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Examining the Role of Local Opioid Prescriptions in Predicting K-12 Educational Outcomes in California, Oregon, and Washington School Districts

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I. Introduction

Since the turn of the twenty-first century, the opioid prescription rate increased rapidly, resulting in what we now call the "opioid epidemic," with increased rates of addiction, overdose deaths, and other externalities. In 1999, for example, there were nearly 3,500 deaths in the United States due to prescription opioid overdoses; by 2017 overdoses due to prescription opioids were over 17,000 (National Institute on Drug Abuse, 2020). A considerable amount of research has been done into many facets of the opioid epidemic; however, I was unable to find existing research that tied the opioid epidemic to children's educational outcomes. In this paper, the goal is to begin answering the question: what role does local opioid prevalence play in predicting K-12 educational outcomes?

Given the lack of published work on the impacts of the opioid epidemic on educational performance, this study takes inspiration from past research into crime, policing, community trauma, and peer effects as they relate to K-12 education. To estimate the role of opioid prevalence in predicting K-12 educational outcomes, this study relies on 2017 data on opioid prescriptions and school district characteristics in California, Oregon, and Washington. Using an Ordinary Least Squares approach, the models suggest that increases in opioid prescriptions per 100 people are correlated with reduced reading and math proficiency in school districts. In terms of reading proficiency, a 1 percent increase in opioid prescriptions per 100 people is associated with a 5.5 percent decrease to average district-wide reading proficiency. This was nearly doubled for math proficiency, where a 1 percent increase in opioid prescriptions per 100 people is associated with a 10.2 percent decrease to average district-wide math proficiency. Both models control for additional variables including the district's enrollment, the student-teacher ratio, the fraction of students in poverty, the fraction of students enrolled in special education, the fraction of students who are English language learners, and the state where they are located.

Ultimately, more research is needed on how the opioid epidemic had impacted K-12 outcomes. Given that this study is only able to suggest correlational relationships, it raises many more questions than it answers. Several aspects of the modeling process should also be addressed in future research – these are discussed in further detail within the body of this report.

II. Literature Review

In looking at the literature, there does not yet appear to be research into the impact of the opioid epidemic on K-12 students' academic success. For this literature review, research on student drug use, the impact of community violence and trauma on education, peer effects, and common themes among high school dropouts. These areas of study can loosely be tied to the approach and motivation for the remainder of this paper.

While this paper does not directly focus on student drug use, the literature in this area offers useful insights and references. For example, as is noted by Dr. Daniel Rees, there have been correlational relationships demonstrated between the use of illicit drugs and "poor educational outcomes, but no causal relationship has been demonstrated as of yet" (2019, p. 1). Dr. Rees attributes this to the fact that "illicit drug use by teenagers is generally unresponsive to policy, so credible natural experiments are rare" (p. 1). He also notes that alcohol and marijuana use seem to negatively impact academic performance among college students, but that the research on high school students is inconclusive at this point (p. 1). Another study set out to determine what student characteristics are correlated with opioid use by high school seniors. These researchers found that seniors who reported using prescription opioids were "significantly more likely to be male, White, and have lower grade point averages," as well, more likely to smoke cigarettes, drink alcohol, and use marijuana and other drugs (McCabe, Boyd, Teter, 2004, p. 225). A third study built on past work that had established a causal link between alcohol use and lower grades among university students. Dr. Wright and Dr. Krieg found that marijuana legalization in Washington led to lower grades among university students, especially in quantitative classes (2018, p. 607). While these researchers focused on student use of drugs and alcohol, the research presented in this paper looks at drug use within the community where K-12 students are going to school.

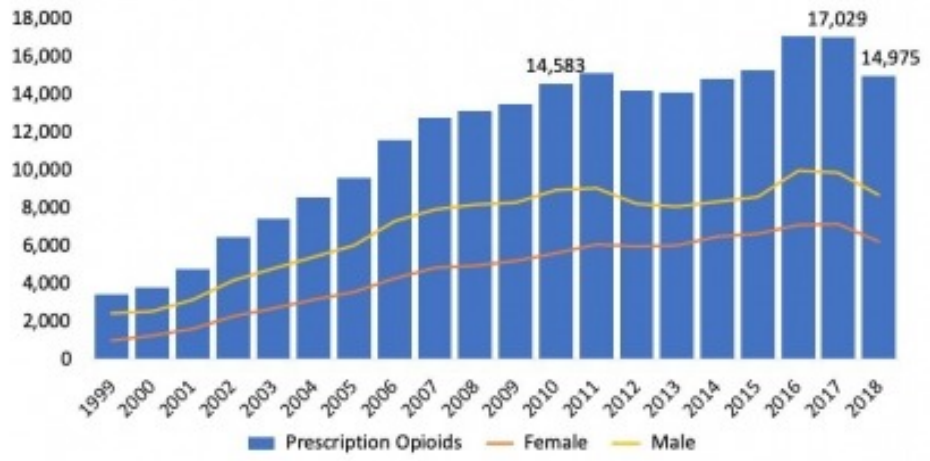
While not focused on opioid or other drug use, there is also a substantial body of literature into the impact of various community stressors or trauma and how they relate to academic performance by K-12 students. Researchers have found that everything from acts of police violence (Ang, 2020) and school shootings (Beland and Kim, 2016), to terrorist attacks (Gershenson and Tekin, 2018) and natural disasters (Gibbs et. al, 2019) can have persistent negative impacts on student performance and retention in the months and even years following the incident. In many cases, these decreases in performance were more pronounced in quantitative classes. Unlike the focuses of these studies, the opioid epidemic does not necessarily lend itself to an individual incident that can be studied to determine causal impacts.

At an individual and peer-level, research has also shown that violent, stressful, or traumatic events can play a role in reducing academic performance and increasing the likelihood of a student dropping out of high school. One study of Canadian high school students found that

students who had recently dropped out were far more likely to have experienced a recent stressor – family death, substantial financial change, assault, etc. – than a student who was demographically similar but remained enrolled (Dupéré et al, 2017). Yet traumatic events in one student's life have also been shown to have an impact on peers. In one study, researchers found that classrooms with a student who was experiencing domestic violence "significantly decrease the reading and math test scores of their peers and increase misbehavior in the classroom" (Carrell and Hoekstra, 2010, pp. 211). Similarly, a 2018 study found that students who were exposed to local neighborhood violence were likely to see reduced academic achievement, as were their peers (Burdick-Will). While these studies did not focus on the opioid epidemic, they suggest that students exposed to stress or trauma due to the epidemic may see similar outcomes to those studied under different stressful circumstances.

While many stressors can be associated with the opioid epidemic, two that may directly impact K-12 students are being placed in foster care and family death. Between 2012 and 2015, there was a nearly 8 percent increase in the number of children in foster care (Children's Bureau, 2016). During the same period, the percentage of children who were put into foster care due, in part, to parental substance use increased by 13 percent (Children's Bureau). In terms of deaths due to prescription opioid overdose, between 2010 and 2017 there was a 21 percent increase (National Institute on Drug Abuse, 2020). Between 1999 and 2017, prescription overdose rates increased by nearly 400 percent (National Institute on Drug Abuse). Both being place in foster care and having a family member die due to an opioid overdose could be considered traumatic or stressful events, thus suggesting similar academic outcomes to those seen in past studies.

Figure 4. National Drug Overdose Deaths Involving Prescription Opioids, Number Among All Ages, 1999-2018



Source: Centers for Disease Control and Prevention, National Center for Health Statistics. Multiple Cause of Death 1999-2018 on CDC WONDER Online Database, released January, 2019

III. Data Description

For this research, I combined a variety of datasets. First, the Urban Institute's Education Data Explorer was used to gather school district data on district and student characteristics. This database, in turn, pulls data from the Common Core of Data, EDFacts, and Small Area Income and Poverty Estimates. Using county FIPS codes, the Urban Institute data was joined with the Centers for Disease Control and Prevention dataset on opioid prescribing rates. The sample being examined in this study is comprised of 1,202 school districts – all districts for which data was available – in California, Washington, and Oregon during 2017. See Table 1 for a description of the analytical sample.

The dependent variables in this study are reading/language arts and mathematics proficiency. As noted by the Urban Institute, this is measured on a 0-100 scale and reported as the "midpoint of the range used to report the share of students scoring proficient on [an] assessment." In other words, a value of 47 would indicate that 47 percent of students were deemed "proficient" in a given subject.

In this sample, the average math proficiency is 39.18. There was significant variation between school districts, however, with proficiency ranging from 2.50 to 90.00. Reading proficiency, on the other hand, was generally higher – a mean proficiency of 50.65. Again, these values varied widely from a sample low of 12.00 to a high of 91.00.

To measure the prevalence of opioids within communities, a variable for opioid prescriptions per 100 people is used. This data is limited to the county level, so all school districts within a county are assigned the same opioid value. Because of this limitation, there are two reasons for concern. It can reasonably be assumed that opioid use can vary significantly within a county and that these smaller regional differences could have a greater impact on how K-12 students are exposed to the opioid epidemic. This also exacerbates the issue of spatial autocorrelation (see Methods for more detail), because neighboring school districts are likely to be assigned the same opioid prescription rate for the purpose of this study. Among the analytical sample of school districts, there was a mean opioid prescription level of 56.14 per 100 people. This varied by county from a 2.80 to 133.80 per 100 people.

Poverty is measured as the percentage of those aged 5-17 who have a household income below the poverty line. On average, school districts in the sample had a poverty rate of 17 percent, with individual districts varying from 0 to 49 percent poverty rates among their students.

Data on the number of special education students and English language learners within a school district was divided by enrollment to create variables for the percentage of students in each category. The average school district had a student body that was comprised of 12.6 percent

special education students and 16.5 percent English language learners. Special education enrollment varied from 0.4 to 64.4 percent and English language learner enrollment varied from 0.2 to 78.6 percent.

The average enrollment across the sample of school districts is 6,379 students. Between school districts, however, there was a significant variation in enrollment – between 13 and 621,414 students.

To construct a student-teacher ratio, enrollment in each district was divided by the number of full-time equivalent teachers in the district. Within this sample, the mean ratio is 21.06 students per teacher. The lowest number of students per teacher in the sample is 4.33 and the highest is 60.30 students per teacher.

Lastly, dummy variables were created to indicate the state the school district is located in. California is the reference case, with approximately 71 percent of school districts located within the state. The variable for WA takes on the value 1 when a district is located in the state and 0 otherwise. The same process was used for the Oregon dummy variable. Approximately 18 percent of the sample's districts are in Washington and 11 percent are in Oregon.

Table 1: Descriptive Statistics

Variable	Mean	Standard Deviation	Minimum Value	Maximum Value	Number of Observations
Median math proficiency	39.18	16.51	2.50	90.00	1,202
Median reading proficiency	50.65	15.35	12.00	91.00	1,202
Opioid prescriptions per 100	56.14	22.65	2.80	133.80	1,202
Fraction in poverty	0.170	0.091	0.000	0.490	1,202
Fraction special education	0.126	0.039	0.004	0.644	1,202
Fraction English language learners	0.165	0.159	0.002	0.786	1,202
Enrollment	6,379	20,251.41	13	621,414	1,202
Student-teacher ratio	21.06	3.98	4.33	60.30	1,202
Fraction WA	0.182	0.386	0	1	1,202
Fraction OR	0.106	0.308	0	1	1,202

IV. Methods

In this study, the goal is to determine whether the prevalence of opioids within a community play a statistically significant role in predicting K-12 educational outcomes. Two outcome variables are used – reading and math proficiency – thus two models have been fitted. Both Model 1 (reading) and Model 2 (math) use Ordinary Least Squares (OLS) regression to estimate the correlation between a variety of district-level variables and educational outcomes. Note, the results of the models are not sufficient to indicate any causal impacts.

(1) $$ln(Reading_i) = \beta_0 + \beta_1 ln(Opioids_i) + \beta_2 Poverty_i + \beta_3 ln(SpecialEd_i) + \beta_4 ln(ELL_i) + \beta_5 ln(Enrollment_i) + \beta_6 ln(StudentTeacherRatio_i) + \beta_7 WA_i + \beta_8 OR_i + \varepsilon_i$$

(2) $$ln(Math_i) = \beta_0 + \beta_1 ln(Opioids_i) + \beta_2 Poverty_i + \beta_3 ln(SpecialEd_i) + \beta_4 ln(ELL_i) + \beta_5 ln(Enrollment_i) + \beta_6 ln(StudentTeacherRatio_i) + \beta_7 WA_i + \beta_8 OR_i + \varepsilon_i$$

To allow for a clearer interpretation of results and to make relationships between independent and dependent variables more linear, natural logarithms were used. This is especially useful when some variables are percentages. Before running the regression, the natural log of all variables – except poverty, WA, and OR due to some observations being 0 – was calculated. Coefficients on these variables can be interpreted as the estimated percent change in the dependent variable given a one-percent change in the associated independent variable – all else equal. Transforming some variables and not others results in individual coefficients being interpreted differently; however, it is not essential that all variables in a model be transformed.

Both models control for local opioid prevalence; the percent of students who are in poverty, enrolled in special education, or English language learners; school district enrollment; student-teacher ratios; and the state where the district is located. While these variables can all be hypothesized to play a role in predicting the educational proficiency of a district's students, there are likely other variables that could be included to better improve the models' accuracy in predicting educational outcomes. As such, it can be assumed that there is some level of omitted variable bias – over or understating the importance of the variables in the model – in the results of the models.

Additionally, the output of the models should be taken with some skepticism. As the saying goes, no man is an island – meaning that everything an individual does is impacted by, and impacts, others. The same is true of systems, school districts in this case, which are geographically close. This raises concerns that the models used in the analysis may be impacted by spatial autocorrelation. By applying more advanced analytical processes, it may be possible for further research into this topic to adjust for these similarities which occur due to geographic proximity.

V. Results

In examining the model output (see Table 2), the primary coefficient of interest for this study is that associated with opioid prescriptions per 100 people. For both reading and math proficiency, we see that there is a statistically significant relationship between opioids and educational outcomes. For reading proficiency, a one percent increase in opioid prescriptions per 100 people corresponds to an average decrease of 5.5 percent to reading proficiency, all else equal. For math proficiency, the relationship was nearly doubled – a 10.2 percent decrease in reading proficiency associated with a one percent increase in prescriptions per 100 people, all else equal. As mentioned previously, because opioid prescription data was reported at the county level and all districts within a county are assigned the same prescription rate, the output loses some accuracy because it does not account for within-county variation in prescription or use rates. Also, note that the model output does not demonstrate a causal relationship and that opioid prescriptions per 100 people may be a proxy for other factors that impact student success.

The model also reports coefficients for the fraction of the student body who are in special education. Based on this, a one percent increase in special education students is associated with a predicted reading proficiency that is 15 percent lower and math proficiency that is 24 percent lower than an otherwise similar school district. Assuming all students are administered the same test, the fact that this coefficient is negative can be seen as reflecting that students in special needs programs have lower reading and math proficiency than their peers who are not enrolled in a special needs program. The magnitude of the effect, however, is notably larger than many other district characteristics.

Looking at the fraction of a student body who are categorized as English language learners, the model output indicates that a one percent increase in ELL students is associated with a predicted district reading proficiency that is 6 percent lower and a predicted math proficiency that is 7 percent lower than an otherwise identical district.

In terms of district enrollment, a one percent increase in enrollment is associated with a 2 percent increase to both math and reading proficiency, all else equal. This may be related to school funding or access to resources, as smaller school districts are likely in rural areas.

Based on the output generated by the models, there is not a statistically significant link between a district's student-teacher ratio and its reading or math proficiency rates. That is not to say that, in the real world, the student-teacher ratio does not play a role; however, it may be the case that other variables in the model (the student poverty rate, for instance) may already capture some of the factors that may lead to a school having a higher or lower student-teacher ratio.

Unlike other variables, the percent of students in poverty was not transformed using a natural log due to some observations being 0; this leads to a slightly different interpretation of the model output. For a one *percentage point* increase in the student poverty rate, the model estimates a 1.9 percent decrease in district-wide reading proficiency and a 2.5 percent decrease in math proficiency, all else equal.

Lastly, consider the state where the school district is located. In Washington, the average school district is expected to have a reading proficiency score 11 percent higher and a math proficiency score 20 percent higher than an, otherwise similar, district in California. In Oregon, reading proficiency is predicted to be 8 percent higher than a comparable California district; however, there is no statistically significant difference in math proficiency. These results could potentially be explained by differences in testing, curricula, or omitted variable bias.

Table 2: Model Results

Variable	**(1) Effect on Log Reading Proficiency**	**(2) Effect on Log Math Proficiency**
Log opioid prescriptions per 100	-0.055220**	-0.102159***
	(0.019408)	(0.027958)
Fraction in poverty	-1.910933***	-2.532735***
	(0.088457)	(0.127422)
Log fraction special education	-0.153535***	-0.236772***
	(0.021238)	(0.030594)
Log fraction English language learners	-0.061617***	-0.067106***
	(0.006833)	(0.009843)
Log enrollment	0.022140***	0.019128**
	(0.005099)	(0.007345)
Log student-teacher ratio	-0.012876	-0.025737
	(0.043553)	(0.062738)
WA	0.114817***	0.200191***
	(0.020721)	(0.029849)
OR	0.077967**	0.045090
	(0.025939)	(0.037365)
Intercept	3.787583***	3.638222***
	(0.143140)	(0.206192)

Notes: Standard errors are reported in parentheses. Levels of significance are denoted with "*". Coefficients marked with * correspond to $p < .1$, ** are for $p < .05$, and *** denotes $p < .01$.

VI. Conclusion and Proposed Further Research

In the United States, the opioid epidemic has had far-reaching impacts across the country. Within the country, however, there is a great deal of variation in opioid use by state, county, and city. This study looks at whether local opioid prevalence plays a statistically significant role in predicting K-12 educational outcomes and finds that, in terms of reading and math proficiency, there does appear to be a correlation. Based on the models and data in this report, a 1 percent increase in opioid prescriptions per 100 people is correlated with a 5.5 percent decrease in predicted district-wide reading proficiency and a 10.2 percent decrease in predicted district-wide math proficiency, after controlling for a series of school district characteristics. While a causal relationship cannot be concluded, this research suggests that there is a relationship between the areas that have been hardest hit by the opioid epidemic and regions with lower math and reading proficiency among K-12 students.

Ultimately, the research in this paper may raise more questions than it answers. To expand on this study, a few possibilities can be explored. First, expanding the dataset. There is a great deal of variation in the opioid epidemic by state – as well as at a more local level – which suggests that looking at data for all 50 states may be useful when researching the opioid epidemic and K-12 education in the United States. In addition, expanding the dataset to cover multiple years may allow for future researchers to begin exploring causal links. Second, in terms of the data itself, researchers can consider additional independent variables and perhaps different dependent variables. The independent variable used as an indicator of the opioid epidemic can also be revisited (i.e. prescriptions, pills, or overdoses per capita) and will ideally be able to be broken down to geographies smaller than counties. Third, the model presented in this paper did not account for spatial autocorrelation; however, future research can improve upon this. Lastly, if researchers find that there is a causal relationship between the opioid epidemic and worsened educational outcomes, this can be added to the body of research on the ongoing economic and social impact of the opioid epidemic in terms of communities having a less or worse educated population.

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