years after treatment[13].

For test scores one possibility is to investigate heterogenous effects of math and reading tests. As described previously, Pacula *et al.* (2003) found evidence that marijuana consumption disproportionately affects math scores relative to other types of tests, such as reading. To test this, I ran panel event studies of standardized math and reading scores on the indicator for at least one dispensary within five miles. I present the results in Figures 2c and 2d, which show similar trends for both reading and math scores. Their post-treatment trends are essentially identical, though the reading scores do have a small pre-trend[14].

[13] The full results are presented in Table 5.
[14] The full results are presented in Table 6.

6. Mechanisms

There are many possible mechanisms that could be driving these results, but I will focus on two. The first are selection effects. These could take many forms, from parents transferring their kids to avoid areas with large amounts of dispensaries to gentrification of areas with lots of marijuana dispensaries. There is some evidence for the latter from a couple different papers. Cheng, Mayer, and Mayer (2018) found that Colorado municipalities which allowed retail marijuana shops were associated with a 6% increase in housing values. Burkhardt and Flyr (2018) found a similar effect on homes in Denver, where homes which had a new dispensary open within half a mile were associated with a 7.7% higher value.

To see if this mechanism explains my results, I ran an event study of the school's mobility rate on the indicator for at least one dispensary within five miles. The mobility rate is the percentage of students who moved into or out of the district in that school year. The results from this regression are presented in Figure 4. There is a somewhat chaotic pre-treatment period, but there is no trend. The post-trend shows no effect, except for a small negative association in the first year after treatment, but this goes away by year two.

Another way I looked at this mechanism was to look at how my controls varied over time. To do this I ran a modified version of my main panel event study where I regressed my controls individually on the lag and lead variables, the year fixed effects, and the school fixed effects, but not the other controls. The results are presented in Figures 5a through 5e. Of particular interest are the percentage of students who are white and the percentage of students eligible for the free and reduced lunch program. Neither one has a significant pre- or post-trend, which goes against a gentrification mechanism.

One other interesting piece of evidence against the gentrification mechanism comes from Figure 5d, district-level per pupil funding. This graph shows that there is a significant pre- and post-trend of decreasing per-pupil funding in treatment schools. Since education is often funded through property taxes one would expect the opposite trend if these dispensaries were kickstarting a gentrification process[15].

The next mechanism to talk about is student consumption of, and attitudes toward, marijuana and alcohol. Towards this end I used the Healthy Kids Colorado Survey to run difference-in-difference regressions of the percentage of students who say they used alcohol in the last thirty days, the percentage who say they used marijuana in the last thirty days, the percentage who say marijuana is easy to get, the percentage who say it is wrong for someone their age to use marijuana, and the four-year graduation rate on the indicator variables, fixed effects, and controls. The results are presented in Table 3.

The initial period for both the 2015 and 2017 results is 2013, and the sample size is smaller than the main results due to the survey not being administered in every school. The 2015 results are not terribly consistent and none of them are statistically significant. The one notable result is the robustness check of including the four-year graduation rate as a dependent variable. This is to test if restricting the sample would change the sample enough to make the results incomparable to our main results. We see here the same pattern as Table 2, no effect from the below-median schools and a larger (though statistically insignificant due to the smaller sample size) effect from the above-median schools. These statistically insignificant results for ease of access to marijuana are consistent with Harpin *et al.* (2017)

[15] While not discussed in detail, it should be noted that Figure 5a shows a significant reduction in the number of students in treated schools. While my data cannot fully explain this, at least part of this would be due to students graduating more quickly on average as a result of the increasing four-year graduation rate.

which found that marijuana dispensaries located within two miles of a school was not associated with perceived ease of access to marijuana.

The 2017 results are where we start to see evidence for an effect. We see the same pattern in the graduation rates as the 2015 results, and statistically significant negative associations for alcohol and marijuana consumption. These consumption reductions are consistent across the treatment variables and represent incredibly significant decreases in consumption. The 4 percentage point negative association in alcohol consumption is 11.7% of treated schools' 2013 consumption levels. The 5 percentage point negative association is even more economically significant, at 19.5%.

These statistically significant results are also accompanied by interesting results, albeit not statistically significant, from the other variables. There is a 4 percentage point negative result for the ease of access to marijuana, which is the same magnitude as the alcohol consumption reduction, but noisier. While not conclusive, it provides a reason for why consumption of marijuana went down so drastically and represents 15% of the percentage of students who said marijuana was easy to get in treated schools in 2013. The results for how wrong students consider it to be for someone their age to use marijuana are also negative and have the added benefit of being consistent with the 2015 results. They are smaller than the other results, but still interesting to note the implication that these dispensaries are normalizing marijuana consumption even among those who are not allowed to legally buy it.

7. Conclusion

As more and more states legalize recreational marijuana, it is important to understand how these laws affect education outcomes. While there is a growing literature on this subject,

much of it looks at medical marijuana and focuses on state-level effects. This study contributes to the literature by looking directly at the consumption of marijuana by high schoolers, and how this interacts at a micro level with how far schools are from recreational dispensaries.

I start by using four-year graduation rate and college admissions test score data from the Colorado Department of Education to show that there is a 4.3 percentage point positive association between four-year graduation rates and the presence of at least one recreational marijuana dispensary within five miles of the school. I also show that there is a .0652 standard deviation positive association between these test scores and the presence of at least one dispensary within five miles. These results are driven by schools with above-median numbers of recreational dispensaries and that non-white students are driving the graduation rate increases.

To understand why these results are happening, I used mobility rate and student demographic data to show that there is not evidence of gentrification or other selection effects in this sample. I then take the Healthy Kids Colorado Survey data and use it to show that there is a 4 percentage point negative association of alcohol consumption with dispensary presence and a 5 percentage point negative association of marijuana consumption with dispensary presence. While not statistically significant, this reduction in marijuana consumption seems driven by a decrease in the percentage of students who say marijuana is easy to get.

These results are consistent with the literature surrounding teenage marijuana use. There is ample evidence that marijuana use is negatively associated with test scores and school performance. In this case the dispensaries caused a reduction in the ability of students to get

marijuana, they used it less, and thus their grades improved. It is unclear how these results relate to the literature surrounding the question of if marijuana and alcohol are substitutes. While the consumption of marijuana and alcohol did move together in this data, it should be noted that really there are three markets here. An alcohol market, a legal marijuana market, and an illegal marijuana market. This data set is not able to conclusively figure out how these three markets are interacting.

The results of this study have important implications for policy makers. Perhaps the most important is what is not in the results, rather than what is. These results do not show negative education outcomes from dispensaries being located near schools, which is useful information for local government officials who may be contemplating exercising local-option laws to ban retail dispensaries in their municipality. These results also show the importance of reducing marijuana and alcohol consumption by teenagers, which has important implications for many types of drug and education policy.

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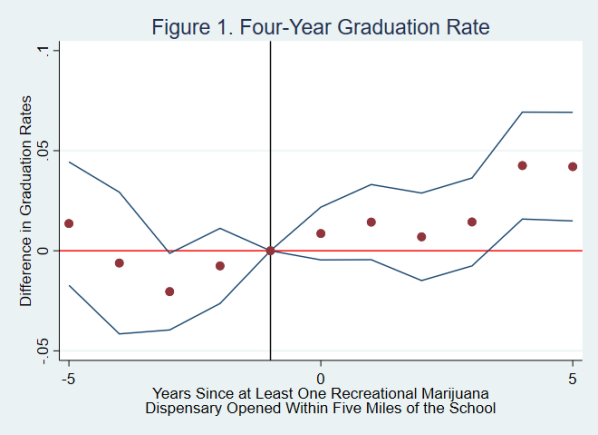
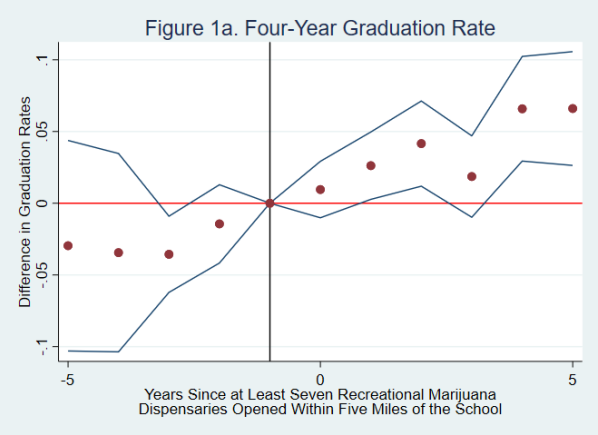
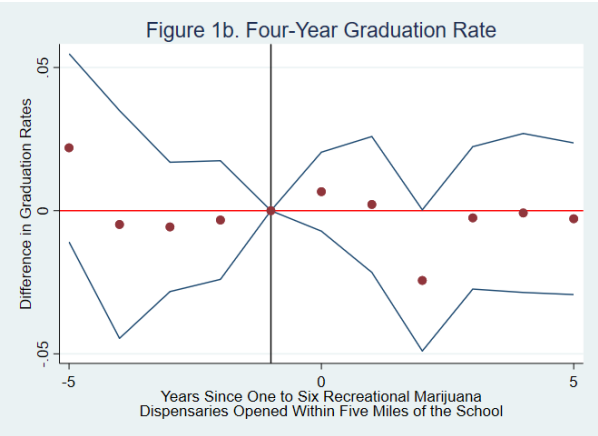
Table 1. Summary Statistics

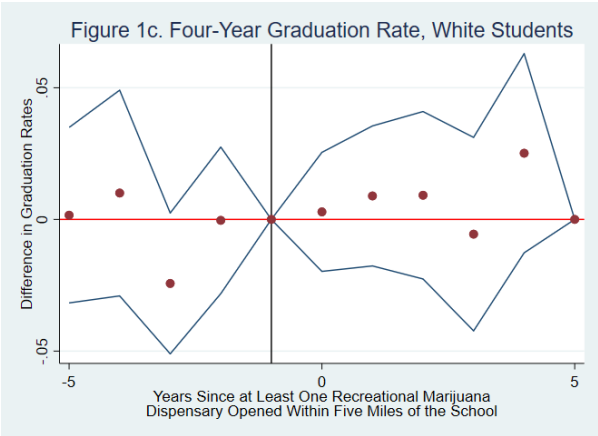
	N	Mean	Minimum	Maximum	5th PCT	95th PCT
Controls						
Number of Students	3420	679.73	9.00	4153.00	47.00	2074.00
Percent of Students Eligible for Free and Reduced Lunch	3420	0.42	0.00	1.00	0.07	0.81
Student-Teacher ratio	3420	37.11	1.14	7777.78	7.25	46.82
District-Level per Pupil Funding	3420	7868.34	6047.58	17109.09	6215.42	12466.47
Percent of Students Who are White	3420	0.60	0.00	1.00	0.08	0.90
Independent Variables						
No Medical Marijuana Presence	3420	0.52	0.00	1.00	0.00	1.00
One to Three Medical Dispensaries	3420	0.14	0.00	1.00	0.00	1.00
More than Three Medical Dispensaries	3420	0.34	0.00	1.00	0.00	1.00
No Recreational Marijuana Presence	3420	0.74	0.00	1.00	0.00	1.00
One to Six Recreational Dispensaries	3420	0.14	0.00	1.00	0.00	1.00
At Least Seven Recreational Dispensaries	3420	0.12	0.00	1.00	0.00	1.00
At Least One Recreational Dispensary	3420	0.26	0.00	1.00	0.00	1.00
Dependent Variables						
Four-Year Gradaution Rate	3390	0.77	0.00	1.00	0.18	1.00
Standardized College Admissions Test Scores	2814	-0.38	-2.40	1.39	-1.21	0.44
Percentage of Students Who Used Alcohol in the Last Thirty Days	472	0.29	0.00	0.68	0.15	0.46
Percentage of Students Who Used Marijuana in the Last Thirty Days	472	0.21	0.00	0.75	0.04	0.46
Percentage of Students Who Say it is Easy to Get Marijuana	463	0.45	0.00	1.00	0.18	0.72
Percentage of Students Who Say it is Wrong for Someone Their Age to Use Marijuana	463	0.46	0.00	0.89	0.16	0.74

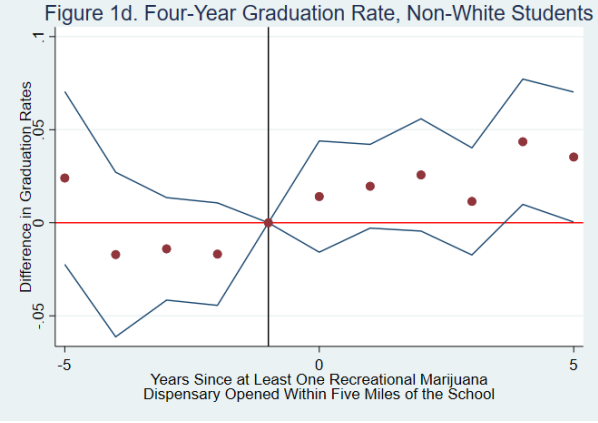
Notes: While there are significant outliers in both student population and student-teacher ratio data, these outliers are few in number. The number of observations for the HKCS is due to the fact that the survey does not survey all schools. The college admissions test scores were standardized using national numbers.

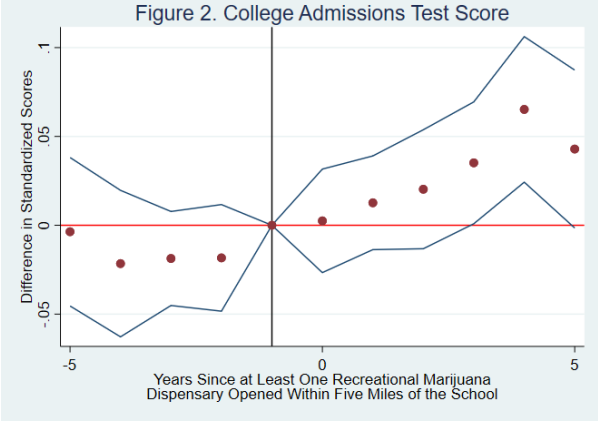






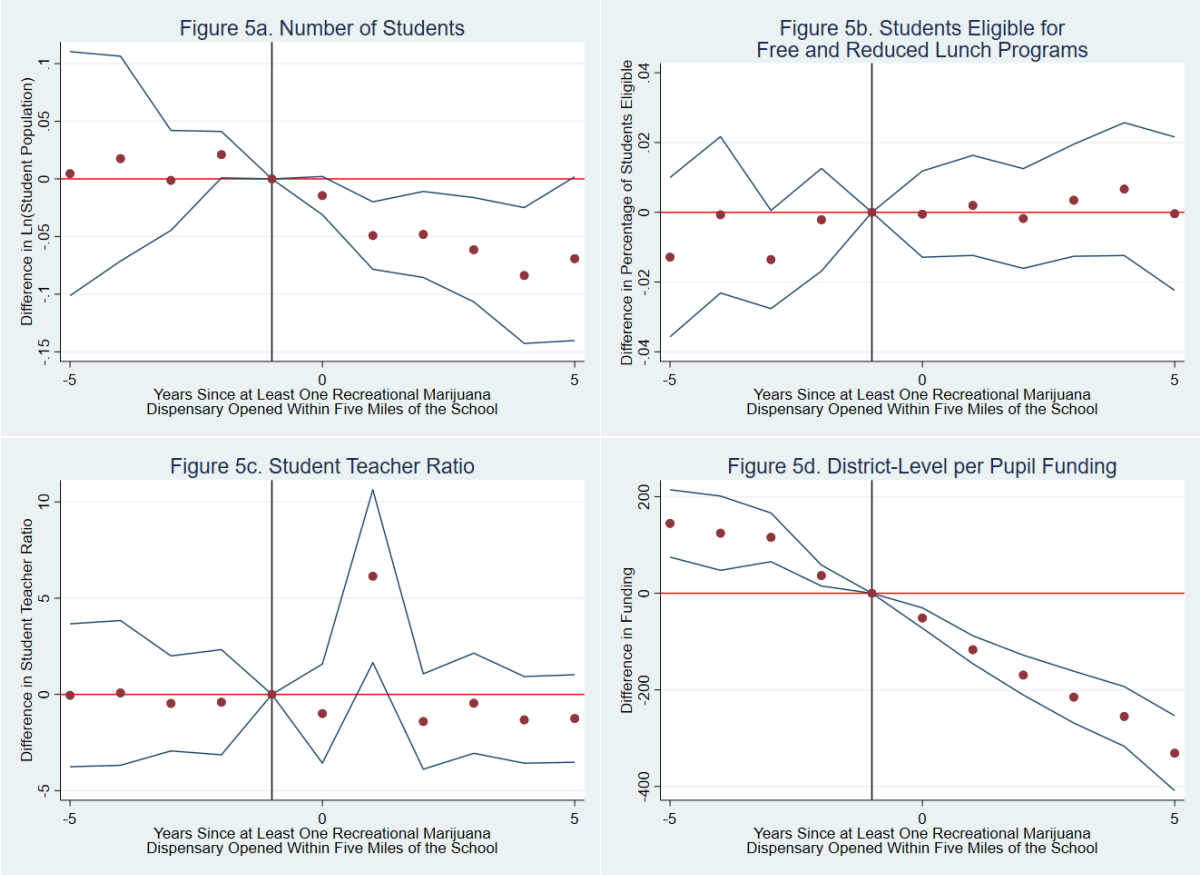






Notes: These results are were calculated using Colorado Department of Education for the 2010-2011 through 2018-2019 school years, in addition to Colorado Department of Revenue data on the location of dispensaries. These results are displayed with a 90% confidence interval, and standard errors are clustered at the school level. Controls include the natural log of the student population, percent of students eligible for free-and-reduced lunch programs, student-teacher ratio, district-level per pupil funding, percent of students who identify as white, dummy variables indicating the level of medical dispensaries present, and state and year fixed effects. The dependent variables are four-year graduation rates and standardized college admissions test scores from the ACT, for the 2010-2011 through 2015-2016 years, and the SAT, for the 2016-2017 through the 2018-2019 years.

Notes: These results are were calculated using Colorado Department of Education for the 2010-2011 through 2018-2019 school years, in addition to Colorado Department of Revenue data on the location of dispensaries. These results are displayed with a 90% confidence interval, and standard errors are clustered at the school level. Controls include the natural log of the student population, percent of students eligible for free-and-reduced lunch programs, student-teacher ratio, district-level per pupil funding, percent of students who identify as white, dummy variables indicating the level of medical dispensaries present, and state and year fixed effects. Standardized college admissions test scores are from the ACT, for the 2010-2011 through 2015-2016 years, and the SAT, for the 2016-2017 through the 2018-2019 years. Dropout rates are calculated by dividing the total number of dropouts in a given school year divided by the total number of students who were a part of the student population in that year. Mobility rates are calculated by taking the unduplicated number of students who transferred in or out of the district each year divided by the total number of students who were a part of the student population that year.



Notes: These results are calculated using a stripped-down version of the main panel event study specification. In this case these regressions are regressing each control variable in turn on the lead and lag variables as well as the year and school fixed effects. The results are shown with a 90% confidence interval, and standard errors are clustered at the school level. The data comes from the CDE and uses data for the 2010-2011 school year through the 2018-2019 school year. Dispensary location data is from the CDR. 90% confidence intervals are presented. Student population numbers were transformed with a natural log. The funding figures are at the district level.

Table 2. Graduation Rates and Standarized College Admissions Test Scores

	At Least One Dispensary		One to Six Dispensaries		At Least Seven Dispensaries	
	Graduation Rate	Test Scores	Graduation Rate	Test Scores	Graduation Rate	Test Scores
Five Years Pre-Treatment	0.0136	-0.00363	0.0220	0.00462	-0.0296	-0.0117
	(0.73)	(-0.14)	(1.10)	(0.17)	(-0.67)	(-0.36)
Four Years Pre-Treatment	-0.00612	-0.0216	-0.00482	-0.0213	-0.0345	0.0264
	(-0.29)	(-0.86)	(-0.20)	(-0.83)	(-0.82)	(0.88)
Three Years Pre-Treatment	-0.0204*	-0.0187	-0.00567	-0.00331	-0.0356**	-0.0296
	(-1.76)	(-1.17)	(-0.41)	(-0.18)	(-2.21)	(-1.33)
Two Years Pre-Treatment	-0.00756	-0.0184	-0.00327	-0.0152	-0.0144	-0.00669
	(-0.66)	(-1.01)	(-0.26)	(-0.79)	(-0.87)	(-0.29)
Year of Treatment	0.00861	0.00249	0.00664	-0.000370	0.00954	0.0201
	(1.08)	(0.14)	(0.79)	(-0.02)	(0.80)	(0.94)
One Year After Treatment	0.0143	0.0127	0.00217	-0.00224	0.0262*	0.0345
	(1.26)	(0.79)	(0.15)	(-0.12)	(1.84)	(1.59)
Two Years After Treatment	0.00697	0.0203	-0.0244	0.00160	0.0416**	0.0311
	(0.53)	(1.00)	(-1.63)	(0.07)	(2.31)	(1.11)
Three Years After Treatment	0.0144	0.0351*	-0.00251	0.000705	0.0186	0.0575**
	(1.08)	(1.69)	(-0.17)	(0.03)	(1.08)	(2.05)
Four Years After Treatment	0.0426***	0.0652***	-0.000803	0.0138	0.0658***	0.0906***
	(2.63)	(2.63)	(-0.05)	(0.46)	(2.98)	(2.85)
Five Years After Treatment	0.0420**	0.0429	-0.00282	-0.0142	0.0660***	0.0811**
	(2.55)	(1.59)	(-0.18)	(-0.50)	(2.74)	(2.07)
Number of Schools	380	347	380	347	380	347

* Statistically significant at the 10% level, ** at the 5% level, and *** at the 1% level

Notes: Data is from the CDR for the 2010-2011 through 2018-2019 school years. Standardized test statistical information is from the National Center for Education Statistics (2011-2018) and CollegeBoard (2019). Dispensary location information is from the CDR. The dependent variables are four-year graduation rates and standardized college admissions test scores. Controls include the natural log of the student population, percent of students eligible for free-and-reduced lunch programs, student-teacher ratio, district-level per pupil funding, percent of students who identify as white, dummy variables indicating the level of medical dispensaries present, and state and year fixed effects. Standard errors are clustered at the school level.

Table 3. Student Consumption and Attitudes

	2015					2017				
	Graduation Rate	Alcohol Use	Marijuana Use	Easy to Get Marijuana	Wrong to Use Marijuana	Graduation Rate	Alcohol Use	Marijuana Use	Easy to Get Marijuana	Wrong to Use Marijuana
At Least One Dispensary	0.0159	0.00902	-0.0183	0.00295	-0.0249	0.00716	-0.0402**	-0.0497**	-0.0401	-0.0226
	(0.79)	(0.38)	(-1.30)	(0.09)	(-0.76)	(0.39)	(-2.07)	(-2.45)	(-0.93)	(-0.51)
At Least Seven Dispensaries	0.0318	-0.0253	-0.0261	0.0134	-0.0339	0.0267	-0.0506**	-0.0467	-0.0481	-0.0337
	(1.33)	(-1.03)	(-1.60)	(0.36)	(-1.06)	(1.27)	(-2.06)	(-1.66)	(-0.80)	(-0.55)
One to Six Dispensaries	0.00570	0.0309	-0.0133	-0.00455	-0.0184	-0.00835	-0.0320	-0.0520**	-0.0334	-0.0133
	(0.26)	(1.15)	(-0.79)	(-0.10)	(-0.44)	(-0.38)	(-1.47)	(-2.47)	(-0.69)	(-0.27)
Number of Schools	69	69	69	66	66	90	90	90	87	87

* Statistically significant at the 10% level, ** at the 5% level, and *** at the 1% level

Notes: The data comes from the Healthy Kids Colorado Survey, which was taken in fall 2013, 2015, and 2017. Dispensary location data is from the CDR. In both the 2015 and 2017 panels the initial year of comparison is 2013. Thus, the 2015 panel is the change from 2013 to 2015 and the 2017 panel is the change from 2013 to 2017. Controls include the natural log of the student population, percent of students eligible for free-and-reduced lunch programs, student-teacher ratio, district-level per pupil funding, percent of students who identify as white, dummy variables indicating the level of medical dispensaries present, and state and year fixed effects. Robust standard errors are reported.

Table 4. Treatment Distances

	Graduation Rate	Standardized Test Scores	Marijuana Use
Distance From School to Nearest Dispensary			
Zero to One Miles	0.0458***	0.0511**	-0.0651*
	(3.10)	(2.51)	(-1.68)
One to Two Miles	0.0390**	0.0210	-0.0537
	(2.30)	(1.20)	(-1.30)
Two to Five Miles	0.00736	0.0142	-0.0602
	(0.69)	(0.93)	(-1.13)
Five to Ten Miles	0.0165	0.00406	-0.0389
	(1.52)	(0.30)	(-1.04)
Ten to Fifteen Miles	0.0156	-0.00458	0.0174
	(1.34)	(-0.29)	(0.33)
Fifteen to Twenty Miles	0.0303	-0.0373**	-0.0564
	(1.20)	(-2.07)	(-0.81)
Number of Schools	380	347	90

* Statistically significant at the 10% level, ** at the 5% level, and *** at the 1% level

Notes: School outcome and demographic data comes from the CDE for the 2010-2011 through 2018-2019 school years. Dispensary location info is from the CDR. Student marijuana use data is from the HKCS. For graduation rates and test scores, standard errors are clustered at the school level. For marijuana robust standard errors are reported. Controls include the natural log of the student population, percent of students eligible for free-and-reduced lunch programs, student-teacher ratio, district-level per pupil funding, percent of students who identify as white, dummy variables indicating the level of medical dispensaries present, and state and year fixed effects.

Table 5. White and Non-White Graduation Rates

	White Graduation Rate	Non-White Graduation Rate
Five Years Pre-Treatment	0.00161	0.0240
	(0.08)	(0.85)
Four Years Pre-Treatment	0.0100	-0.0171
	(0.42)	(-0.64)
Three Years Pre-Treatment	-0.0243	-0.0140
	(-1.50)	(-0.84)
Two Years Pre-Treatment	-0.000354	-0.0169
	(-0.02)	(-1.01)
Year of Treatment	0.00287	0.0141
	(0.21)	(0.78)
One Year After Treatment	0.00892	0.0196
	(0.55)	(1.44)
Two Years After Treatment	0.00918	0.0257
	(0.48)	(1.41)
Three Years After Treatment	-0.00559	0.0115
	(-0.25)	(0.66)
Four Years After Treatment	0.0251	0.0435**
	(1.10)	(2.13)
Five Years After Treatment	0	0.0353*
	(.)	(1.67)
Number of Schools	380	378

* Statistically significant at the 10% level, ** at the 5% level, and *** at the 1% level

Notes: Data is from the CDE for the 2010-2011 through 2018-2019 school years. Dispensary location data is from the CDR. Standard errors are clustered at the school level. Controls include the natural log of the student population, percent of students eligible for free-and-reduced lunch programs, student-teacher ratio, district-level per pupil funding, percent of students who identify as white, dummy variables indicating the level of medical dispensaries present, and state and year fixed effects.

Table 6. Reading and Math Scores

	Math	Reading
Five Years Pre-Treatment	0.00201	-0.0384
	(0.08)	(-1.41)
Four Years Pre-Treatment	0.00544	-0.0501*
	(0.23)	(-1.79)
Three Years Pre-Treatment	0.00258	-0.0212
	(0.16)	(-1.26)
Two Years Pre-Treatment	-0.000218	-0.0403**
	(-0.01)	(-2.12)
Year of Treatment	0.00779	0.00226
	(0.51)	(0.13)
One Year After Treatment	0.00641	0.0175
	(0.40)	(1.06)
Two Years After Treatment	0.0159	0.0176
	(0.82)	(0.87)
Three Years After Treatment	0.0414**	0.0184
	(2.03)	(0.89)
Four Years After Treatment	0.0606**	0.0551**
	(2.48)	(2.15)
Five Years After Treatment	0.0385	0.0333
	(1.50)	(1.24)
Number of Schools	348	348

* Statistically significant at the 10% level, ** at the 5% level, and *** at the 1% level

Notes: School outcome and demographics data are from the CDE for the 2010-2011 through 2018-2019 school years. Dispensary location data is from the CDR. Controls include the natural log of the student population, percent of students eligible for free-and-reduced lunch programs, student-teacher ratio, district-level per pupil funding, percent of students who identify as white, dummy variables indicating the level of medical dispensaries present, and state and year fixed effects. Standard errors are clustered at the school level.

Appendix

One critical part of the analysis in this paper is choosing appropriate distances to use to determine the treatment status of a given school. Arbitrarily picked values are insufficient, as it's conceivable that the distance at which a dispensary affects schools could be a large range of distances. To find a more data-based distance range to use, I ran a regression of the following form:

$$Y_{idt} = \alpha + \beta_f Distance_{idt} + \theta_t + \mu_i + \gamma X_{idt} + \varepsilon_{idt}$$

Where Y is the dependent variable, θ_t are year fixed effects, μ_i are school fixed effects, X_{idt} are a vector of controls, ε_{idt} is the error term, and the β_f are the coefficients of interest. $Distance_{idt}$ are a series of dummy variables each representing a band of ranges which contain the closest marijuana dispensary to the school. These dummies are constructed to be mutually exclusive and exhaustive, so only the band representing the closest dispensary holds a value of one. These dummies are defined as zero to one mile, one to two miles, two to five miles, five to ten miles, ten to fifteen miles, fifteen to twenty miles, and untreated schools.

I regressed four-year graduation rates, standardized college admissions test scores, and marijuana consumption among students on this specification. The results are presented in Table 4. This table shows us the expected pattern, schools closest to the dispensaries have the strongest and most statistically significant coefficients. Unfortunately, the effect on each dependent variable drops off slightly differently, so there is no clear choice of which range to use. In this case I decided to use a distance of up to five miles since both standardized college admissions test scores and marijuana consumption show results through the two to five mile band, even if they aren't statistically significant.