The Effect of Cannabis Dispensaries on Student Achievement; Evidence from Washington State

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Abstract:

Employing public educational and commercial data from the State of Washington, this study aims to estimate the impact of the establishment of a marijuana dispensary on neighborhood school's student growth percentiles (SGPs) on standardized Math and English exams using difference-in-difference regression analysis. The results of the study indicate that the placement of a recreational marijuana dispensary in the vicinity of a school is correlated to negative effects on student growth rates, corresponding to a statistically significant 2.81 percentage point reduction in the proportion of students achieving high growth on all subjects and a 2.32 point increase in students reporting low growth. In contrast with previous studies estimating the effects of dispensaries and cannabis use on teens, the negative impact on growth is largely driven by a pronounced effect on English scores rather than Math scores, with a 3.35 point decrease in high growth and 3.1 point increase in low growth students when accounting for school fixed effects. The results suggest that there are educational consequences to marijuana legalization and accessibility that may influence long-term student outcomes; therefore, it is important for policy makers to consider the impact of marijuana not just in terms of legislation, but also of zoning regulations and its impact on availability to teens.

Intro:

Although contemporary politics in the United States are characterized by an alarming increase in polarization, attitudes towards cannabis legalization are softening across the political spectrum. As of 2019, 67% of Americans are in favor of decriminalizing recreational cannabis use (including 55% of self-identified Republicans) and only 32% are opposed, down 20 percentage points in only 9 years (Pew Research 2019). These attitudes persist despite various scientific studies linking cannabis use to decreased cognitive functioning. However, rapid growth in support for recreational cannabis laws (RCLs) is not only a product of progressive, nationwide trends or consumer preferences; it is concurrently driven by the immense tax revenue potential of licensed marijuana dispensaries, a development that incites interest from lawmakers of both major parties. Washington became the second state behind Colorado to legalize recreational cannabis sales in 2012, effective as of January 2014, and the first recreational dispensaries in the state opened in July of 2014. The state collected nearly $400 million in tax revenue from dispensaries in 2019 alone, nearly half of which is routed towards their Basic Health Plan Trust Account that provides "necessary basic health care services to working persons and others who lack coverage" (Washington State Treasury 2020). Increased funding for this initiative improves health outcomes among the most vulnerable in society, reducing statewide inequities in health care with the added benefit of plausibly enhancing the program's future solvency.

Colorado, the first state to decriminalize cannabis, generated $1.2 billion in revenue from sales and excise taxes since licensed dispensaries began operations in 2014, a significant portion of which served to supplement state educational grants to schools as well as fund school renovation and maintenance costs (State of Colorado 2020). Many studies find correlation between increased educational funding and better outcomes; one study found that 10% increases in expenditures were associated with increased test scores and lower dropout rates, especially among poorer school districts (Kreisman and Steinberg 2019). Additionally, there is evidence linking cannabis availability to lower Medicare Part D expenditures (Bradford and Bradford 2018) and opiate prescriptions (McMichael et al. 2020), insinuating that cannabis legislation is possibly an effective tool in combating the Opioid Crisis.

Nonetheless, critics argue that benefits generated from taxable marijuana sales are overstated; many states are reporting lower than expected revenues which are more than offset by the various costs explicit and implicit costs associated with individual use and availability. Detractors characterize cannabis as a "gateway" drug that is associated with use of more dangerous substances and claim that dispensaries promote increased use, further exacerbating marijuana's perceived negative impacts on educational attainment, time use, etc. Additionally, there is a common belief that legalization would cause individuals to discount the present and future negative effects of cannabis consumption, leading to more widespread and intensive use among younger persons. These sentiments are echoed in the Executive branch of the federal government; the Trump Administration, which previously held more lax views regarding marijuana legislation, is now considering removing medical marijuana protections in 2021. Trump himself recently stated that cannabis use causes a loss in IQ (Chicago Tribune 2020), and former Attorney General Jeff Sessions, a particularly vocal opponent, went as far as attacking the morals of cannabis users, claiming "Good people don't smoke marijuana" (Newsweek 2017).

Consequently, marijuana policy debates will be especially important as its popularity increases. Roughly 1 in 7 American adults reported marijuana use in 2017 (Reuters 2018) and 11.8 million young adults reported use in 2018, making marijuana the second most prevalent psychoactive drug besides alcohol (National Institute of Drug Abuse 2020). There are currently 11 states where recreational cannabis use is decriminalized in addition to 37 where medicinal use is legal. Sales are even persisting amid the 2020 COVID-19 pandemic; U.S. cannabis sales set records last month and 23 states declared dispensaries, among other elements of the cannabis industry, "essential" businesses (NPR 2020). This further indicates that attitudes towards cannabis are becoming more permissive as it establishes a stronger foothold in mainstream society.

This study is novel for several reasons. Generally, studies analyzing the educational implications of marijuana legislation identify the implementation of a statewide medicinal law as their event of interest. This study instead focuses on recreational dispensary openings which expand marijuana availability and use to a much greater degree, plausibly pronouncing the effect on response variables related to academic performance. This would provide a deeper understanding of how the effects of marijuana commerce and policy at local levels differ compared to state levels. Rather than measuring changes in test scores, this study aims to measure changes in test score growth rates which are a stronger indication of relative performance. Additionally, this study will evaluate the effects on school level score growth for various racial and socioeconomic demographics, controlling for school fixed effects and variables such as geography school funding. The results of this study will provide valuable information on the marijuana policy debate by informing lawmakers of some of the most important implications of localized marijuana commerce on youth outcomes.

Literature Review:

Existing cannabis literature focuses primarily on medicinal cannabis laws (MCL's), which currently provide more data by virtue of their greater frequency and duration compared to recreational cannabis laws (RCL's). Partial cannabis legalization first came about in 1996 in California, at the time only permitting medicinal use. Despite being classified by the DEA as a schedule I drug, defined as having "no currently accepted medical use" (DEA 2020), medicinal cannabis is shown to be useful in treating chronic pain, migraines, and nausea resulting from chemotherapy. Its effectiveness as a pain reliever is such that it may be powerful mechanism for combating the Opioid epidemic, evidence suggesting that adoption of MCL's reduces total statewide opioid prescriptions (McMichael et al 2020) in addition to prescriptions under

Medicare Part D, producing the added benefit of nearly $1.2 billion in annual Medicare savings if adopted nationwide (Bradford and Bradford 2018).

Other results related to individual effects of MCL's are marginal; studies find weak correlation between employment rates of older adults and MCL implementation (Sabia and Nguyen 2018) as well as their number of hours worked and self-reported physical health (Nicholas and Maclean 2019). Labor results are driven by the selectivity of medicinal cannabis use; older adults are more likely to be suffering from labor-limiting chronic symptoms that can be treated with cannabis, so it is not surprising that their demographic responds positively to the legislation.

Notwithstanding, MCL's do not in theory expand marijuana availability to the same degree as RCL's and dispensaries because they come with significant transaction costs, requiring potential consumers to obtain a note from their physician approving treatment of a chronic condition with cannabis prior to purchase. MCL's produce potentially biased results because they underestimate the negative impacts of marijuana use that disproportionately affect younger persons who are less likely to respond to changes in medicinal availability (Anderson et al. 2015). Questions as to what extent RCL's, which plausibly extend availability much further, promote teen cannabis use and onset age are important in judging their long-term impacts.

The main psychoactive compound in cannabis, THC, negatively affects cognitive functioning, especially in younger individuals whose brains are still developing (Olivier and Zolitz 2017). Empirical studies utilizing longitudinal, household survey data find that early onset cannabis exposure, compounded by intensity of use, is known to detrimentally impact educational outcomes, reducing probability of high school completion (Cobb et al. 2015) and the mean number of years in school (van Ours and Williams 2007). Said effects disproportionately burden lower-income teens, fueling existing educational and socioeconomic inequality. Additionally, marijuana use may negatively affect mental health outcomes, corresponding to slightly increased suicidal thoughts among men (van Ours and Williams 2015). Reductions in human capital accumulation can lead to long-term consequences for teens, limiting future wages and employment (van Ours and Williams 2007), undercutting the financial benefits (i.e., tax revenue) of cannabis commerce.

Olivier and Zolitz 2017 suggests that limiting cannabis access can reverse adverse educational effects; taking advantage of a Dutch law that forbid foreigners from frequenting pot shops, the researchers measured changes in university passing rates in addition to course evaluation responses with a difference-in-difference approach that compared domestic and foreign student's outcomes over time. Foreign students responded positively to losing legal access to pot, passing courses at higher rates (particularly quantitative courses requiring strong cognitive skills such as mathematics) and claiming better understanding of course material (Olivier and Zolitz 2017), insinuating that cannabis access may limit student achievement.

Existing dispensary literature generally focuses on neighborhood level impacts rather than educational outcomes. Besides reducing transaction costs for obtaining marijuana, a well-located dispensary can elicit an inflow of residents into a neighborhood if locals place value in living close to the business. *Burkhardt and Flyr 2019* employed commercial data from the City of Denver and applied an "event study" method, one frequently utilized to answer the questions posed in dispensary studies, to map home sales to radii surrounding recently opened dispensaries, controlling for neighborhood fixed effects and home characteristics. The study discovered a strong, positive correlation between selling prices and distance to dispensaries (Burkhardt and Flyr 2019).

Crime rates are another dependent variable of importance relating to dispensary openings that are analyzed in similar ways, although findings are not fully in agreement across the literature. Dispensary closings are shown to correspond with upticks in violent crime within the immediate vicinity of the dispensary (Chang and Jacobson 2017) while openings generate the opposite effect; violent crime as well as marijuana related offenses decreased significantly outside of new dispensaries, although vehicle break-ins increased in frequency (Burkhardt and Goemens 2019). Alternate studies replicating said results also account for exogenous variation in dispensary density, suggesting that Denver dispensaries are more apt to be locate themselves near highways and areas with greater employment (Brinkman and Mok-Lamme 2017). Heightened private security and increased police presence are both possible mechanisms driving these responses. However, it is worth noting that said effects are highly localized, within only a 1/10-mile radius in the case of *Chang and Jacobson 2017*, and did not generate spillover effects in surrounding areas.

Fewer studies explicitly assess the impact of commercial cannabis access on individual outcomes. If the location of cannabis sources influences transactional costs, one would expect that those living closer to a source may be more prone to partaking in its use. *Van Ours and Palali 2015* provides valuable insight regarding the spatial effects of Dutch pot shops on individuals and how one could measure similar effects from U.S. dispensaries. The authors used longitudinal survey data to account for teen's onset age of marijuana exposure and commercial data to record distance to a dispensary, constructing a logistic regression to gauge how distance affects the probability of using cannabis by age 16. Those located within 20 km of a dispensary were more likely to have used marijuana by age 16 and their likelihood increased with every 10 km decrease in distance (van Ours and Palali 2015). Although the results alone hold no welfare implications, educational outcomes are shown to be affected by onset use (Cobb et al 2015 and van Ours and Williams 2017), indicating the possibility of a secondary relationship between dispensary location and educational outcomes.

This paper elaborates on this possibility by studying the responses of educational variables, standardized test score growth rates, in relation to the presence of licensed dispensaries in Washington school districts. It will control for individual characteristics, such as race and income, while also accounting for neighborhood and school district characteristics using a difference-in-difference method. The method utilized in this study represents an improvement on previous studies because it measures instead how student growth rates respond to the presence of a dispensary and possesses built-in mechanisms that control for certain unobservable area attributes. Results will provide novel information involving the external costs to teens associated with cannabis dispensaries and improve upon our collective understanding of the implications of cannabis policy.

I predict that the spatial effects of dispensaries on test score growth rates will be negative, but also relatively insignificant. Math scores may respond to a greater degree than English scores due its dependency on cognitive skills, skills that are more susceptible to the negative effects of marijuana use (Olivier and Zolitz 2019). Nonetheless, a recreational dispensary only extends availability to individuals over the age of 21, and although *van Ours and Palali 2015* finds correlation between the percentage of students reporting onset use of marijuana at age 16 and neighborhood dispensaries, the oldest students in our study are aged 14 and presumably less likely to be using marijuana in any legislative circumstance. As a result, I believe that the negative impact of early onset use detailed in *Cobb et al. 2015* and *van Ours and Williams 2007* is unlikely to be as pronounced in my model.

Data:

The data employed in performing the statistical analysis for this study contains three main aspects: locational data of schools and dispensaries, test score data, and individual school characteristics. Data detailing district level school funding and school demographics is available through the Washington Office of Superintendent of Public Instruction (OSPI) and its Report Card data, a repository that also includes the test score data utilized in this study. Every year, students in grades 3-8 are assessed on math, science, and language arts skills through the Smarter Balanced Assessments (SBAs). Schools are required to administer the assessments at any time between March and the beginning of June. The state began administering said exams in 2014 to assess student progress and ensure that Washington schools met common core standards. OSPI test score data is especially useful because it measures a school's performance through student growth percentiles (SGP's). Math and English and Language Arts scores will be the focus of this study. A student's SGP represents "a student's growth compared to other students with similar prior test scores" (OSPI 2019), categorizing growth as either high, medium, or low. For example, a student who reported "low growth" had an SGP in the bottom third percentile of their peers, "middle growth" being in the middle third percentile compared to their peers, and "high growth" representing a growth rate in the top third percentile of all students with similar prior scores. The period growth rates of interest are from 2014 to 2015 and 2015 to 2016 growth.

Using growth rates as a response plausibly provides more valuable information regarding relative performance than using test scores themselves; for instance, already high achieving schools may see no relative change in mean test scores but could still experience a decrease in its proportion of students with high growth relative to neighboring districts, indicating a worse outcome. Included in the dataset are results by school district, school, gender, race, income, disability status, and whether a student is homeless, a migrant, or has a parent in the military. The presence of a category for “low income” is particularly important for my own study because previous studies suggest that the negative effects of marijuana use and availability are exacerbated by income status (Cobb et al 2015, van Ours and Williams 2017). If this is the case, we can expect to see lower income schools respond more negatively to the presence of a dispensary. Furthermore, exploring response differences across race may help to test whether any racial inequalities are present. We will control for these variables in our model to provide a more accurate estimation of the true impact of the dispensary.

The preliminary cannabis data that this study employs is from the State of Washington Liquor and Cannabis Board’s online data archives and 502data.com, an independent site that the state utilizes to compile monthly sales, sales rankings, and tax data for every one of the 446 operating dispensaries in the state. The Washington State Liquor and Cannabis Board provides data on the locations, years in operation, and licensing details of all current and potential cannabis dispensaries in the state; they account for not only open recreational dispensaries, but also locations of medicinal dispensaries, dispensaries awaiting licensing approval, and processing plants. To differentiate between schools that are and are not located adjacent to a dispensary, we create a categorical independent variable labeled “treatment”, classifying said group as the school districts where a dispensary is present after March of 2015 and the control group as being school districts containing dispensaries that began operations after June of 2016. As a result, the treatment group will consist of schools in which a dispensary was present nearby when they administered the SBA in 2016, but not in 2014 and 2015. Consequently, the control group will consist of schools where nearby dispensaries are present only after the test score data used in the study (2014-2016) was compiled.

We designate the groups in this fashion to plausibly control for some unobservable differences between areas. On the microeconomic level, dispensary owners are trying to maximize profits; to do so, they seek to open their businesses in areas where they believe that they can sell the most product. Empirical evidence suggests exogenous variation in dispensary density (Brinkman and Mok-Lamme 2017), therefore it is possible that those identified areas, whether it be due to area characteristics, local preferences, real estate, infrastructure etc., share more similarities than areas that do not contain dispensaries.

Data on Alcohol Impact Areas (AIA's) is obtained via the Liquor and Cannabis Board as well. AIA's are designated by the state of Washington so that "local authorities have a process to mitigate problems with chronic public inebriation or illegal activities linked to the sale or consumption of alcohol within a geographic area of their city, town or county" (Liquor and Cannabis Board 2020). There are currently 10 AIA's located within 6 cities. Sales of certain alcoholic beverages, generally inexpensive, high alcohol products, are prohibited in these areas. This variable is included as a potential control for area substance abuse; it is plausible that the residents of an AIA are more inclined to abuse alcohol and other drugs, pronouncing the negative effects on student achievement in these areas. We will employ the geographic distribution of AIA's as a categorical variable attributed to schools that are either located within an AIA or directly adjacent to one.

Methodology:

This study employs difference-in-difference estimation via a multilinear regression model containing categorical and quantitative variables. To organize the data, each dispensary operating as of June 2016 was identified and all the schools containing 6th through 8th grade students within a 3-mile radius of said dispensaries were recorded. 3-miles is chosen for the radius because we consider it to be a conceivable maximum distance for which families living in the outer limits of a school's jurisdiction could walk to. We consider the entire family unit because the dispensary itself, while not necessarily increasing availability for young teens, does provide better availability for parents who may become more permissive regarding their children's potential marijuana use. The majority of said schools are either Elementary or Middle schools, with several interspersed K-8 schools. Schools surrounding dispensaries that commenced operations between March and May of 2015 are denoted as the treatment group while the remaining schools make up the control group. 72 schools are included in the control group and 38 in the treatment, generating 979 total observations when breaking down by grade level.

Math score growth rates make up 490 of the total observations and the remaining 489 observations detail English score growth. Each school included in the study is then broken down by student, school, and geographic characteristics to generate explanatory variables. Student characteristics consist of the proportions of students by racial and ethnic group, gender, grade level, income level, with "low income" students defined as students receiving free and or reduced meals, disability status, and English Language Learners (ELL) status for each school. Geographic characteristics are included via 2 categorical variables denoting whether a school is in a rural area or adjacent to an AIA. An added control, "PerPupil", signifies per student school funding. Per capita spending is included because of the possibility that it independently affects student performance, as proposed in *Kreisman and Steinberg 2019*.

Table 1

Variable	Obs	Mean	Std. Dev.	Min	Max
PercentHigh	336	0.336	0.134	0.087	0.882
PercentTypical	336	0.341	0.068	0.059	0.538
PercentLow	336	0.323	0.121	0.043	0.651
Asian	336	0.061	0.079	0	0.430493
Black	336	0.054	0.073	0	0.358871
Hispanic	336	0.235	0.173	0	0.806202
Female	336	0.489	0.06	0.315	0.694444
ELL	336	0.08	0.074	0	0.48718
Disabled	336	0.132	0.057	0	0.363636
LowIncome	336	0.561	0.178	0.151	1
TwoRaces	336	0.076	0.062	0	0.384615
White	336	0.567	0.242	0.028	1
PerPupil	336	14950	2330	8684	25952
Rural1	336	0.414	0.493	0	1

Table 2

Variable	Obs	Mean	Std. Dev.	Min	Max
PercentHigh	153	0.363719	0.139	0.105	0.909
PercentTypical	153	0.336281	0.057	0.091	0.468
PercentLow	153	0.300078	0.125	0	0.581
Asian	153	0.093957	0.088	0	0.356061
Black	153	0.036655	0.044	0	0.241206
Hispanic	153	0.182395	0.116	0.0378	0.527778
Female	153	0.490128	0.055	0.358491	0.704698
ELL	153	0.057213	0.062	0	0.348485
Disabled	153	0.132595	0.054	0	0.296703
LowIncome	153	0.432261	0.222	0.058559	0.893939
TwoRaces	153	0.084107	0.046	0.029	0.285714
White	153	0.595594	0.16	0.106061	0.931
PerPupil	153	14659.95	1458	12296	19022
Rural1	153	0.169935	0.377	0	1

Tables 1 and 2 detail the mean demographics of the control and treatment groups in the first period (2014). The number of observations reflects the number of grade levels per school for each group. On average, schools in the treatment group performed better at the outset in terms of student growth, with 36.3% achieving high growth and only 30.0% exhibiting low growth compared to 33.6% and 32.3% in the control group. Treated schools have higher proportions of Asian American students but are less diverse overall with more white students and lesser amounts of Hispanic, African American, and English Language learners. Control schools are much more likely to be located rurally; this reflects trends in the recreational cannabis market, as many earlier dispensaries are in major cities such as Seattle and Spokane rather than rural areas. Mean per capita spending between the two groups is relatively similar. Perhaps most importantly, treated schools display lower proportions of low-income students. Due to the potential exacerbated effects of cannabis use unique to poor students (Cobb et. al 2015), it will be imperative to control for the proportion low-income students at each school.

The below figure describes the setup of the baseline regression model utilized in the study. A categorical variable “post” differentiates between growth rates from 2014-2015 and 2015-2016, the latter defining the “post” group. Our variable of interest is the difference-in-difference variable “treated_post”, an interaction term that isolates the impact of a dispensary opening on the response variable and controls for the explanatory variables. School SGP’s represent our response variables; we measure the change in the proportion of students recording low, medium, and high growth at each school. We estimate the effect on all three terciles of growth to provide a better understanding of the direction and amplitude of response. For example, if the high and low growth terciles responded strongly to the difference-in-difference variable, but not the typical growth tercile, it is possible that the presence of the dispensary is associated with a more pronounced decline in growth.

$$Y_{i,t} = \beta_0 + \beta_1 treat_i + \beta_2 post_t + \beta_3(treat_i * post_t) + \beta_4 grade_1 + \beta_5 grade_2 + \beta_6 asian + \beta_7 AA + \beta_8 hispanic + \beta_9 female + \beta_9 ELL + \beta_{10} disabled + \beta_{11} lowincome + \beta_{12} tworace + \beta_{13} white + \beta_{14} perpupil + \beta_{15} AIA + \beta_{16} rural + \varepsilon$$

Three categories exist for each level of response: the change in English score growth, Math score growth, and combined English and Math score growth. One question that arises in this model is whether the group of predictors significantly improve the estimated impact of the dispensary. To answer this, we provide both a full and reduced model for predicting changes in growth percentiles. The reduced model includes, in order, the constant term, treatment term, period term, diff-in-diff term, grade level term, and random error term. The order of the variables appearing in the full model is as follows; the constant term, treatment term, period term, diff-in-diff term, grade level, proportions of race and student type, per pupil spending, AIA status, rural status, and the random error term. Full and reduced models are broken into three categories, “weighted”, “unweighted”, and “clustered”. “Weighted” regressions weight each school based on its student count, while the "unweighted" regressions place equal value on all schools regardless of enrollment. "Clustered" regressions denote data that is clustered based on school name to control for school fixed effects.

Table 3

	HIGH GROWTH		TYPICAL GROWTH		LOW GROWTH	
	(1)	(4)	(9)	(10)	(15)	(16)
VARIABLES	Full	Full Weighted	Full	Full Weighted	Full	Full Weighted
treated	0.00528	0.00229	0.00474	0.000503	-0.00997	-0.00273
	(0.0139)	(0.0130)	(0.00639)	(0.00539)	(0.0126)	(0.0121)
post	-0.00430	-0.00775	0.00579	0.00539	-0.00144	0.00242
	(0.0101)	(0.00961)	(0.00502)	(0.00384)	(0.00935)	(0.00935)
treated_post	-0.0243	-0.0281*	0.00233	0.00465	0.0218	0.0232
	(0.0165)	(0.0157)	(0.00825)	(0.00647)	(0.0154)	(0.0152)
Asian	0.377***	0.375***	-0.107**	-0.0226	-0.270***	-0.352***
	(0.100)	(0.0937)	(0.0492)	(0.0391)	(0.0824)	(0.0863)
Black	0.0162	0.118	0.0492	-0.0149	-0.0655	-0.103
	(0.113)	(0.0980)	(0.0513)	(0.0432)	(0.100)	(0.0948)
Hispanic	0.0768	0.159**	0.0106	0.0254	-0.0875*	-0.185***
	(0.0649)	(0.0636)	(0.0326)	(0.0273)	(0.0527)	(0.0604)
Female	0.161**	0.0650	-0.00407	0.0229	-0.157**	-0.0878
	(0.0717)	(0.0702)	(0.0378)	(0.0324)	(0.0670)	(0.0706)
ELL	0.0828	-0.00221	0.0729	0.01000	-0.155	-0.00682
	(0.114)	(0.110)	(0.0601)	(0.0421)	(0.102)	(0.105)
Disabled	0.130	-0.0288	-0.166***	-0.158***	0.0356	0.186**
	(0.0818)	(0.0890)	(0.0456)	(0.0366)	(0.0724)	(0.0839)
LowIncome	-0.0971***	-0.119***	0.00314	0.0138	0.0940***	0.105***
	(0.0300)	(0.0287)	(0.0162)	(0.0131)	(0.0262)	(0.0275)
TwoRaces	-0.143	-0.202*	0.102*	0.0631	0.0415	0.139
	(0.113)	(0.118)	(0.0604)	(0.0510)	(0.102)	(0.111)
White	0.161**	0.155**	0.00816	0.0147	-0.169***	-0.169***
	(0.0660)	(0.0668)	(0.0342)	(0.0294)	(0.0561)	(0.0628)
PerPupil	5.69e-06**	5.45e-06**	-1.95e-07	1.29e-06	-5.50e-06**	-6.75e-06**
	(2.60e-06)	(2.63e-06)	(1.27e-06)	(9.50e-07)	(2.44e-06)	(2.65e-06)
Constant	0.0801	0.152*	0.335***	0.297***	0.585***	0.551***
	(0.0847)	(0.0856)	(0.0451)	(0.0373)	(0.0756)	(0.0810)
Observations	979	979	979	979	979	979
R-squared	0.086	0.128	0.046	0.043	0.071	0.119

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, *

<u>Results:</u>

All Subjects:

The effect on the proportion of students exhibiting high, low, and typical growth varied depending on both the subject and the regression method. Furthermore, the regressions produced several unanticipated results. In every instance, the full model provided a much better fit to the response than the reduced models. Table 3 displays select, estimated coefficients of the weighted and unweighted full models measuring the response of combined math and English test score terciles. Above numbers indicate the value of the coefficient for each predictor while the parenthesized value indicates standard error. A common trend among the models measuring responses of different subjects is that the weighted regression provides the best overall fit; in this case, the R squared us 0.128 compared to 0.086 in the unweighted model.

Schools in treated areas performed slightly more favorably compared to control schools; on average, said schools exhibited higher proportions of high and typical growth students and a lesser proportions of low growth students, although none of the coefficients proved significant, signaling that there is not a large difference in baseline performance between the groups. The diff-in-diff variable takes on greater significance in the weighted model, likely due to the high variability in the response of smaller schools. According to the weighted models, the impact of the dispensary is correlated with on average a 2.81 percentage point decrease in the proportion of students achieving high growth, a 0.465-point increase in students with typical growth, and a 2.32-point increase in students with low growth compared to their peers. However, only the effect on high growth proved significant at the 10% level. The results imply that the spatial effect of a dispensary, while not strongly significant, are still impactful as the effects on growth extremes are more pronounced. Students are performing relatively worse at a significant level;

however, it is unknown whether it be a result of known negative impacts of dispensaries and marijuana use or a set of unobservable variables. School demographics played an important role in estimating each growth level. All else equal, the percentage of Asian American, Hispanic, and Caucasian students positively correlates with high growth rates, with a percentage point increase in the proportion of Asian students corresponding to a 0.375-point increase in students with high growth. The proportion of African American students, while not significant, does positively correlate with high growth. Although the proportion of multi-racial students negatively affects the likelihood of high growth, overall, the results suggest that diversity enhances a school's relative performance. Demographics produce similarly impactful results on the proportion of low growth students, albeit with opposite signs. One of the most significant determinants of high and low growth is income level; every 1 percentage point increase in the proportion of poor students corresponds to a 0.119-point drop in a school's proportion of students with high growth and a 0.105-point rise in students with low growth, both of which are significant at the one percent level. Reflecting the findings of *Kreisman and Steinberg 2019*, our model found that per pupil spending is a significant determinant of student success; every $1 increase in funding both increases the proportion of high growth students and reduces the proportion of low growth student. In estimating typical growth rates, only the proportion of disabled students proved significant, reducing the probability of maintaining typical growth and correlating with an increase in low growth students. Grade level, geography, ELL students, and gender makeup did not significantly correlate to any changes in growth rates. These results suggest that all test score growth rates are affected by dispensary openings, however it is unknown whether said results are being driven more by changes in Math or English scores.

Math:

Table 4

	HIGH GROWTH		TYPICAL GROWTH		LOW GROWTH	
	(4)	(5)	(10)	(11)	(16)	(17)
VARIABLES	Full	Weighted	Full	Weighted	Full	Weighted
treated	-0.0103	-0.0155	0.00787	0.00454	0.00250	0.0111
	(0.0215)	(0.0184)	(0.00963)	(0.00737)	(0.0184)	(0.0167)
post	-0.0194	-0.0185	0.0102	0.0106*	0.00925	0.00790
	(0.0160)	(0.0151)	(0.00748)	(0.00554)	(0.0142)	(0.0145)
treated_post	-0.0147	-0.0145	0.00150	0.00251	0.0130	0.0117
	(0.0256)	(0.0230)	(0.0122)	(0.00893)	(0.0231)	(0.0220)
Asian	0.432***	0.417***	-0.166**	-0.0570	-0.266**	-0.360***
	(0.167)	(0.152)	(0.0773)	(0.0593)	(0.131)	(0.133)
Black	-0.0526	0.169	0.0307	-0.0814	0.0226	-0.0862
	(0.181)	(0.154)	(0.0791)	(0.0618)	(0.160)	(0.144)
Hispanic	0.0957	0.191*	-0.0184	0.00133	-0.0774	-0.192**
	(0.113)	(0.100)	(0.0497)	(0.0393)	(0.0854)	(0.0901)
Female	0.221**	0.0300	-0.0240	-0.00573	-0.196**	-0.0240
	(0.107)	(0.103)	(0.0517)	(0.0438)	(0.0933)	(0.101)
ELL	0.0423	-0.0119	0.114	0.0315	-0.155	-0.0189
	(0.193)	(0.171)	(0.0953)	(0.0583)	(0.162)	(0.161)
Disabled	0.0175	-0.120	-0.0950	-0.133**	0.0778	0.254**
	(0.131)	(0.137)	(0.0679)	(0.0552)	(0.111)	(0.127)
LowIncome	-0.0665	-0.109**	-0.0345	-0.00804	0.101**	0.117***
	(0.0496)	(0.0455)	(0.0250)	(0.0194)	(0.0394)	(0.0405)
TwoRaces	-0.0349	-0.200	0.0782	0.0331	-0.0424	0.168
	(0.183)	(0.192)	(0.0916)	(0.0793)	(0.152)	(0.176)
White	0.203*	0.217**	-0.0261	-0.0110	-0.176**	-0.205**
	(0.110)	(0.110)	(0.0523)	(0.0452)	(0.0870)	(0.0963)
PerPupil	8.12e-06*	8.36e-06**	-1.66e-06	9.98e-07	-6.47e-06*	-9.36e-06**
	(4.36e-06)	(4.25e-06)	(1.89e-06)	(1.36e-06)	(3.81e-06)	(4.31e-06)
Constant	0.00578	0.110	0.407***	0.353***	0.587***	0.536***
	(0.139)	(0.138)	(0.0652)	(0.0536)	(0.114)	(0.128)
Observations	490	490	490	490	490	490
R-squared	0.079	0.142	0.045	0.058	0.086	0.152

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Marijuana negatively affects cognitive function which would plausibly generate more pronounced effects on courses that require more cognitive skills, such as math. Prior to running these regressions, my hypothesis guessed that math scores would be more responsive to the dispensary opening. However, somewhat surprisingly, Math growth rates are not significantly responsive to the presence of the dispensary, contrasting with the results found in *Olivier and Zolitz 2017*. Table 4 displays coefficients of explanatory variables predicting the proportion of high, typical, and low math test score growth rates in accordance with each model. The weighted model displayed the highest predictive capability with an R squared value of 0.142. Schools in the treated group experienced a 1.85 point decrease in their proportion of high growth students and a 1.17 point increase in the proportion of low growth students; however, none of the models found significant correlation between the percentage of students exhibiting high growth and the presence of a nearby recreational marijuana dispensary. In no case was the t-value of the diff-in-diff variable ever greater than 0.73, casting doubt on the hypothesis that math acumen deteriorates with heightened access to marijuana.

Variables that did significantly correlate with the response include several quantitative school characteristic indicators. Significant at the one percent level is the proportion of students of Asian descent at a school; a one percentage point increase in the proportion of Asian Americans correlates to a 0.417 percentage point increase in the proportion of the school population achieving high math score growth. The proportions of female students (in unweighted and clustered regressions), white, and Hispanic (weighted regression), and per pupil spending all proved to be positively correlated with high improvement in mathematics. Per pupil funding positively affects growth; for every $1 increase in per capita spending, the proportion of students achieving high growth in math grew by 0.000836 percentage points which is significant at the 5% level in the weighted model. Unsurprisingly, a school's proportion of low-income students invoked a significantly negative effect on the proportion of high growth students in each model.

Each of the previously mentioned variables induced similarly opposite effects on the proportion of students with low growth, while the proportion of disabled students is again the only variable with a stronger than 5% significant effect on typical growth.

English:

Table 5

	High Growth		Typical Growth		Low Growth	
	(4)	(5)	(10)	(11)	(16)	(17)
VARIABLES	Full	Full Weighted	Full	Full Weighted	Full	Full Weighted
treated	0.0210	0.0199	0.00203	-0.00352	-0.0230	-0.0164
	(0.0172)	(0.0180)	(0.00821)	(0.00787)	(0.0171)	(0.0171)
post	0.0109	0.00272	0.00161	0.000106	-0.0125	-0.00268
	(0.0122)	(0.0119)	(0.00674)	(0.00524)	(0.0123)	(0.0118)
treated_post	-0.0335	-0.0413**	0.00219	0.00662	0.0311	0.0344*
	(0.0207)	(0.0208)	(0.0108)	(0.00914)	(0.0204)	(0.0201)
Asian	0.334***	0.336***	-0.0515	0.00672	-0.282***	-0.342***
	(0.111)	(0.110)	(0.0604)	(0.0512)	(0.0998)	(0.105)
Black	0.0718	0.0544	0.0668	0.0522	-0.139	-0.107
	(0.139)	(0.125)	(0.0646)	(0.0586)	(0.128)	(0.126)
Hispanic	0.0567	0.122	0.0401	0.0497	-0.0968	-0.172**
	(0.0601)	(0.0826)	(0.0411)	(0.0381)	(0.0609)	(0.0812)
Female	0.106	0.102	0.0152	0.0420	-0.121	-0.144
	(0.0954)	(0.0966)	(0.0567)	(0.0468)	(0.0956)	(0.0981)
ELL	0.107	0.00776	0.0306	-0.0230	-0.137	0.0164
	(0.124)	(0.134)	(0.0750)	(0.0607)	(0.126)	(0.130)
Disabled	0.229**	0.0484	-0.229***	-0.178***	-0.000762	0.129
	(0.101)	(0.114)	(0.0608)	(0.0484)	(0.0943)	(0.108)
LowIncome	-0.115***	-0.123***	0.0365*	0.0330*	0.0785**	0.0904**
	(0.0350)	(0.0362)	(0.0208)	(0.0178)	(0.0350)	(0.0367)
TwoRaces	-0.252**	-0.211	0.113	0.0760	0.138	0.135
	(0.119)	(0.143)	(0.0780)	(0.0654)	(0.127)	(0.138)
White	0.123*	0.0926	0.0377	0.0348	-0.160**	-0.127
	(0.0718)	(0.0818)	(0.0430)	(0.0382)	(0.0710)	(0.0826)
PerPupil	3.35e-06	2.52e-06	1.23e-06	1.52e-06	-4.59e-06	-4.06e-06
	(2.79e-06)	(3.19e-06)	(1.67e-06)	(1.30e-06)	(3.07e-06)	(3.21e-06)
Constant	0.144	0.195*	0.269***	0.252***	0.587***	0.553***
	(0.0984)	(0.108)	(0.0619)	(0.0515)	(0.0998)	(0.103)
Observations	489	489	489	489	489	489
R-squared	0.133	0.144	0.086	0.076	0.081	0.124

Robust standard errors in parentheses

If the results suggest that, overall, growth rates respond significantly to dispensary opening, but Math scores do not, we presume that English scores must be driving the patterns in our findings. Table 5 details the effects of each variable on each growth level of English and Language Arts scores. Our diff-in-diff variable is significant at the 5% level when measuring changes in high growth and the 10% level when measuring changes in low growth. All else equal, the opening of a dispensary in the vicinity of a school is associated with a 4.13%-point decrease in the proportion of students achieving high growth and a 3.44%-point increase in the proportion of students with low growth.

The reasoning behind these trends is not concrete; it is possible that marijuana use among students in the treatment group increased, mirroring the findings in *van Ours and Williams 2007,* which produced effects like those found in *Cobb et al. 2015.* Parent behavior may also be affecting our results; it is possible that marijuana use among parents increases in the treated group, generating secondary effects on their children either via more permissive attitudes towards drugs, less time spent together, etc. However, without student survey data, we can only postulate that these secondary effects are occurring and instigating the effect of the diff-in-diff variable. Again, the diff-in-diff variable generates insignificant effects on the typical growth response. Many of the remaining explanatory variables maintained the same sign as in the other two regressions, although only the Asian American and low-income variables maintained significance in estimating each response. The proportion of ELL students, while statistically insignificant, differs in its effect on the response compared to the previous regressions. Greater proportions of ELL students increase the proportion of high and low growth students, while decreasing the proportion of students with typical growth. Intuitively, it makes sense that ELL students may be more inclined to experience high relative growth; because said students are in the early stages of learning the English language, they are likely improving their skills at a more exponential rate than native speakers. Conversely, schools with differing exogenous characteristics, such as lower quality teachers, would see higher levels of ELL students correspond to low growth because an ELL student's success is more dependent on their educational resources than a non-ELL student.

Table 6

	All Subject			Math			English		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	High	Typical	Low	High	Typical	Low	High	Typical	Low
treated	0.00237	0.000450	-0.00276	-0.0103	0.00787	0.00250	0.0210	0.00203	-0.0230
	(0.0201)	(0.00633)	(0.0183)	(0.0269)	(0.0101)	(0.0228)	(0.0210)	(0.00876)	(0.0211)
post	-0.00776	0.00539	0.00242	-0.0194	0.0102	0.00925	0.0109	0.00161	-0.0125
	(0.00741)	(0.00411)	(0.00768)	(0.0142)	(0.00741)	(0.0110)	(0.0102)	(0.00727)	(0.0101)
treated_post	-0.0280**	0.00460	0.0232**	-0.0147	0.00150	0.0130	-0.0335*	0.00219	0.0311*
	(0.0110)	(0.00590)	(0.0109)	(0.0210)	(0.0125)	(0.0179)	(0.0177)	(0.0104)	(0.0171)
Asian	0.376**	-0.0228	-0.353**	0.432*	-0.166	-0.266	0.334**	-0.0515	-0.282**
	(0.165)	(0.0540)	(0.147)	(0.243)	(0.101)	(0.188)	(0.142)	(0.0612)	(0.126)
Black	0.120	-0.0161	-0.104	-0.0526	0.0307	0.0226	0.0718	0.0668	-0.139
	(0.181)	(0.0484)	(0.181)	(0.262)	(0.0917)	(0.252)	(0.177)	(0.0607)	(0.185)
Hispanic	0.162	0.0236	-0.186	0.0957	-0.0184	-0.0774	0.0567	0.0401	-0.0968
	(0.135)	(0.0297)	(0.133)	(0.194)	(0.0579)	(0.152)	(0.0851)	(0.0335)	(0.0871)
Female	0.0670	0.0215	-0.0885	0.221*	-0.0240	-0.196*	0.106	0.0152	-0.121
	(0.0920)	(0.0361)	(0.0941)	(0.116)	(0.0565)	(0.110)	(0.0916)	(0.0556)	(0.0842)
ELL	-0.00434	0.0114	-0.00611	0.0423	0.114	-0.155	0.107	0.0306	-0.137
	(0.175)	(0.0516)	(0.169)	(0.248)	(0.0750)	(0.245)	(0.133)	(0.0769)	(0.137)
Disabled	-0.0289	-0.158***	0.186	0.0175	-0.0950	0.0778	0.229*	-0.229***	-0.000762
	(0.159)	(0.0416)	(0.146)	(0.172)	(0.0642)	(0.152)	(0.118)	(0.0538)	(0.111)
LowIncome	-0.119**	0.0142	0.105**	-0.0665	-0.0345	0.101**	-0.115**	0.0365	0.0785*
	(0.0471)	(0.0159)	(0.0431)	(0.0636)	(0.0321)	(0.0485)	(0.0449)	(0.0224)	(0.0420)
TwoRaces	-0.199	0.0612	0.138	-0.0349	0.0782	-0.0424	-0.252	0.113	0.138
	(0.240)	(0.0656)	(0.216)	(0.266)	(0.0910)	(0.222)	(0.158)	(0.0727)	(0.148)
White	0.156	0.0144	-0.169	0.203	-0.0261	-0.176	0.123	0.0377	-0.160*
	(0.131)	(0.0388)	(0.119)	(0.175)	(0.0664)	(0.134)	(0.101)	(0.0452)	(0.0935)
PerPupil	5.47e-06	1.28e-06	-6.75e-06	8.12e-06	-1.66e-06	-6.47e-06	3.35e-06	1.23e-06	-4.59e-06
	(5.39e-06)	(1.32e-06)	(6.06e-06)	(6.45e-06)	(2.05e-06)	(6.04e-06)	(4.31e-06)	(1.20e-06)	(4.51e-06)
Observations	979	979	979	490	490	490	489	489	489
R-squared	0.129	0.046	0.119	0.079	0.045	0.086	0.133	0.086	0.081

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Fixed Effects:

In addition to the weighted and unweighted models provided above, we constructed a weighted clustered model adjusting for intra-school standard error to measure the impact of our variables when accounting for school fixed effects. Table 6 details the coefficients corresponding to this model for each subject and level of our response. If the coefficients do not significantly deviate from the other models, we presumably are doing a good job accounting for differences across schools.

What we find is that the coefficients of the fixed effects model are identical to the coefficients found in our weighted model when our response includes all subjects. The coefficients of the fixed effects regressions modeling Math and English instead corresponded to their respective unweighted models. While the value of the coefficients does not change, the significance of said values are slightly adjusted. In the regression modeling the response of all subjects, our coefficients gain significance when controlling for school effects; our diff-in-diff variable is now significant at the 5% level rather than the 10% level when measuring proportions of high and low growth. The t-value of our diff-in-diff coefficient corresponding to Math scores, although still insignificant, rises slightly in the fixed effects model compared to the unweighted model; however, its value is less significant than in the full weighted model. Likewise, the diff-in-diff variable in the English model is only significant at the 10% level in the fixed effects model. In the new model, the dispensary opening corresponds to a 3.35 point reduction in the proportion of high growth students and a 3.11 point increase in the proportion of low growth students.

Adding fixed effects to our model does not significantly impact our findings. It does suggest that the coefficients of the unweighted subject models may be more reliable than those in the weighted models, resulting in slightly less significant values for our diff-in-diff coefficients. However, our previous conclusions are largely unaltered; it still appears that the presence of a dispensary negatively affects a school's student growth rates via a significant drop in English scores. Likewise, the effect on all subjects is even more significant, serving to reinforce our findings regarding the negative spatial effects of recreational marijuana dispensaries.

Conclusion:

I hypothesized that a dispensary opening would likely produce a statistically insignificant negative impact on a school's SGPs. In addition, I postulated that the effect on Math score growth would be greater than the effect on English due to the negative effect on cognitive skills due to expanded marijuana accessibility. Overall, the impact of dispensary openings exceeded my expectations; schools located near a dispensary experienced a statistically significant 2.81 point reduction in their proportion of high growth students and a 2.32%-point increase in low-growth students, although it is worth noting that the effect on typical growth rates is not significant. Surprisingly, the combined subject results are driven by a large impact on English growth rather than Math; dispensaries reduced the proportion of high growth students by 4.13 percentage points and increased the proportion low growth students by 3.44 points, both statistically significant, compared to changes of 1.85 and 0.79 points for Math scores. When accounting for school fixed effects, a more accurate way of estimating the coefficients, I found similar effects on both subjects, with the proportion of high growth and low growth English students changing by -3.35 and 3.11 respectively. Not only do growth rates respond more strongly to the opening of a nearby dispensary, but the results also suggest that the effect is more pronounced. Typical growth rates do not vary greatly between the treated and control group, however, the movement between high and low growth is quite large, indicating that the afflicted students are much worse off because of the dispensary opening.

It is worth noting that the R squared value of all weighted regressions is low; none can account for more than 15.2% of variation in growth percentile response. It is possible that, in the presence of exogenous variables, our diff-in-diff variable is insignificant. Our model fails to control for variation in the distance of a dispensary from a school in addition to school characteristics such as student to teacher ratios. Many more unobservable effects may be influencing the outcome of our response. Plausible unobservable school characteristics include variables such as teacher quality, student engagement, and student attitudes regarding standardized tests. 2014 marked the first year that Washington administered SBA's to elementary and middle school students; it is possible that students taking the exam the first and second time placed greater emphasis on their individual scores, then became more indifferent to their performance when they took the exam in 2016. This would generate a reduction in growth rates, although it does not explain the difference in response across disciplines. Students may also exhibit some fundamental differences from year to year; one group may be more committed to their educational outcomes than another, or the parents of said group may be involved in their child's education to a greater or lesser degree. Unaccounted for Neighborhood characteristics can also play a role in our response; for instance, higher crime rates would likely inhibit growth, while attitudes towards marijuana, in addition to the pervasiveness of substance abuse, could also be independently affecting growth rates.

Future studies should control for the above mentioned unaccounted for variables while simultaneously attempted to reconcile independent, unobservable effects. Nonetheless, our study finds significant correlation between test score growth and the presence of a dispensary near a school, validating the findings of related studies. Negative impacts on the educational achievement of younger students can lead to significantly negative future outcomes in terms of attainment of higher education and earnings. In enacting marijuana legislation, it is imperative that policymakers do not discount these effects, as the negative impact in terms of dollars on students may outweigh the tax revenue generated by the marijuana industry. Updating zoning laws to force dispensaries further away from schools could truncate the educational impact on students. Another possible solution could be diverting more marijuana tax revenue into schools; each regression found positive correlation between per pupil spending and high growth, indicating that at least some of the negative effects of dispensaries could be offset by increasing spending. As more states move to legalize recreational cannabis, Congress voted to decriminalize marijuana use earlier this week, questions regarding the effect of said legislation of students will be of greater importance. Consequently, it is important that policymakers respond prudently to the challenges associated with the implementation of marijuana legislation.

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