

# Opioid Use Disorder Treatment and Mortality: Evidence from Variation in Services Offered

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## Abstract:

In this paper, I estimate the impact of substance abuse treatment facilities on the opioid related death rate and other outcomes that may be impacted by the opioid epidemic. Identifying variation comes from the opening and closing of treatment facilities at the county level. I exploit a new source of variation, variation across treatment facilities based on services offered and insurance type accepted. I find significant heterogeneity across treatment facilities. Treatment centers offering Medication Assisted Treatment and accepting Medicaid have a larger negative impact on the opioid related death rate than other treatment facilities.

## *1. Introduction*

In 2016, 2.1 million Americans struggled with opioid use disorder (National Center for Health Statistics, 2017). From 1999-2016, over 367,000 deaths have been attributed to opioid overdose according to the Wonder CDC database (ICD-10 Codes: T40.0, T40.1, T40.2, T40.3, T40.4 and T40.6, CDC, 2018). Important questions remain regarding the effectiveness of treatment for opioid use disorder and whether sufficient levels of treatment are accessible. Further, among the population with opioid use disorder seeking treatment, often patients themselves do not know what type of treatment to seek. In this study, I examine the impact that treatment facilities are having on the opioid related death rate within the counties they are located. I utilize variation in the location of substance abuse treatment facilities at the county level and variation in the services offered and insurance type accepted by those facilities to generate causal estimates of the impact of these services on opioid related mortality. I find significant heterogeneity across different types of treatment facilities with respect to the impact they're having on opioid related mortality. The opening of one additional substance abuse facility offering Medication Assisted Treatment and accepting Medicaid reduces the county level opioid death rate by about 0.75 to 1 percent while one additional substance abuse facility (of any type) reduces the county level opioid death rate by about 0.1 to 0.2 percent.

## *2. Literature Review*

Many studies have found improvements in patient outcomes following admission to substance use disorder (SUD) treatment (Darke et al., 1996; Stewart et al., 2002; Hossop et al., 2003; Lu and McGuire, 2002; Swensen, 2015). Darke et al. (1996) finds that heroin users who sought treatment or were active in treatment faced a substantially lower risk of overdose. Stewart et al. (2002) finds that admission to treatment led to reductions in non-fatal overdoses. Beyond

the individual health risks, SUD imposes costs on society through health care use, use of public services, crime and traffic accidents (Maclean and Saloner, 2018). From this perspective, treatment for SUD can reduce external costs. Bondurant et al. (2018) find that the opening of a treatment facility (at the county level) leads to a reduction in country level crime rates including homicide, aggravated assault, robbery, auto theft, and burglary. The opioid epidemic was estimated to cost the US economy \$504 billion (2.8 percent of GDP) in 2015 (The Council of Economic Advisers, 2017).

Swensen (2015) exploits county level variation in the number of substance abuse treatment facilities and finds that a 10% increase in the number of treatment facilities leads to a 2% decline in the drug related mortality rate. This study builds on Swensen (2015) by examining the relationship between treatment centers and opioid related mortality. Further, I exploit a new source of variation, that is, variation across different types of facilities. With respect to treatment for opioid use disorder, medication assisted treatment (MAT) is an important service that the American Society of Addiction Medicine (ASAM) recommends be offered in conjunction with behavioral therapies (Grogan et al., 2016). Three medications have been approved by the FDA to treat opioid use disorder: methadone, buprenorphine, and naltrexone. Methadone and buprenorphine, the most common opioid use disorder medications, both suppress the body's cravings to use opioids and treat opioid withdrawal. Different opioid use disorder medication may be appropriate for different patients given differences in detox requirements, class of medication and frequency of dosage (Jones et al., 2018).

While substance abuse treatment facilities are increasingly offering MAT services, a significant gap still remains. Jones et al. (2018) examine data from the National Survey of Substance Abuse Treatment Services (N-SSATS) and find that in 2016, only 4,950 of the 12,029

substance abuse facilities in the US report offering any MAT service. There may also be a mismatch between insurance type accepted by substance abuse treatment facilities and the coverage of patients. In 2016, 7,466 of the 12,029 substance abuse facilities in the US report accepting Medicaid (Jones et al., 2018). Among adult Medicaid beneficiaries, an estimated 12% have a SUD (Center for Medicaid and CHIP Services, 2015). Approximately one out of every five Americans is covered by Medicaid (Kaiser Family Foundation, 2018).

This potential mismatch between services offered and insurance type accepted may be particularly problematic given the importance of the location of substance abuse treatment facilities. In 2015, 89 percent of all patients in substance abuse treatment received treatment in an outpatient setting (SAMHSA, 2017). Treatment facilities may be facing capacity constraints. Rapp et al. (2006) survey patients with SUDs to identify potential barriers to receiving treatment. 20.2 percent of patients identified difficulty getting to and from treatment (Rapp et al., 2006). 34.3 percent of patients identified capacity constraints reporting they would have to be on a waiting list to receive treatment (Rapp et al., 2006). Given the importance of proximity to treatment from a patient perspective, this study examines the impact of access to treatment and what type of treatment is available at the county level.

### *2.1 SUD Treatment and Health Insurance*

Cost offers a significant barrier to treatment making insurance an important means of access to care. While treatment facilities have traditionally relied on public grants and subsidies for funding, public and private insurance revenue has increased in importance in recent years. (Bondurant et al., 2018). The Mental Health Parity and Addiction Equity Act of 2008 (MHPAEA) requires health insurance issuers provide parity of benefits with respect to mental health and substance use disorder benefits as would be provided for medical/surgical benefits

(Centers for Medicare and Medicaid Services, 2018b). Dave and Mikerjee (2011) leverage state differences in parity laws prior to the MHPAEA; they find that state level substance abuse parity legislation increased treatment admission, lowered the cost of treatment to the individual and reduced the probability that treatment visits were uninsured (Dave and Mikerjee, 2011).

The Affordable Care Act (ACA) bolstered the MHPAEA by requiring non-grandfathered health plans to cover ten essential health benefits which include mental health and substance use disorder treatment (Centers for Medicare and Medicaid Services, 2018a). In 2014, as the majority of provisions of the ACA were implemented, 20.2 million Americans struggled with a SUD (Center for Behavioral Health Statistics and Quality, 2015). The expansion of Medicaid extended health insurance coverage to millions of American including 1.6 million individuals with a SUD (Grogan et al., 2016). Private market expansions further extended coverage to individuals with SUDs. New evidence points to unintended consequences resulting from the ACA and MHPAEA. Increased access to treatment requires vacancies at treatment facilities; treatment facilities may be constrained by capacity to admit additional patients. Maclean and Saloner (2018) examine the Massachusetts health reform of 2006 which expanded health insurance access and benefits with respect to SUDs. They find that the reform had little effect on treatment quality or access to treatment (Maclean and Saloner, 2018).

More problematic may be the perverse incentives created by the ACA and MHPAEA. A scheme which has been called the “Florida Shuffle” involves treatment centers partnering up with brokers who find patients with substance use disorders and generous health insurance benefits. Treatment centers bill insurance issuers thousands of dollars per services like urine screening or counseling session (Seville et al., 2017). These fraudulent treatment centers rely heavily on online searches and advertising and do not offer legitimate services that patients

desperately need. These treatment centers have admitted many patients that subsequently died of overdose (Seville et al., 2017).

## *2.2 Efficacy of Methadone and Buprenorphine*

Methadone and buprenorphine (the most common forms of MAT) have been thoroughly studied in the medical literature. Mattick et al. (2009) review eleven studies that compared opioid users treated with methadone therapy to no opioid replacement therapy. Patients were found have improved outcomes across a number of different measures including patient retention and subsequent drug screens with methadone therapy (Mattick et al., 2009). Further, patients receiving methadone maintenance were found to have reduced criminal activity and mortality (though these results were not statistically significant), (Mattick et al., 2009). Mattick et al. (2014) review thirty one difference studies that test the efficacy of buprenorphine. A series of randomized clinical trials have shown buprenorphine to be more effective in terms of patient retention in treatment compared to placebo (Mattick et al., 2014). Gowing et al., (2017) review six studies comparing buprenorphine and methadone treatment and conclude that despite somewhat limited evidence: “Buprenorphine and methadone in tapered doses appear to have similar efficacy in managing opioid withdrawal”. Connock et al. (2007) find that using a flexible dosing strategy, methadone maintenance therapy led to marginally better health gains compared to buprenorphine maintenance therapy.

Increasingly, scientific evidence points to an increased probability of success for opioid users receiving MAT in addition to psychosocial treatment compared to no MAT. In a clinical trial for an extended release formulation of buprenorphine, after 24 weeks, about 40% of patients receiving the treatment were abstaining from other opioid use compared to only 5% of patients receiving the placebo (National Academies of Sciences, Engineering, and Medicine, 2018). The

Prescription Opioid Addiction Treatment Study (POATS) followed patients dependent on prescription opioids over 42 months. Throughout multiple follow ups over 42 months, patients receiving opioid agonist therapy were found to have better outcomes (Weiss et al., 2015).

Considering the social costs associated with opioid use disorder, we may also consider the cost effectiveness of MAT. Buprenorphine maintenance therapy costs about \$6,000 per year (Wen et al., 2017). Methadone maintenance therapy is similar in cost in an outpatient setting. Connock et al. (2007) review of the buprenorphine and methadone literature concludes that both buprenorphine maintenance therapy and methadone maintenance therapy are more cost effective compared to no MAT. By utilizing variation across treatment facilities, this study compares the impact of treatment facilities that offer MAT to those that do not offer MAT on outcomes related to the opioid epidemic and other county level labor market outcomes.

### *2.3 Access to Treatment and MAT*

Barriers to receiving treatment include capacity constraints, geographical constraints and insurance constraints noted above (Gryczynski et al., 2011; Andrews et al., 2013; Rosenblum et al., 2011; Sigmon, 2014). Jones et al. (2015) compare rates of opioid abuse to rates of treatment capacity and find a large shortcoming in combined buprenorphine and methadone treatment capacity. Access to buprenorphine and methadone is restricted due to the potential abuse of these medications. Specifically, the Drug Addiction Treatment Act of 2000 restricts the number of patients that certified physicians can treat with buprenorphine/naloxone to 30 patients in the first year following certification and 100 in subsequent years (Blum et al., 2016). These restrictions may be preventing patients with opioid use disorder from obtaining these medications, particularly in rural areas in which there are a limited number of prescribers (Blum et al., 2016). In part, due to these restrictions, access to MAT has not grown as quickly as the population of

Americans struggling with opioid use disorder. Access to MAT is more likely problematic in rural counties than in urban counties. Stein et al. (2015) found that there were 11.4 opioid treatment programs offering buprenorphine therapy in urban counties for every one such treatment program in rural counties.

A particular concern in this study is the potential endogeneity of services offered by treatment facilities. For this reason, I consider why treatment facilities may or may not offer MAT. Olsen (2015) offers possible explanations for the opposition to offering MAT among treatment facilities. Several addition specialists from the Providers' Clinical Support System for Medication Assisted Treatment (PCSS-MAT) identified three possibilities in the following quote from Olsen (2015):

1. Owners of “drug-free” or “abstinence-based” facilities often do not have clinical backgrounds so have personal or ideological perspectives on addiction and its care.
2. Treatment facilities may have financial incentives for restrictive clinical policies as relapse may result in re-admissions and additional revenue.
3. The historical context of the “drug-free” model does not adequately differentiate between different substance use disorders. It is a useful framework for treating addiction to alcohol where available medications have limited effectiveness, and is virtually the only model for treating and preventing relapse to stimulants and cannabis where no medications exist. It is not a justifiable primary framework for the treatment of opioid addiction anymore.

Beyond the restrictions affecting provision of MAT, these stigma and financial barriers may be contributing to a lack of patient access to MAT. Using an email survey of physicians, Huhn and Dunn (2017) identified key concerns that physicians had with prescribing buprenorphine including a lack of time for additional patients requiring MAT, a lack of belief in the use of agonist treatment and proper reimbursement for time and services offered.

Following Swensen (2015) and Bondurant et al. (2018), I will conduct a number of ancillary tests to consider the validity of the research design. Of particular concern is the endogeneity of the opening/closing of treatment facilities. Grants, subsidies and public/private



insurance funding for treatment is likely to increase as drug abuse becomes more problematic. As Bondurant et al., (2018) argue: “Assuming these sources of financing generally increase with drug abuse and related problems, analyses of the effect of treatment provision on drug-related outcomes may understate the actual effect of treatment.” (Bondurant et al., 2018)

### 3. Data

Data regarding the location, services offered and insurance type accepted by substance abuse treatment facilities comes from the Substance Abuse and Mental Health Services Administration (SAMHSA) National Survey of Substance Abuse Treatment Services (N-SSATS). The N-SSATS is a survey of treatment facilities and so is not a universal database of these facilities. The response rate varies from year to year but is generally high. For example, in 2010 the response rate was 91.4% and in 2013 the response rate was 94% (N-SSATS, 2018). N-SSATS data is aggregated to the county, year level. I consider the following count measures:

- 1) Facilities Providing Substance Abuse Services
- 2) Facilities Providing Substance Abuse Services Accepting Medicaid
- 3) Facilities Providing Some Medication Assisted Treatment
- 4) Facilities Providing Some Medication Assisted Treatment and Accepting Medicaid
- 5) Facilities Providing at Least Two Different Forms of Medication Assisted Treatment
- 6) Facilities Providing at Least Two Different Forms of Medication Assisted Treatment and Accepting Medicaid

Next, I merge the N-SSATS data with restricted use county level mortality data obtained from the National Association for Public Health Statistics and Information Systems (NAPHSIS). Opioid related deaths are identified using the *International Classification of Disease, Tenth Revision* (ICD-10) codes. All opioid deaths are classified as including ICD-10 codes: T40.0 (opium), T40.1 (heroin), T40.2 (other opioids), T40.3 (methadone), T40.4 (other synthetic narcotics) and T40.6 (other/unspecified narcotics). The opioid death rate is calculated by aggregating opioid deaths to the county, year level, then dividing by the county population

obtained from the National Center for Health Statistics (NCHS), Bridged-Race Population Estimate

Finally, I merge these data with a set of covariates. Demographic controls including age and race covariates come from the NCHS Bridged-Race Population Estimate. These demographics include the fraction of the county population that is: white, black, female, ages 0-15, ages 16-34 and ages 35-64 years old. Controls for economic conditions include data regarding the unemployment rate obtained from the Bureau of Labor Statistics Local Area Unemployment Statistics (LAUS). County level per capita income data come from the U.S. Bureau of Economic Analysis (BEA), regional data.

I consider additional outcomes to understand the broader impact of treatment facilities on the communities they serve. Substance Abuse and Mental Health Services Administration's Treatment Episode Data Set: Admissions (TEDS-A) contains records of admissions into treatment facilities. Unfortunately, the TEDS-A data does not contain county level identifiers. I merge the TEDS-A with the N-SSATS by aggregating both to the state year level. Following Maclean and Saloner (2017), I calculate the admissions rate per 100,000 by state year. The TEDS-A indicates whether methadone or buprenorphine was involved in the client's treatment plan. From 2010-2015, 7.8 percent of admissions involved either methadone or buprenorphine (SAMHSA, 2018). Further, the use of methadone or buprenorphine is relatively well reported and is only missing in 4.3% of admissions records between 2010-2015 (SAMHSA, 2018). While health insurance status is also collected, between 2010-2015 insurance status is either missing or unknown for 56.8% of admissions (SAMHSA, 2018). Further, I examine the local economic impact of treatment facilities using the county level labor force participation rate from the American Community Survey (ACS) Employment Status 1 year estimates.

#### 4. Identification Strategy

I closely follow the identification strategy of Swensen (2015) and Bondurant et al. (2018), which relies on plausibly exogenous variation coming from the opening or closing of a treatment facility. This relationship can be represented by the following equation:

$$Mortality_{c,t} = \alpha + \beta * Facility_{c,t-1} + X_{c,t} \gamma + \delta_C + \rho_T + \theta_{c,t} + \epsilon_{c,t} \quad (1)$$

$Facility_{c,t-1}$  is the number of treatment facilities in county  $c$  in year  $t-1$ .  $\delta_C$  is the county fixed effect and  $\rho_T$  is the year fixed effect.  $\theta_{c,t}$  represents the state by year fixed effect. Whereas Swensen (2015) considers the impact of any treatment facility, I exploit variation across treatment facilities and construct different measures of  $Facility_{c,t-1}$  to capture the number of treatment facilities offering some MAT, multiple forms of MAT and/or accepting Medicaid (as described in section 3). Further, while Swensen (2015) considers the drug induced mortality rate, I consider the opioid induced mortality rate.  $Mortality_{c,t}$  is the opioid related death rate per 100,000 in county  $c$  in year  $t$ . These estimates are weighted by county level population. Standard errors are clustered at the county level. I include demographic controls (fraction of country population that is: white, black, female, ages 0-15, ages 16-34 and ages 35-64 years old) and controls for economic conditions (unemployment rate and log per capita income).

To further examine the validity of my identification strategy, I estimate the following event study model:

$$Mortality_{c,t} = \alpha + \sum_{t=-5}^5 ES_{c,t} \beta + X_{c,t} \gamma + \delta_C + \rho_t + \theta_{c,t} + \epsilon_{c,t} \quad (2)$$

I define an event year as the year in which a substance abuse treatment facility opens in county  $c$ . I include a set of dummy variables within that country for each five years before and after the facility/facilities opening. Of course, some counties may experience multiple openings and/or closing throughout the sample period. I present event studies of two types. First, I estimate the impact of the opening of a treatment facility in counties in which no previous treatment facility of that type. Second, I estimate the impact of the opening of a treatment facility in counties which experience only a single opening throughout the sample period. I repeat these exercise of treatment facility closings.

## *5. Results*

In table 2, I examine the impact of substance abuse treatment facility offering MAT on opioid related death rate. The outcome variable, the opioid death rate at the county year level, is transformed using the inverse hyperbolic sine function (rather than the natural log) because of the non-negligible number of observations for which the outcome variable equals zero. For each type of facility, the opening of a treatment facility offering MAT services decreases the county level opioid related death rate. One additional substance abuse facility offering MAT reduces the county level opioid related death rate by about 0.25 to 0.75 percent (panel A). One additional substance abuse facility offering MAT represents a 10.6 percent increase compared to the existing mean capacity. One additional substance abuse facility offering MAT and accepting Medicaid reduces the county level opioid related death rate by about 0.75 to 1 percent (panel B) where one additional facility represents an 18 percent increase in the existing mean capacity. Comparing panels b and c, it appears that facilities offering some MAT and accepting Medicaid have a similar effect to facilities offering at least two forms of MAT and accepting Medicaid.

However, facilities offering MAT and accepting Medicaid have a larger negative impact on the opioid related death rate than any facility offering MAT.

In table 3, I compare the impact of any substance abuse treatment facilities and those accepting Medicaid on opioid related mortality. One additional substance abuse facility reduces the county opioid death rate by about 0.1 to 0.2 percent (panel B) where one additional facility represents about a 2.6 percent increase in the existing mean capacity. Facilities accepting Medicaid have a larger negative impact on the opioid related death rate (column 1) though the coefficient is no longer statistically significant with the inclusion of a full set of controls and fixed effects. One additional treatment facility accepting Medicaid represents about a 5.9 percent increase in the existing mean capacity

### *5.1 Treatment Episode Data Set: Admissions Analysis*

Next, I consider outcomes from the TEDS-A. In table 4a, I find that the opening/closing of substance abuse facilities accepting Medicaid have a larger impact on the county level admissions rate than any substance abuse treatment facility. I find that one additional facility accepting Medicaid leads to an increase of the state level treatment admissions rate per 100,000 by about 0.8. In table 4b, I restrict the TEDS-A sample to admissions in which methadone or buprenorphine was involved in the client's treatment plan (hereafter referred to as admission involving MAT). Facilities providing two or more forms of MAT and accepting Medicaid had the largest impact on the treatment involving MAT admissions rate. In table 11, I examine TEDS admission by the primary substance abuse problem restricting the sample to admissions related to opioid use disorder. In panels a-c, I find that facilities offering MAT and accepting Medicaid

and facilities offering two plus forms of MAT and accepting Medicaid had the largest impact on the county level opioid admissions rate.

## *5.2 Other Economic Outcomes*

Next, I consider the impact of treatment facilities on local economic outcomes. In these specifications, economic outcomes may be impacted through treatment for opioid use disorder or any other type of substance abuse treatment. In table 5, I consider the impact on the labor force participation rate using two different measures. The first measure of the labor force participation rate comes from the ACS Employment Status 1-Year Estimates. This data set does not include every county in the US. The second measure contains the majority of US counties. It was constructed by the author taking the county labor force as a count obtained from the BLS and dividing by the county level working age population from the NCHS. Using both measures, treatment facilities appear to have a positive economic impact on the communities they serve. Facilities offering MAT and accepting Medicaid led to the largest increases in the labor force participation rate. In table 6, I consider a number of measures of income from the ACS Income in the past 12 months 1-Year Estimates. While the effect size is small, treatment facilities appear to have a positive impact on median and mean county income.

## *5.3 Heterogeneity*

In table 7, I compare substance abuse treatment taking place in Florida to the rest of the U.S. In 5 of 6 specifications, the coefficient of interest is positive when the sample is restricted to counties within Florida and negative when considering all counties outside of Florida. These results may be indicative of the perverse incentives created by the ACA and MHPAEA. While these results do not provide an identification strategy to test for fraud in the treatment industry in

Florida, they are suggestive of such effects. There are accounts of such effects in the media on a case by case basis but no published research of broader scope to date (Seville et al., 2017).

In table 8, I explore the heterogeneity of these effects by gender. Each type of treatment facilities appears to have a similar effect on the male and female opioid related death rate. For both genders, the most effective type of treatment facility appears to be facilities offering some MAT and accepting Medicaid or those offering at least two forms of MAT and accepting Medicaid. One additional substance abuse facility offering MAT and accepting Medicaid reduces the county opioid death rate by about 0.65 to 1.2 percent for both genders. The population weighted mean male opioid related death rate is about twice that of the female opioid related death rate. In table 9, I explore the heterogeneity of these effects by race. When considering the white and black opioid related death rates, again, the most effective type of treatment facility appears to be facilities offering some MAT and accepting Medicaid or those offering at least two forms of MAT and accepting Medicaid. With respect to the Hispanic opioid related death rate, I find no significant result. The weighted mean white opioid related death rate is about twice that of the black death rate and the Hispanic death rate.

Finally, I explore the heterogeneity of these effects by county size. I split the data by county population, categorizing counties as urban, medium or rural. In table 10, it appears that reductions in opioid related deaths are driven by the opening of treatment facilities in urban counties. Treatment facility openings have a larger negative impact in rural counties though the coefficient of interest is no longer significant. This may be driven by a lack of identifying variation as there are fewer openings in rural counties throughout the sample period.

#### *5.4 Event Study Analysis*

In order to test the validity of the research design, I present event studies that examine the impact of a treatment facility opening on the opioid related death rate in each year before and after the opening. I examine county level outcomes each year before and after the opening of a treatment facility to determine the timing of the effects. The event study evidence supports the notion that the identifying variation used in this study is plausibly exogenous. First I consider different types of facilities with respect to MAT availability. Figure 5 shows the impact of any substance abuse treatment facility opening, within counties with no previous treatment facility, on the county level opioid related death rate. While there are no visible trends prior to opening, the opioid related death rate declines, most prominently 2-5 years after opening. Figure 6 offers similar evidence with respect to the opening of a treatment facility offering MAT within counties in which no such capacity existed previously. Comparing figures 6 and 7 reveals a larger negative impact with respect to the opening of a treatment facility offering two or more forms of MAT rather than any facility offering MAT. In figure 8, I use the same framework but consider facility closings instead. While the opening of any facility offering two or more forms of MAT leads to a visible decline in the opioid related death rate (figure 7), the closing of such a facility leads to a visible increase in the opioid related death rate (figure 8).

Next, I consider different types of facilities with respect to whether Medicaid is accepted or not. Figure 9 reveals a large visible decline in the opioid related death rate in years 0-5 following the opening of any substance abuse facility accepting Medicaid. Figures 9 and 10 offer similar evidence: figure 9 measures the impact of an opening in counties with no facility accepting Medicaid prior to the opening. Figure 10 measures the impact within counties that experienced a single opening. Figure 11 shows a visible increase in the opioid related death rate following the closure of a treatment facility that accepts Medicaid and offers MAT. A similar



effect appears following the closure of a treatment facility that accepts Medicaid and offers two plus forms of MAT (figure 12). Throughout the event studies, effect sizes appear insignificant and/or small in the years leading up to the opening/closing of a treatment facility across facility types. While the event studies do restrict the identifying variation (for example by examining the impact of opening/closing in counties with a single opening/closing), they offering evidence in support of the validity of the identification strategy used throughout this study.

### 5.5 Robustness

In table A2, it appears that my primary results are robust when estimating unweighted models and to different functional form. In panel A, I present unweighted OLS results. In panel B, I present unweighted Poisson results in which the outcome variable is a count (number of deaths per county per year) rather than a county level death rate. I test potential reverse causality of this relationship. I construct an indicator variable equal to one if a treatment facility has opened in county  $c$  in year  $t$  and equal to zero otherwise. I estimate the following linear probability model:

$$Opening_{c,t-1} = \alpha + \beta * Mortality_{c,t} + X_{c,t} \gamma + \delta_c + \rho_t + \theta_{c,t} + \epsilon_{c,t} \quad (3)$$

I include the same set of controls. Table A3 presents the results from the test of reverse causality. I present estimates from equation 2 with a one and a two year lag of the measure of treatment facility openings. I find no significant result from twelve total specifications. Overall, the county level opioid death rate was not found to be predictive of the opening of treatment facilities. Next, I examine the potential for changes in the composition of county level population in response to the opening and closing of treatment facilities. In table A4, I put county level demographics on

the left hand side and find that overall, the opening/closing of treatment facilities do not explain changes in county level demographics.

## *6. Conclusion*

In this study, I find that substance abuse treatment facilities have a statistically significant negative impact on the opioid related death rate within the county they are located. The results presented in the paper point to substantial heterogeneity of this impact when comparing different types of treatment facilities. I find that facilities offering MAT and accepting Medicaid have a larger negative impact on the opioid related death rate within county. Treatment facilities accepting Medicaid and offering MAT were also found to have a larger positive impact on treatment admissions rates and on the local economy. These results support the notion that MAT should be offered to patients seeking treatment for opioid use disorder and that the existing capacity for such treatment in the U.S. may not be sufficient.

## 7. References

American Community Survey. Employment Status 1-year estimates. 2005-2016

American Community Survey. Income in the past 12 months 1 Year Estimates. 2005-2016

Andrews, Christina M., Hee-Choon Shin, Jeanne C. Marsh, and Dingcai Cao. "Client and Program Characteristics Associated with Wait Time to Substance Abuse Treatment Entry." *The American Journal of Drug and Alcohol Abuse* 39, no. 1 (2013): 61-68.

Bureau of Labor Statistics, Local Area Unemployment Statistics. 2005-2016

Blum, Kenneth, Mark Gold, H. Westley Clark, Kristina Dushaj, and Rajendra D. Badgaiyan. "Should the United States Government Repeal Restrictions on Buprenorphine/Naloxone Treatment?" *Substance Use & Misuse* 51, no. 12 (2016): 1674-679.

Bondurant, Samuel R., Lindo, Jason M. and Swensen, Isaac D. (2018). "Substance abuse treatment centers and local crime". *Journal of Urban Economics*, 104, 124-133.

Center for Behavioral Health Statistics and Quality. 2015. Behavioral Health Trends: Results from the 2014 National Survey on Drug Use and Health, Center for Behavioral Health Statistics and Quality: Rockville, MD.

Centers for Disease Control and Prevention, National Center for Health Statistics. Multiple Cause of Death Files 1999-2016 on CDC WONDER Online Database. December, 2017.

Centers for Disease Control and Prevention, National Center for Health Statistics (NCHS), Bridged-Race Population Estimates, United States July 1st resident "population by state, county, age, sex, bridged-race, and Hispanic origin.

Centers for Medicare and Medicaid Services. "Information on Essential Health Benefits (EHB) Benchmark Plans". 2018

<https://www.cms.gov/ccio/resources/data-resources/ehb.html>

Centers for Medicare and Medicaid Services. "The Mental Health Parity and Addiction Equity Act (MHPAEA)". 2018

[https://www.cms.gov/ccio/programs-and-initiatives/other-insurance-protections/mhpaea\\_factsheet.html](https://www.cms.gov/ccio/programs-and-initiatives/other-insurance-protections/mhpaea_factsheet.html)

Center for Medicaid and CHIP Services. "New Medicaid Initiative Improves Access to Substance Use Disorder Treatment" by Vikki Wachino, CMS Deputy Administrator and Director for the Center for Medicaid and CHIP Services (2015) July 27

Connock, M, Juarez-Garcia, A, Jowett, S, Frew, E, Liu, Z, Taylor, R J, Fry-Smith, A, Day, E, Lintzeris, N, Roberts, T, Burls, A, and Taylor, R S. "Methadone and Buprenorphine for the

Management of Opioid Dependence: A Systematic Review and Economic Evaluation." *Health Technology Assessment (Winchester, England)* 11, no. 9 (2007): 1-171, iii-iv.

Dave, Dhaval, and Swati Mukerjee. "Mental Health Parity Legislation, Cost-sharing and Substance-abuse Treatment Admissions." *Health Economics* 20, no. 2 (2011): 161-183.

Department of Health and Human Services. Substance Abuse and Mental Health Services Administration. National Survey of Substance Abuse Treatment Services (N-SSATS) 2005-2016

Darke, Shane, Joanne Ross, and Wayne Hall. "Overdose among Heroin Users in Sydney, Australia: I. Prevalence and Correlates of Non-fatal Overdose." *Addiction* 91, no. 3 (1996): 405-11.

Gossop, Michael, John Marsden, Duncan Stewart, and Tara Kidd. "The National Treatment Outcome Research Study (NTORS): 4–5 year Follow-up Results." *Addiction* 98, no. 3 (2003): 291-303.

Gowing, Linda, Robert Ali, Jason M White, and Dalitso Mbewe. "Buprenorphine for Managing Opioid Withdrawal." *The Cochrane Database of Systematic Reviews* 2, no. 2 (2017): CD002025.

Grogan, Colleen M., Christina Andrews, Amanda Abraham, Keith Humphreys, C., Harold A. Pollack, Bikki Tran Smith and Peter D. Friedmann. "Treatment And Opioid Use Disorder Medications Survey Highlights Differences In Medicaid Coverage For Substance Use" *Health Affairs* 35, no.12 (2016):2289-2296

Gryczynski, Schwartz, Salkever, Mitchell, and Jaffe. "Patterns in Admission Delays to Outpatient Methadone Treatment in the United States." *Journal of Substance Abuse Treatment* 41, no. 4 (2011): 431-39.

Huhn, and Dunn. "Why Aren't Physicians Prescribing More Buprenorphine?" *Journal of Substance Abuse Treatment* 78, no. C (2017): 1-7.

Jones, Austin, Brian Honermann, Alana Sharp and Gregorio Millett. "Where Multiple Modes Of Medication-Assisted Treatment Are Available," *Health Affairs Blog*, January 9, 2018. DOI: 10.1377/hblog20180104.835958

Jones, Christopher M, Melinda Campopiano, Grant Baldwin, and Elinore Mccance-Katz. "National and State Treatment Need and Capacity for Opioid Agonist Medication-Assisted Treatment." *American Journal of Public Health* 105, no. 8 (2015): E55-63.

Kaiser Family Foundation. "10 Things to Know about Medicaid: Setting the Facts Straight" by Robin Rudowitz and Rachel Garfield . Mar 12, 2018

Lu, Mingshan, and Thomas G. McGuire. "The Productivity of Outpatient Treatment for Substance Abuse." *The Journal of Human Resources* 37, no. 2 (2002): 309-35

Mattick, Richard P, Courtney Breen, Jo Kimber, and Marina Davoli. "Methadone Maintenance Therapy versus No Opioid Replacement Therapy for Opioid Dependence." *The Cochrane Database of Systematic Reviews*, no. 3 (2009): CD002209.

Mattick, Richard P, Courtney Breen, Jo Kimber, and Marina Davoli. "Buprenorphine Maintenance versus Placebo or Methadone Maintenance for Opioid Dependence." *The Cochrane Database of Systematic Reviews* 2014, no. 2 (2014): CD002207.

Maclean, Johanna Catherine, and Brendan Saloner. "Substance Use Treatment Provider Behavior and Healthcare Reform: Evidence from Massachusetts." *Health Economics* 27, no. 1 (2018): 76-101.

Maclean, Johanna, and Brendan Saloner. "The Effect of Public Insurance Expansions on Substance Use Disorder Treatment: Evidence from the Affordable Care Act." *NBER Working Paper* No 23342, 2017

National Academies of Sciences, Engineering, and Medicine. 2018. Advancing Therapeutic Development for Pain and Opioid Use Disorders Through Public-Private Partnerships: Proceedings of a Workshop. Washington, DC: The National Academies Press. <https://doi.org/10.17226/25060>.

National Association for Public Health Statistics and Information Systems. Mortality - Multiple cause of death, states and all counties. 1999-2016

National Center for Health Statistics. 2016 National Survey on Drug Use and Health, 2 Mortality in the United States, 2016 NCHS Data Brief No. 293, December 2017, 3 CEA Report: The underestimated cost of the opioid crisis, 2017

Olsen , Yngvild. "Ask the PCSS-MAT Experts: Addressing Challenging Issues in Addiction Medicine: "Abstinence Based" Treatment Centers" *ASAM Magazine*. April 10, 2015. <https://www.asam.org/resources/publications/magazine/read/article/2015/04/10/abstinence-based-treatment-centers>

Rapp, Xu, Carr, Lane, Wang, and Carlson. "Treatment Barriers Identified by Substance Abusers Assessed at a Centralized Intake Unit." *Journal of Substance Abuse Treatment* 30, no. 3 (2006): 227-35.

Rosenblum, Andrew, Charles M. Cleland, Chunki Fong, Deborah J. Kayman, Barbara Tempalski, and Mark Parrino. "Distance Traveled and Cross-State Commuting to Opioid Treatment Programs in the United States." *Journal of Environmental and Public Health* 2011, no. 2011 (2011): 204-13.

Ruhm, Christopher J. 2016. "Drug poisoning deaths in the United States, 1999–2012: A statistical adjustment analysis" *Population Health Metrics*, 14(2)

Seville, Lisa Riordan, Anna R. Schecter and Hannah Rappleye. "Florida's Billion-Dollar Drug Treatment Industry Is Plagued by Overdoses, Fraud" NBC News. June 25, 2017

Sigmon, Stacey C. "Access to Treatment for Opioid Dependence in Rural America: Challenges and Future Directions." *JAMA Psychiatry* 71, no. 4 (2014): 359-60.

Stein, Bradley D., Rosalie Liccardo Pacula, Adam J. Gordon, Rachel M. Burns, Douglas L. Leslie, Mark J. Sorbero, Sebastian Bauhoff, Todd W. Mandell, and Andrew W. Dick. "Where Is Buprenorphine Dispensed to Treat Opioid Use Disorders? The Role of Private Offices, Opioid Treatment Programs, and Substance Abuse Treatment Facilities in Urban and Rural Counties." *Milbank Quarterly* 93, no. 3 (2015): 561-83.

Stewart, Gossop, and Marsden. "Reductions in Non-fatal Overdose after Drug Misuse Treatment: Results from the National Treatment Outcome Research Study (NTORS)." *Journal of Substance Abuse Treatment* 22, no. 1 (2002): 1-9.

Substance Abuse and Mental Health Services Administration "Medication-Assisted Treatment of Opioid Use Disorder" SMA16-4892PG. April 5, 2016

Substance Abuse and Mental Health Services Administration, *National Survey of Substance Abuse Treatment Services* (N-SSATS): 2015. Data on Substance Abuse Treatment Facilities. BHSIS Series S-88, HHS Publication No. (SMA) 17-5031, 2017.

Substance Abuse and Mental Health Services Administration, *National Survey of Substance Abuse. Treatment Services* (N-SSATS). 2005-2016

Substance Abuse and Mental Health Services Administration, Center for Behavioral Health Statistics and Quality, National Survey on Drug Use and Health (NSDUH), 2015.

Substance Abuse and Mental Health Services Administration, Treatment Episode Data Set: Admissions (TEDS-A). 2005-2015

Swensen, Isaac D. "Substance-abuse Treatment and Mortality." *Journal of Public Economics* 122 (2015): 13-30.

The Council of Economic Advisers. "The Underestimated Cost of the Opioid Crisis". November 2017

U.S. Bureau of Economic Analysis. Regional Data. Local Area Personal Income and Employment. CA1 Personal Income Summary: Personal Income, Population, Per Capita Personal Income. 2005-2016

Weiss, Potter, Griffin, Provost, Fitzmaurice, Mcdermott, Srisarajivakul, Dodd, Dreifuss, Mchugh, and Carroll. "Long-term Outcomes from the National Drug Abuse Treatment Clinical Trials Network Prescription Opioid Addiction Treatment Study." *Drug and Alcohol Dependence* 150 (2015): 112-19.

Wen, Hefei M., Jason F. Hockenberry, Tyrone G. Borders, and Benjamin Druss. "Impact of Medicaid Expansion on Medicaid-covered Utilization of Buprenorphine for Opioid Use Disorder Treatment." *Medical Care* 55, no. 4 (2017): 336-41.

## 8. Tables and Figures

Table 1: Summary Statistics

Variable	Mean	Std. Dev
Facilities Providing Substance Abuse Services	39.24	77.29
Substance Abuse Services Facilities Accepting Medicaid	16.96	27.58
Facilities Providing Some Medication Assisted Treatment	9.73	17.50
Facilities Providing Some Medication Assisted Treatment and Accepting Medicaid	5.80	10.86
Facilities Providing at Least Two Different Forms of Medication Assisted Treatment	6.19	12.46
Facilities Providing at Least Two Different Forms of Medication Assisted Treatment and Accepting Medicaid	1.81	4.24
All Opioids Death rate per 100k	7.49	7.29
Population Share Ages 0-15	0.21	0.03
Population Share Ages 16-35	0.26	0.04
Population Share Ages 35-64	0.39	0.03
Population Share Female	0.51	0.01
Population Share White	0.79	0.15
Population Share Black	0.13	0.14
Unemployment Rate	6.74	2.63
Log Per Capita Income	10.62	0.28
Labor Force Participation Rate (ACS Employment)	0.66	0.05
Labor Force Participation Rate (BLS)	0.63	0.06
Median Household Income	61,586	15,644
Median Non-Family Household Income	38,221	10,065
Mean Household Income	82,323	20,446
Mean Non-Family Household Income	52,275	13,419

*Notes:* Data - 2005-2016. Summary statistics are weighted by county population. Florida excluded from sample. Data sources: N-SSATS, NAPHSIS, NCHS, ACS, BLS, BEA



Table 2

## Estimated Effects of Treatment Facilities offering Medication Assisted Treatment on Opioid Mortality

	(1)	(2)	(3)	(4)
<i>Panel A</i>				
Facilities Providing	-0.00758***	-0.00340	-0.00266	-0.00263
Some MAT	(0.00125)	(0.00251)	(0.00256)	(0.00260)
<i>N</i>	33,798	33,769	33,769	33,197
<i>Panel B</i>				
Facilities Providing Some MAT	-0.00741**	-0.0100***	-0.00934***	-0.00934***
and Accepting Medicaid	(0.00325)	(0.00343)	(0.00328)	(0.00331)
<i>N</i>	33,798	33,769	33,769	33,197
<i>Panel C</i>				
Providing at least 2 Forms of	-0.00801*	-0.0107***	-0.00902**	-0.00903**
MAT and Accepting Medicaid	(0.00447)	(0.00366)	(0.00378)	(0.00386)
<i>N</i>	33,798	33,769	33,769	33,197
Mean Before Transformation	7.49	7.49	7.49	7.49
State by Year FE	No	Yes	Yes	Yes
Demographic Controls	No	No	Yes	Yes
Economic Conditions Controls	No	No	No	Yes

*Notes:* Dependent variable - Inverse Hyperbolic Sine transformation of opioid death rate per 100,000. Demographic controls include the fraction of the county population that are: white, black, female, ages 0-15, ages 16-34 and ages 35-64 years old. Economic conditions controls include the unemployment rate and the natural log of per capita income. Treatment facilities are a count variable: number in a county by year. Models include county FE and year FE. These estimates are weighted by country population. Standard errors in parenthesis are adjusted for clustering at the county level. \* p<0.10, \*\* p<0.05, \*\*\* p<0.01

Table 3

## Estimated Effect of Treatment Facilities on Opioid Mortality

	(1)	(2)	(3)	(4)
<i>Panel A</i>				
Substance Abuse Facilities	0.000411 (0.000979)	-0.00166** (0.000751)	-0.00156** (0.000767)	-0.00141* (0.000751)
<i>N</i>	33,798	33,769	33,769	33,197
Mean Before Transformation	7.49	7.49	7.49	7.49
<i>Panel B</i>				
Facilities Accepting Medicaid	-0.00397** (0.00196)	-0.00102 (0.00140)	-0.000749 (0.00142)	-0.000556 (0.00139)
<i>N</i>	33,798	33,769	33,769	33,197
Mean Before Transformation	7.49	7.49	7.49	7.49
County and Year FE	Yes	Yes	Yes	Yes
State by Year FE	No	Yes	Yes	Yes
Demographic Controls	No	No	Yes	Yes
Economic Conditions Controls	No	No	No	Yes

*Notes:* Dependent variable - Inverse Hyperbolic Sine transformation of opioid death rate per 100,000. Demographic controls include the fraction of the county population that are: white, black, female, ages 0-15, ages 16-34 and ages 35-64 years old. Economic conditions controls include the unemployment rate and the natural log of per capita income. Treatment facilities are a count variable: number in a county by year. Models include county FE and year FE. These estimates are weighted by country population. Standard errors in parenthesis are adjusted for clustering at the county level. \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Table 4a  
TEDs Admissions

	Substance Abuse Facilities	SA Facilities Accepting Medicaid
<i>Any Admissions</i>	0.250 (0.391)	0.799** (0.395)
<i>N</i>	498	498
<i>Mean</i>	615.14	615.14

Table 4b  
TEDs Admissions Involving MAT

	Facilities Providing Some MAT	Facilities Providing MAT and Accepting Medicaid	Facilities Providing Two or More Forms of MAT	Facilities Providing Two plus forms MAT and Accepting Medicaid
<i>Admissions Involving MAT</i>	0.0591 (0.0390)	0.0890 (0.0663)	0.163** (0.0760)	0.581*** (0.201)
<i>N</i>	413	413	413	413
<i>Mean</i>	45.33	45.33	45.33	45.33

*Notes:* Dependent variable - admissions rate per 100,000 at the state year level. Controls include the fraction of the state population that are: white, black, ages 0-15, ages 16-34 and ages 35-64 years old and the unemployment rate. Models include state FE and year FE. Treatment facilities are a count variable: number in a county by year. These estimates are weighted by state population. Standard errors in parenthesis are adjusted for clustering at the state level. \* p<0.10, \*\* p<0.05, \*\*\* p<0.01

Table 5  
Labor Force Participation Rate

	Substance Abuse Facilities	SA Facilities Accepting Medicaid	Facilities Providing Some MAT	Facilities Providing MAT and Accepting Medicaid	Facilities Providing Two or More Forms of MAT	Facilities Providing Two plus forms MAT and Accepting Medicaid
<i>Panel A: ACS</i>	0.00513* (0.0000262)	0.0177*** (0.0000564)	0.0409*** (0.0000620)	0.0819*** (0.000127)	0.0105*** (0.0000247)	0.0853*** (0.000203)
<i>N</i>	8,307	8,307	8,307	8,307	8,307	8,307
<i>Mean</i>	0.66	0.66	0.66	0.66	0.66	0.66
<i>Panel B: BLS and NCHS</i>	0.00195 (0.0000621)	0.0230* (0.000133)	0.0190 (0.000140)	0.0799*** (0.000255)	0.000889 (0.0000575)	0.0921*** (0.000327)
<i>N</i>	33,769	33,769	33,769	33,769	33,769	33,769
<i>Mean</i>	0.63	0.63	0.63	0.63	0.63	0.63

*Notes:* Dependent variable - labor force participation rate. Linear probability model coefficients scaled up by 100 for interpretation. Controls include the fraction of the county population that are: white, black and female. Models include county FE, year FE and state by year FE. Treatment facilities are a count variable: number in a county by year. These estimates are weighted by country population. Standard errors in parenthesis are adjusted for clustering at the county level. \* p<0.10, \*\* p<0.05, \*\*\* p<0.01

Table 6

## Inflation Adjusted Median and Mean Income

	Substance Abuse Facilities	SA Facilities Accepting Medicaid	Facilities Providing Some MAT	Facilities Providing MAT and Accepting Medicaid	Facilities Providing Two or More Forms of MAT	Facilities Providing Two plus forms MAT and Accepting Medicaid
<i>Panel A: Log Median Household Income</i>	0.0000202 (0.0000826)	0.0000219 (0.000166)	0.000104 (0.000303)	-0.000225 (0.000362)	0.000162* (0.0000876)	0.000595 (0.000447)
Mean	61,585	61,585	61,585	61,585	61,585	61,585
<i>Panel B: Log Median Non-Family Income</i>	0.000267** (0.000107)	0.000525** (0.000260)	0.000417 (0.000283)	0.000754 (0.000549)	0.000273** (0.000135)	0.000551 (0.000623)
Mean	38,220	38,220	38,220	38,220	38,220	38,220
<i>Panel C: Log Mean Household Income</i>	0.000122* (0.0000646)	0.000214* (0.000127)	-0.000166 (0.000238)	-0.000346 (0.000278)	-0.0000295 (0.0000604)	0.000174 (0.000438)
	82,321	82,321	82,321	82,321	82,321	82,321
<i>Panel D: Log Mean Non-Family Income</i>	0.000255*** (0.0000980)	0.000423* (0.000230)	0.0000453 (0.000218)	0.000204 (0.000374)	-0.0000600 (0.000113)	0.000207 (0.000701)
Mean	52,275	52,275	52,275	52,275	52,275	52,275
N	8,343	8,343	8,343	8,343	8,343	8,343

*Notes:* Dependent variable - log county level mean/median income. Controls include the fraction of the county population that are: log county population, white, black, female, ages 0-15, ages 16-34 and ages 35-64 years old and the unemployment rate. Models include county FE, year FE and state by year FE. Treatment facilities are a count variable: number in a county by year. These estimates are weighted by county population. Standard errors in parenthesis are adjusted for clustering at the county level. \* p<0.10, \*\* p<0.05, \*\*\* p<0.01

Table 7

Comparing Florida to the Rest of the U.S.

	Substance Abuse Facilities	SA Facilities Accepting Medicaid	Facilities Providing Some MAT	Facilities Providing MAT and Accepting Medicaid	Facilities Providing Two or More Forms of MAT	Facilities Providing Two plus forms MAT and Accepting Medicaid
<i>Panel A: Florida</i>	0.0163** (0.00783)	0.0265* (0.0155)	0.0290*** (0.00961)	0.0525 (0.0350)	0.0266*** (0.00739)	0.0959* (0.0507)
<i>N</i>	737	737	737	737	737	737
Mean Before Transformation	8.48	8.48	8.48	8.48	8.48	8.48
<i>Panel B: Rest of U.S.</i>	-0.00141* (0.000751)	-0.000556 (0.00139)	-0.00263 (0.00260)	-0.00934*** (0.00331)	-0.00126 (0.00110)	-0.00903** (0.00386)
<i>N</i>	33197	33197	33197	33197	33197	33197
Mean Before Transformation	7.49	7.49	7.49	7.49	7.49	7.49

*Notes:* Dependent variable - Inverse Hyperbolic Sine transformation of opioid death rate per 100,000. Controls include the fraction of the county population that are: white, black, female, ages 0-15, ages 16-34 and ages 35-64 years old, the unemployment rate and per capita income. Models include county FE and year FE. Panel B models also include state by year FE. Treatment facilities are a count variable: number in a county by year. These estimates are weighted by country population. Standard errors in parenthesis are adjusted for clustering at the county level. \* p<0.10, \*\* p<0.05, \*\*\* p<0.01

Table 8  
Heterogeneity by Gender

	Substance Abuse Facilities	SA Facilities Accepting Medicaid	Facilities Providing Some MAT	Facilities Providing MAT and Accepting Medicaid	Facilities Providing Two or More Forms of MAT	Facilities Providing Two plus forms MAT and Accepting Medicaid
<i>Panel A: Male</i>	-0.00144* (0.000766)	-0.000547 (0.00157)	-0.00410 (0.00283)	-0.0120*** (0.00368)	-0.00180 (0.00118)	-0.0110*** (0.00396)
<i>N</i>	33,197	33,197	33,197	33,197	33,197	33,197
Mean Before Transformation	10.01	10.01	10.01	10.01	10.01	10.01
<i>Panel B: Female</i>	-0.00133 (0.00110)	-0.00113 (0.00169)	-0.000892 (0.00275)	-0.00653* (0.00346)	-0.000678 (0.00132)	-0.00904** (0.00459)
<i>N</i>	33,197	33,197	33,197	33,197	33,197	33,197
Mean Before Transformation	5.09	5.09	5.09	5.09	5.09	5.09

*Notes:* Dependent variable - Inverse Hyperbolic Sine transformation of opioid death rate per 100,000. Controls include the fraction of the county population that are: white, black, female, ages 0-15, ages 16-34 and ages 35-64 years old, the unemployment rate and per capita income. Models include county FE, year FE and state by year FE. Treatment facilities are a count variable: number in a county by year. These estimates are weighted by country population. Standard errors in parenthesis are adjusted for clustering at the county level. \* p<0.10, \*\* p<0.05, \*\*\* p<0.01

Table 9  
Heterogeneity by Race

	Substance Abuse Facilities	SA Facilities Accepting Medicaid	Facilities Providing Some MAT	Facilities Providing MAT and Accepting Medicaid	Facilities Providing Two or More Forms of MAT	Facilities Providing Two plus forms MAT and Accepting Medicaid
<i>Panel A: White</i>	-0.00165** (0.000777)	-0.000570 (0.00148)	-0.00247 (0.00258)	-0.00829** (0.00343)	-0.00155 (0.00110)	-0.00851** (0.00384)
<i>N</i>	33,197	33,197	33,197	33,197	33,197	33,197
Mean Before Transformation	8.68	8.68	8.68	8.68	8.68	8.68
<i>Panel B: Black</i>	0.000125 (0.00175)	-0.00283 (0.00256)	-0.00368 (0.00346)	-0.0102** (0.00488)	0.000411 (0.00147)	-0.0108** (0.00535)
<i>N</i>	33,142	33,142	33,142	33,142	33,142	33,142
Mean Before Transformation	4.67	4.67	4.67	4.67	4.67	4.67
<i>Panel C: Hispanic</i>	-0.000647 (0.000870)	-0.00204 (0.00224)	0.000737 (0.00177)	-0.000473 (0.00363)	-0.0000248 (0.00123)	0.00148 (0.00378)
<i>N</i>	33,177	33,177	33,177	33,177	33,177	33,177
Mean Before Transformation	3.84	3.84	3.84	3.84	3.84	3.84

*Notes:* Dependent variable - Inverse Hyperbolic Sine transformation of opioid death rate per 100,000. Controls include the fraction of the county population that are: white, black, female, ages 0-15, ages 16-34 and ages 35-64 years old, the unemployment rate and per capita income. Models include county FE, year FE and state by year FE. Treatment facilities are a count variable: number in a county by year. These estimates are weighted by country population. Standard errors in parenthesis are adjusted for clustering at the county level. \* p<0.10, \*\* p<0.05, \*\*\* p<0.01



Table 10  
Heterogeneity by County Population

	Substance Abuse Facilities	SA Facilities Accepting Medicaid	Facilities Providing Some MAT	Facilities Providing MAT and Accepting Medicaid	Facilities Providing Two or More Forms of MAT	Facilities Providing Two plus forms MAT and Accepting Medicaid
<i>Panel A: Urban</i>	-0.00158*	-0.00168	-0.00128	-0.00682*	-0.00108	-0.00573
	(0.000857)	(0.00154)	(0.00290)	(0.00393)	(0.00115)	(0.00503)
<i>N</i>	2,493	2,493	2,493	2,493	2,493	2,493
Mean Before Transformation	7.88	7.88	7.88	7.88	7.88	7.88
<i>Panel B: Medium</i>	0.00595	0.00503	-0.00754	-0.0126	0.00674	0.00637
	(0.00699)	(0.00852)	(0.0110)	(0.0131)	(0.00799)	(0.0190)
<i>N</i>	7,432	7,432	7,432	7,432	7,432	7,432
Mean Before Transformation	7.3	7.3	7.3	7.3	7.3	7.3
<i>Panel C: Rural</i>	-0.00777	-0.0220	-0.0219	-0.0276	-0.0222	-0.0172
	(0.0167)	(0.0173)	(0.0295)	(0.0337)	(0.0320)	(0.0597)
<i>N</i>	23,162	23,162	23,162	23,162	23,162	23,162
Mean Before Transformation	6.14	6.14	6.14	6.14	6.14	6.14

*Notes:* Dependent variable - Inverse Hyperbolic Sine transformation of opioid death rate per 100,000. Urban counties defined as counties with mean population greater than or equal to 250,000. Rural counties defined as counties with mean population less than or equal to 50,000. Controls include the fraction of the county population that are: white, black, female, ages 0-15, ages 16-34 and ages 35-64 years old, the unemployment rate and per capita income. Models include county FE, year FE and state by year FE. Treatment facilities are a count variable: number in a county by year. These estimates are weighted by country population. Standard errors in parenthesis are adjusted for clustering at the county level. \* p<0.10, \*\* p<0.05, \*\*\* p<0.01

Table 11

## Opioid Use Treatment Admissions Rate

	Substance Abuse Facilities	SA Facilities Accepting Medicaid	Facilities Providing Some MAT	Facilities Providing MAT and Accepting Medicaid	Facilities Providing Two or More Forms of MAT	Facilities Providing Two plus forms MAT and Accepting Medicaid
<i>Panel A: All Opiates</i>	-0.117 (0.108)	-0.0361 (0.150)	0.0750 (0.101)	0.192*** (0.0620)	0.218* (0.110)	0.486** (0.213)
<i>N</i>	498	498	498	498	498	498
<i>Mean</i>	144.91	144.91	144.91	144.91	144.91	144.91
<i>Panel B: Heroin</i>	-0.0900 (0.0925)	-0.0835 (0.102)	-0.00277 (0.0588)	0.00196 (0.0650)	0.129 (0.0957)	0.335* (0.167)
<i>N</i>	493	493	493	493	493	493
<i>Mean</i>	100.63	100.63	100.63	100.63	100.63	100.63
<i>Panel C: Other Opiates Excluding Methadone</i>	-0.0285 (0.0356)	0.0455 (0.0577)	0.0747 (0.0775)	0.182*** (0.0506)	0.0858 (0.0652)	0.144** (0.0604)
<i>N</i>	497	497	497	497	497	497
<i>Mean</i>	43.53	43.53	43.53	43.53	43.53	43.53

*Notes:* Dependent variable - treatment admission rate per 100,000 where primary substance abuse problem is opioid use. Controls include the fraction of the state population that are: white, black, ages 0-15, ages 16-34 and ages 35-64 years old and the unemployment rate. Models include state FE and year FE. Treatment facilities are a count variable: number in a state by year. These estimates are weighted by state population. Standard errors in parenthesis are adjusted for clustering at the state level. \* p<0.10, \*\* p<0.05, \*\*\* p<0.01

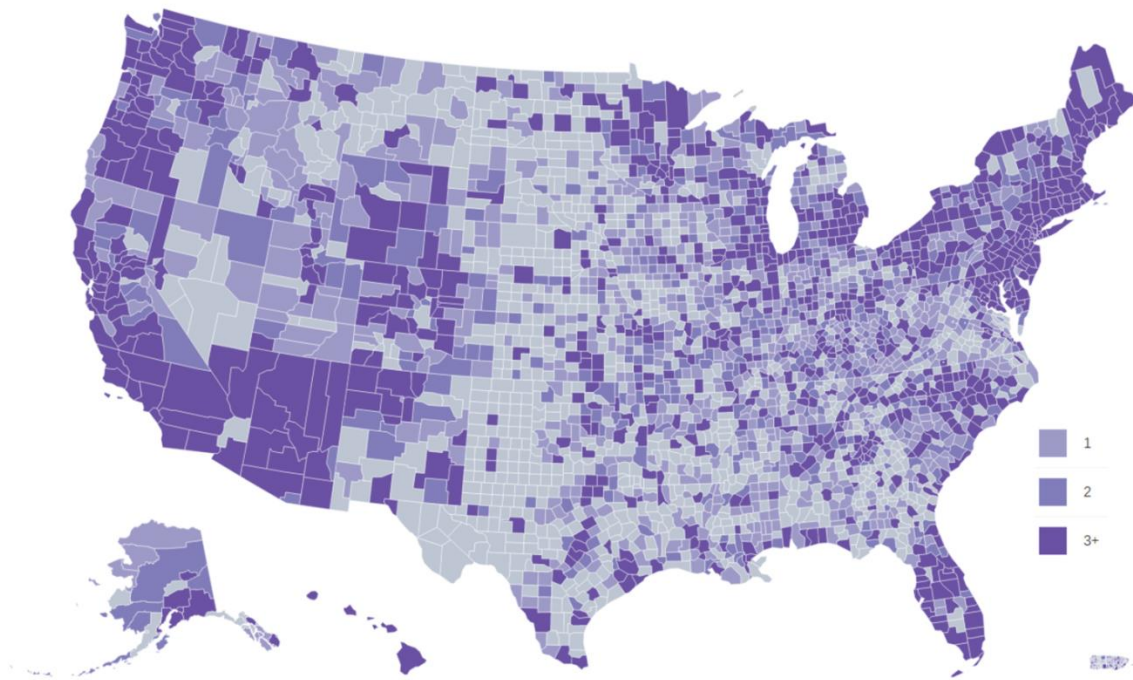
Table 12

Comparing Treatment Facilities to all others not of the Type

	Facilities of that Type	All other Facilities Not of that Type
<i>Panel A</i>		
Facilities Providing Some MAT and Accepting Medicaid	-0.00934*** (0.00331)	-0.000606 (0.00103)
<i>N</i>	33,197	33,197
<i>Panel B</i>		
Facilities Providing at least 2 Forms of MAT and Accepting Medicaid	-0.00903** (0.00386)	-0.000872 (0.000950)
<i>N</i>	33,197	33,197
Mean Before Transformation	7.49	7.49
State by Year FE	Yes	Yes
Demographic Controls	Yes	Yes
Economic Conditions Controls	Yes	Yes

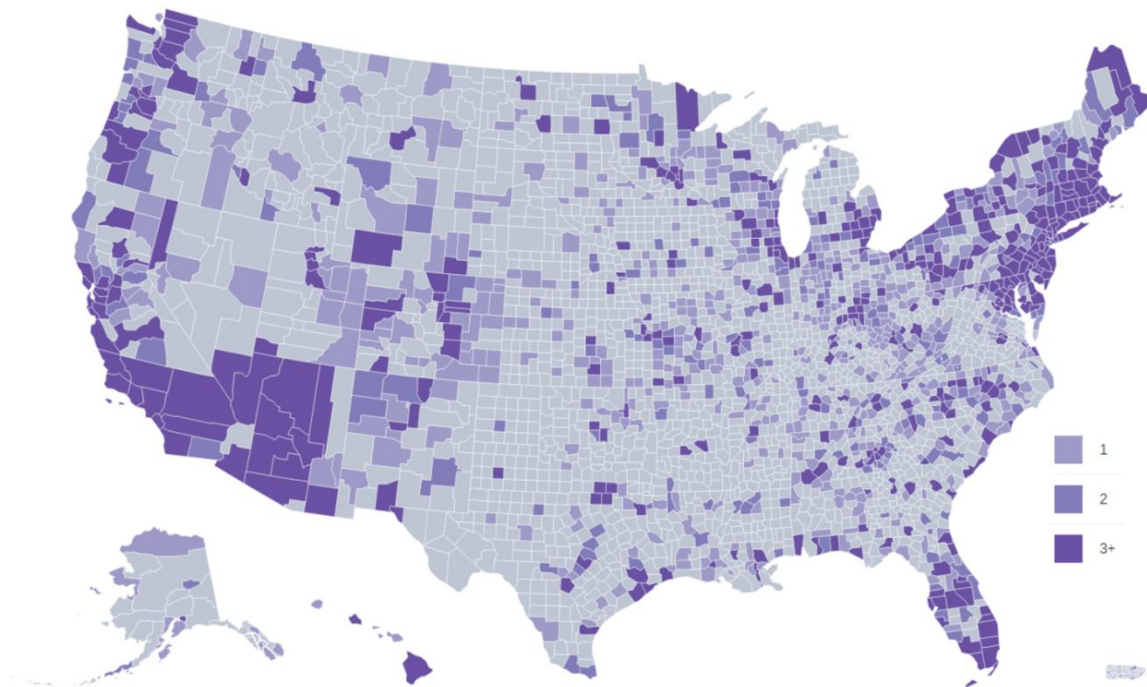
*Notes:* Dependent variable - Inverse Hyperbolic Sine transformation of opioid death rate per 100,000. Demographic controls include the fraction of the county population that are: white, black, female, ages 0-15, ages 16-34 and ages 35-64 years old. Economic conditions controls include the unemployment rate and the natural log of per capita income. Treatment facilities are a count variable: number in a county by year. Models include county FE and year FE. These estimates are weighted by county population. Standard errors in parenthesis are adjusted for clustering at the county level. \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Figure 1: All Substance Abuse Facilities, 2016



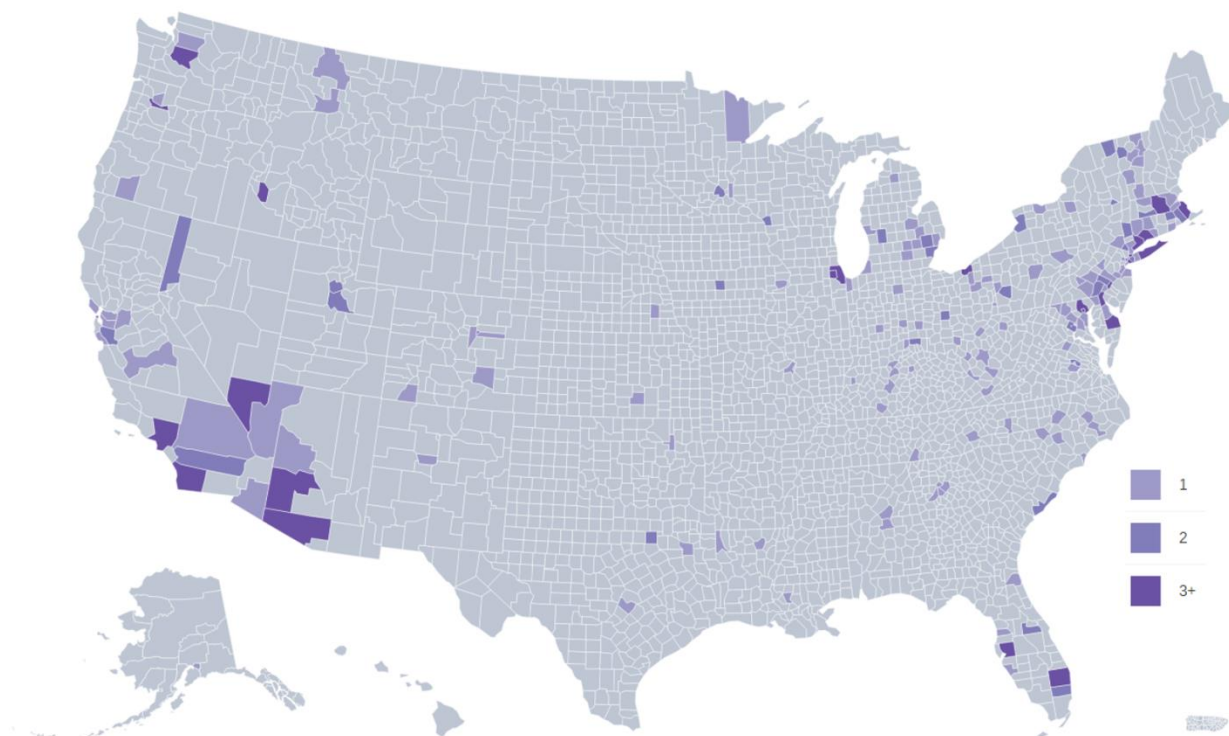
Source: Jones et al., 2018

Figure 2: Substance Abuse Facilities Offering MAT, 2016



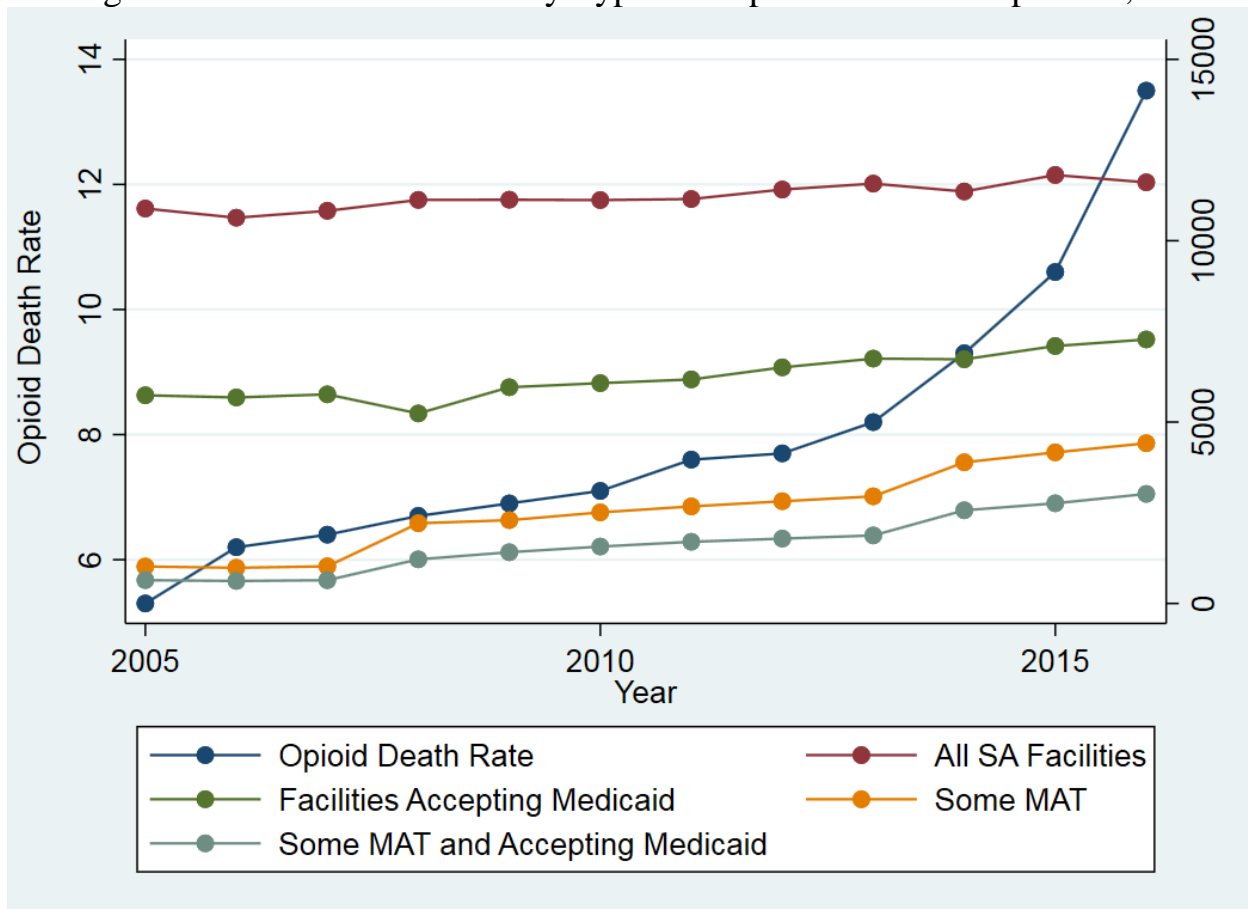
Source: Jones et al., 2018

Figure 3: Substance Abuse Facilities Offering All Three Forms of Medication-Assisted Treatment, 2016



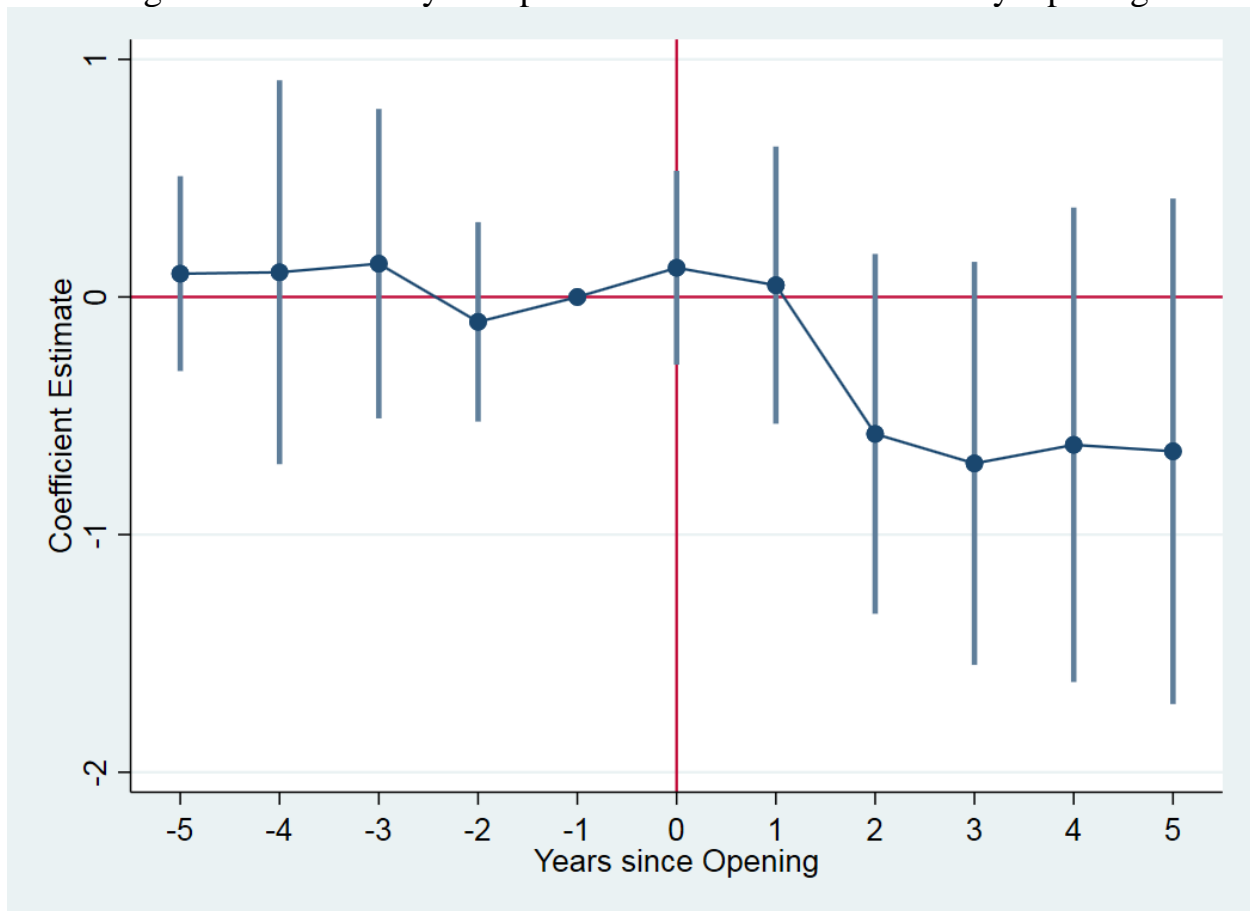
Source: Jones et al., 2018

Figure 4: Treatment Facilities by Type and Opioid Death Rate per 100,000



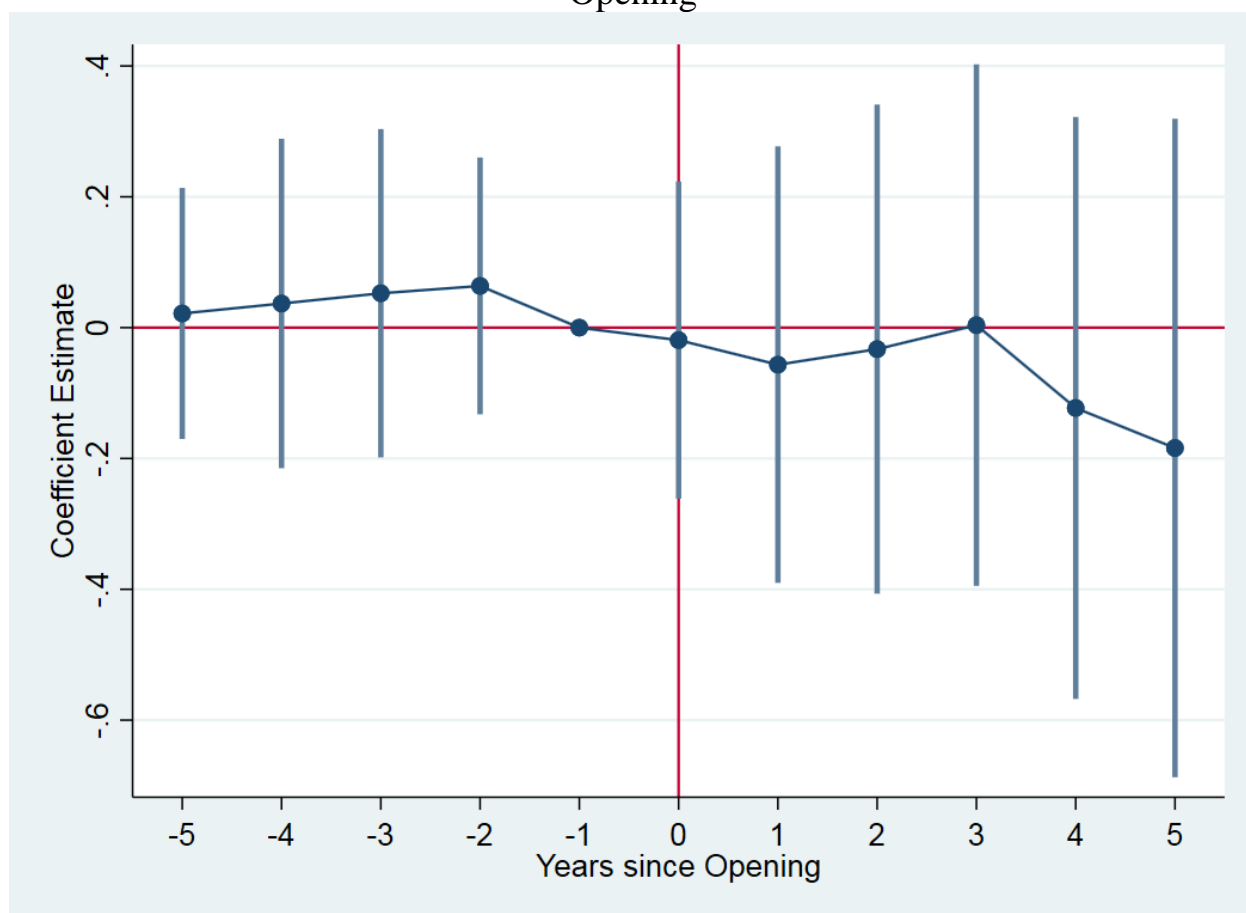
*Notes:* All SA Facilities refers to the any facility offering substance abuse treatment. Some MAT refers to the number of treatment facilities offering any of the three forms of medication assisted treatment: methadone, buprenorphine, and/or naltrexone. Opioid death rate on left vertical axis and number of treatment facilities on right vertical axis.

Figure 5: Event Study – Impact of Substance Abuse Facility Opening



*Notes:* Dependent variable – inverse hyperbolic sine transformation of opioid related death rate per 100,000. Event study of counties with no substance abuse treatment facility with one or more opening throughout 2005-2016. Controls include the fraction of the county population that are: white, black, female, ages 0-15, ages 16-34 and ages 35-64 years old, the unemployment rate and per capita income. Models include county FE and year FE.

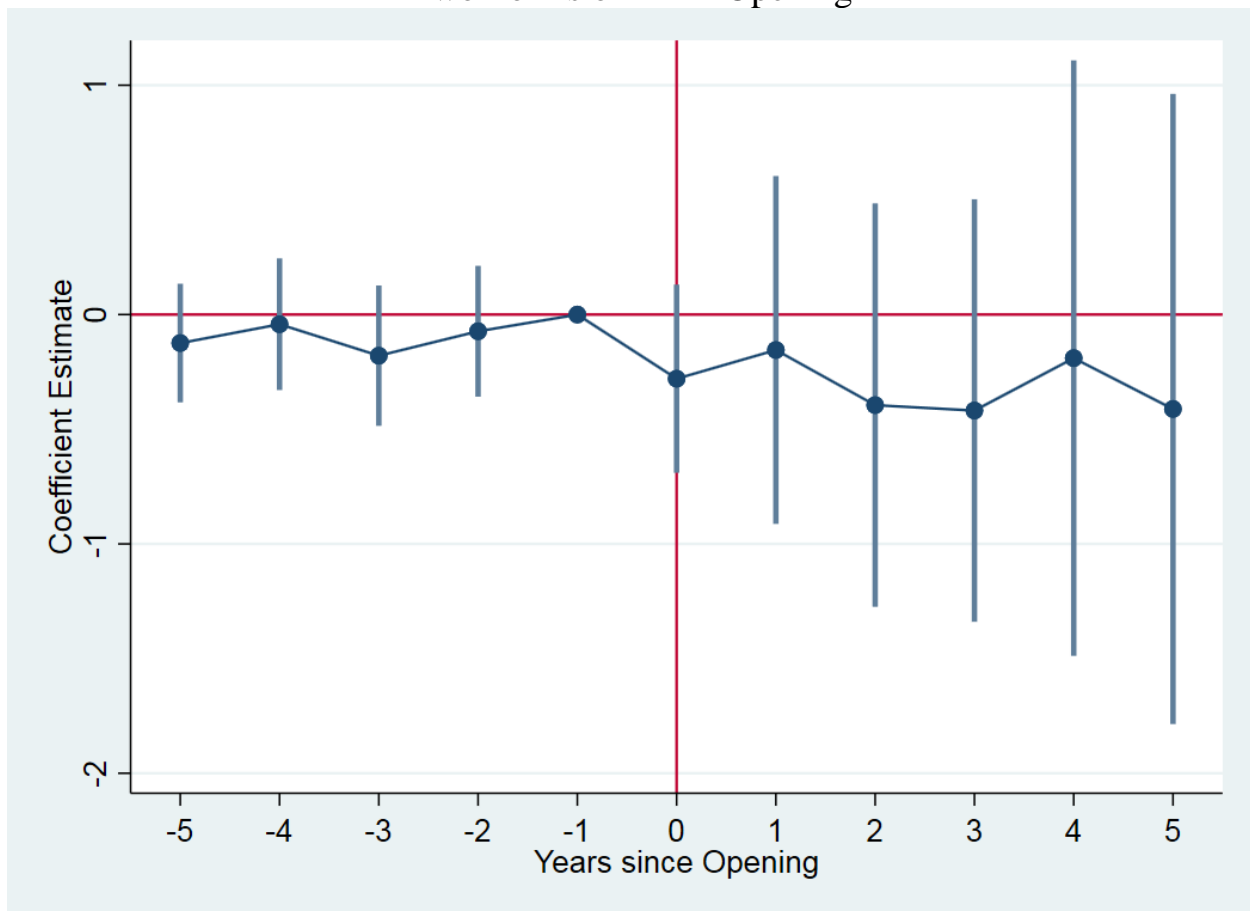
Figure 6: Event Study – Impact of Substance Abuse Facility Offering Some MAT Opening



*Notes:* Dependent variable – inverse hyperbolic sine transformation of opioid related death rate per 100,000. Event study of counties with no substance abuse treatment facility offering some MAT with one or more such opening throughout 2005-2016. Controls include the fraction of the county population that are: white, black, female, ages 0-15, ages 16-34 and ages 35-64 years old, the unemployment rate and per capita income. Models include county FE, year FE and state by year FE.

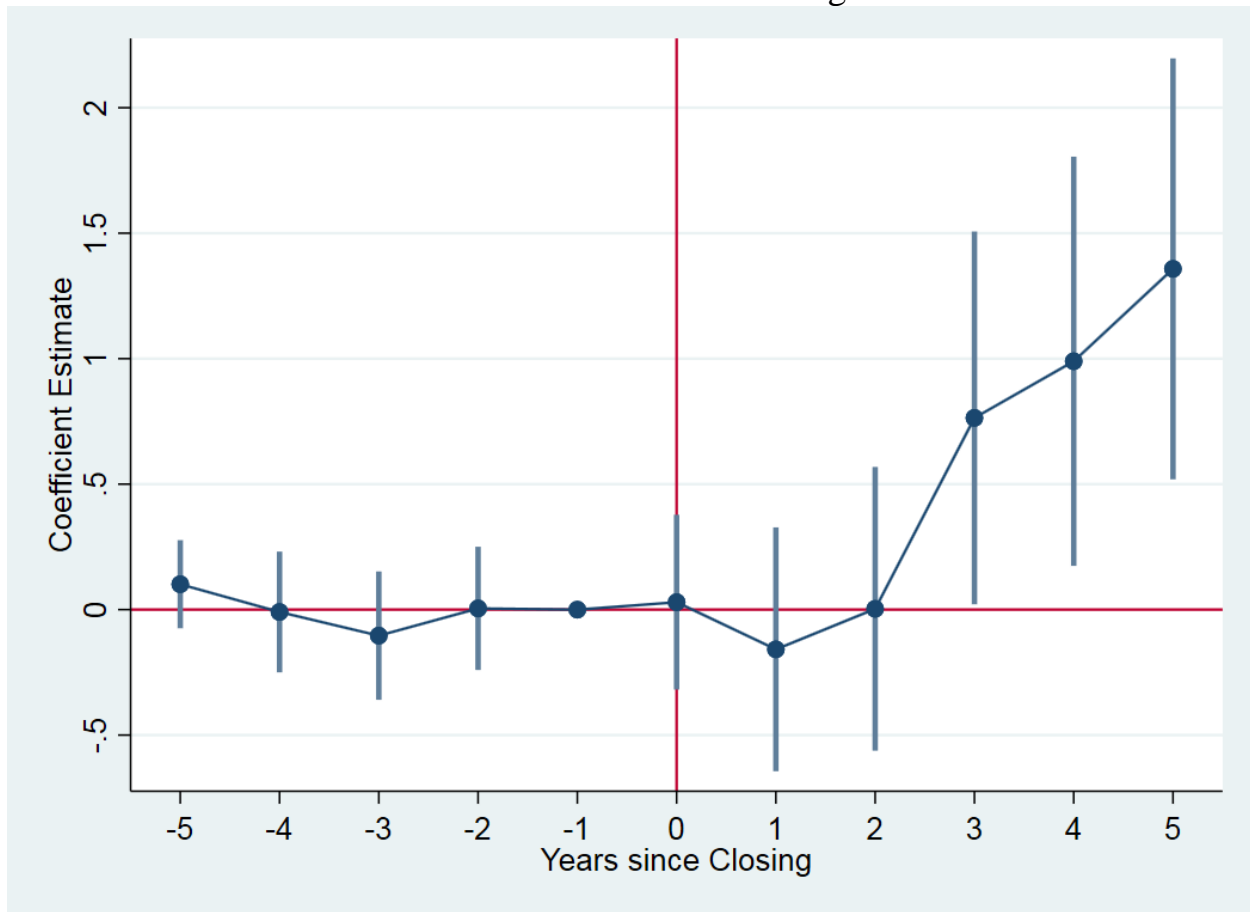


Figure 7: Event Study – Impact of Substance Abuse Facility Offering At Least Two Forms of MAT Opening



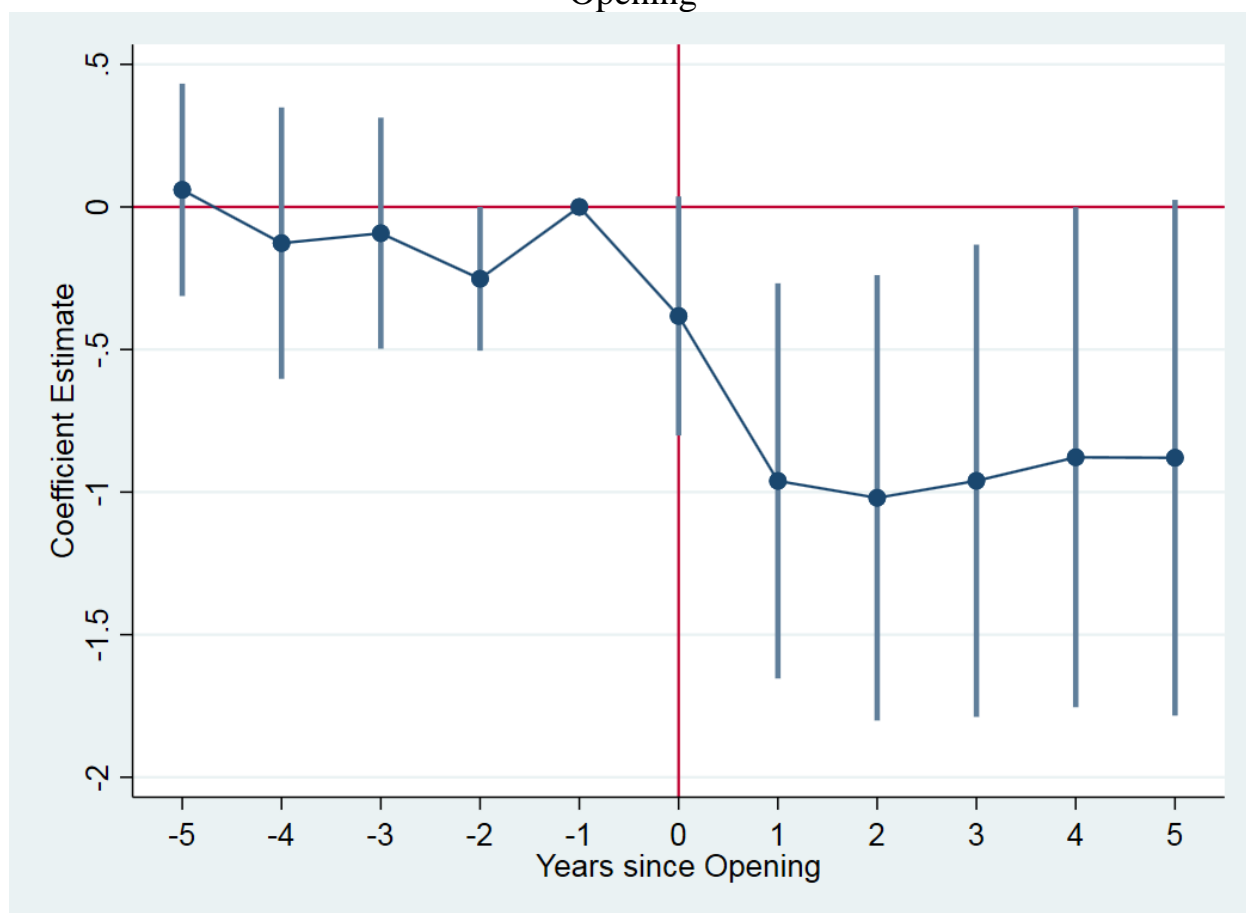
*Notes:* Dependent variable – inverse hyperbolic sine transformation of opioid related death rate per 100,000. Event study of counties with only one substance abuse treatment facility offering at least two forms of MAT opening throughout 2005-2016. Controls include the fraction of the county population that are: white, black, female, ages 0-15, ages 16-34 and ages 35-64 years old, the unemployment rate and per capita income. Models include county FE, year FE and state by year FE.

Figure 8: Event Study – Impact of Substance Abuse Facility Offering At Least Two Forms of MAT Closing



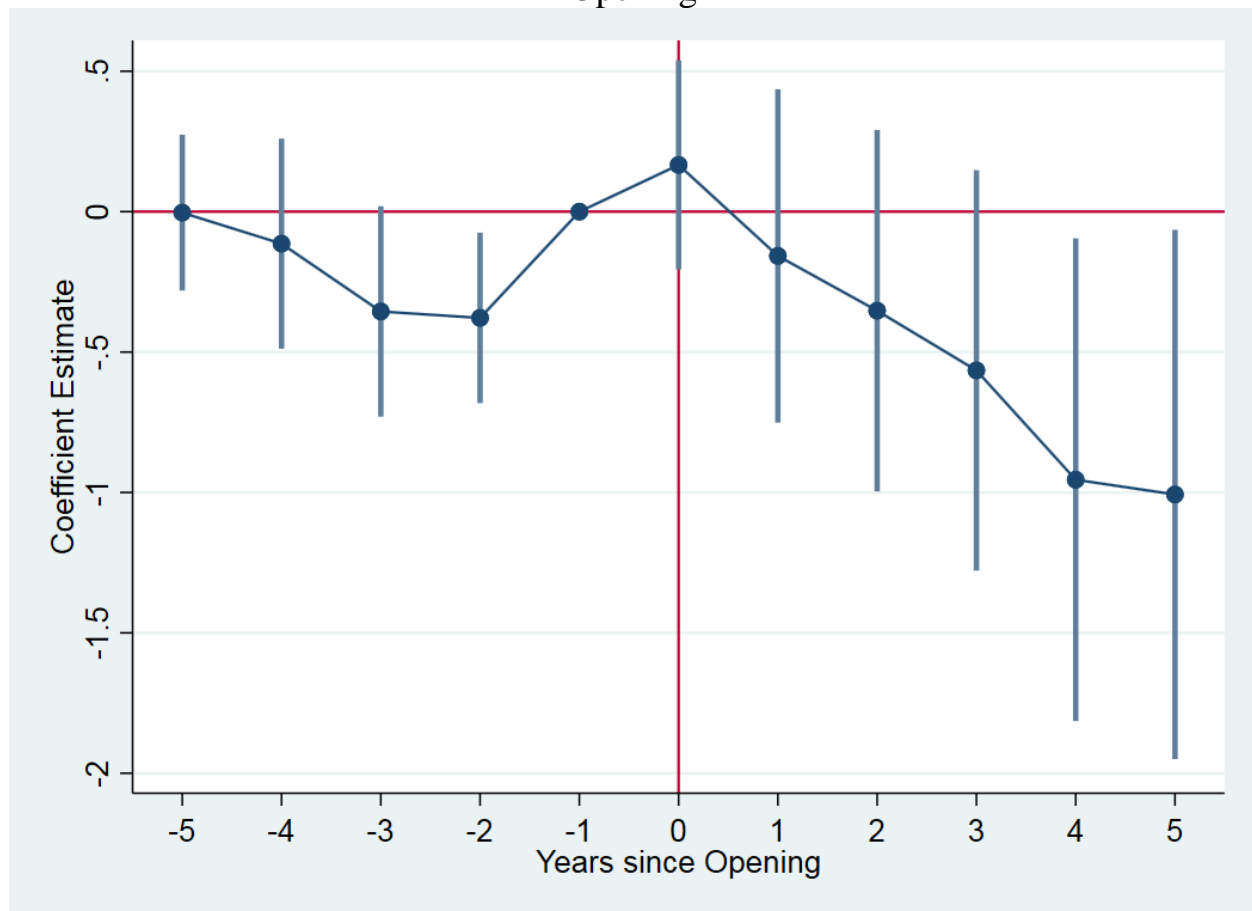
*Notes:* Dependent variable – inverse hyperbolic sine transformation of opioid related death rate per 100,000. Event study of counties with only one substance abuse treatment facility offering at least two forms of MAT closing throughout 2005-2016. Controls include the fraction of the county population that are: white, black, female, ages 0-15, ages 16-34 and ages 35-64 years old, the unemployment rate and per capita income. Models include county FE, year FE and state by year FE.

Figure 9: Event Study – Impact of Substance Abuse Facility Accepting Medicaid Opening



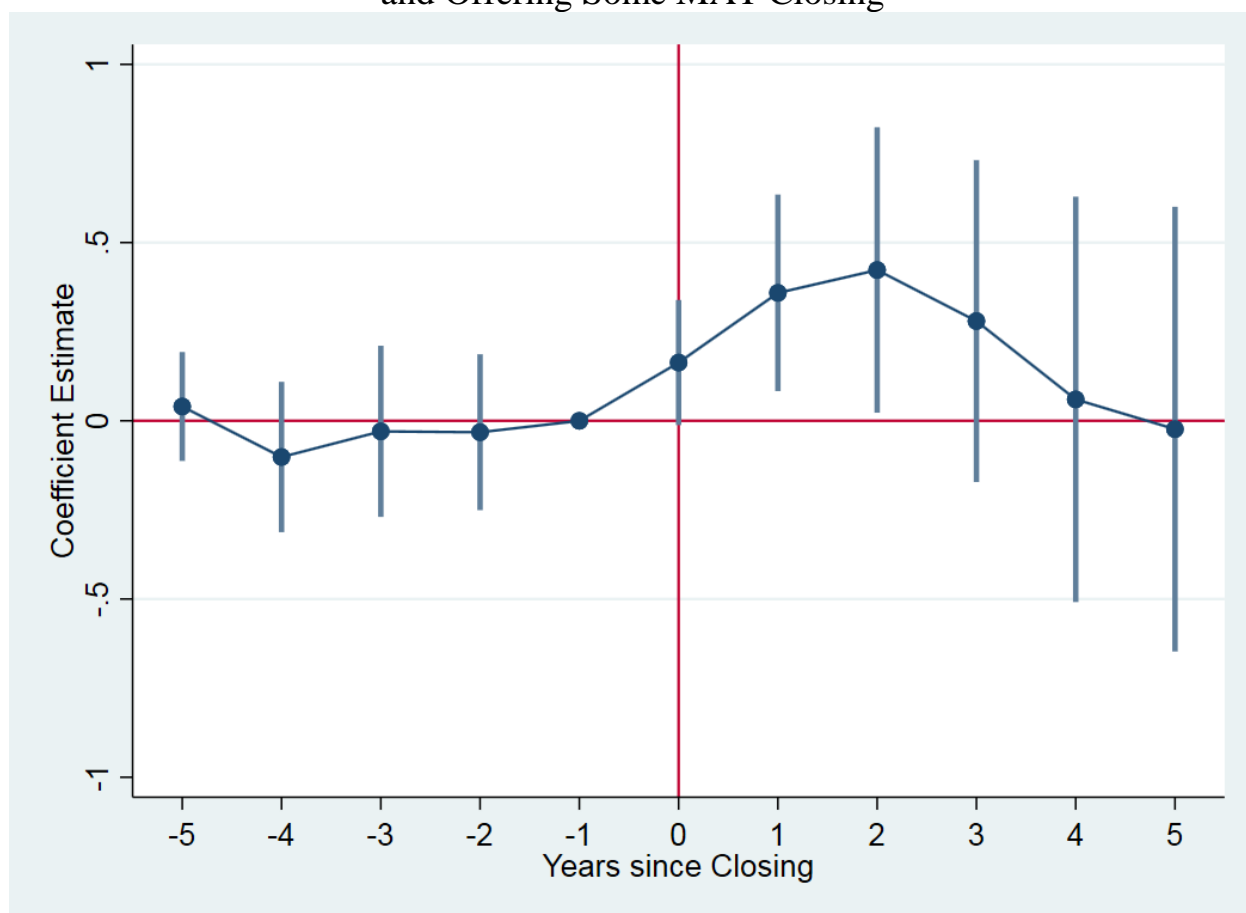
*Notes:* Dependent variable – inverse hyperbolic sine transformation of opioid related death rate per 100,000. Event study of counties with no substance abuse treatment facility accepting Medicaid with one or more such opening throughout 2005-2016. Controls include the fraction of the county population that are: white, black, female, ages 0-15, ages 16-34 and ages 35-64 years old, the unemployment rate and per capita income. Models include county FE, year FE and state by year FE.

Figure 10: Event Study – Impact of Substance Abuse Facility Accepting Medicaid Opening



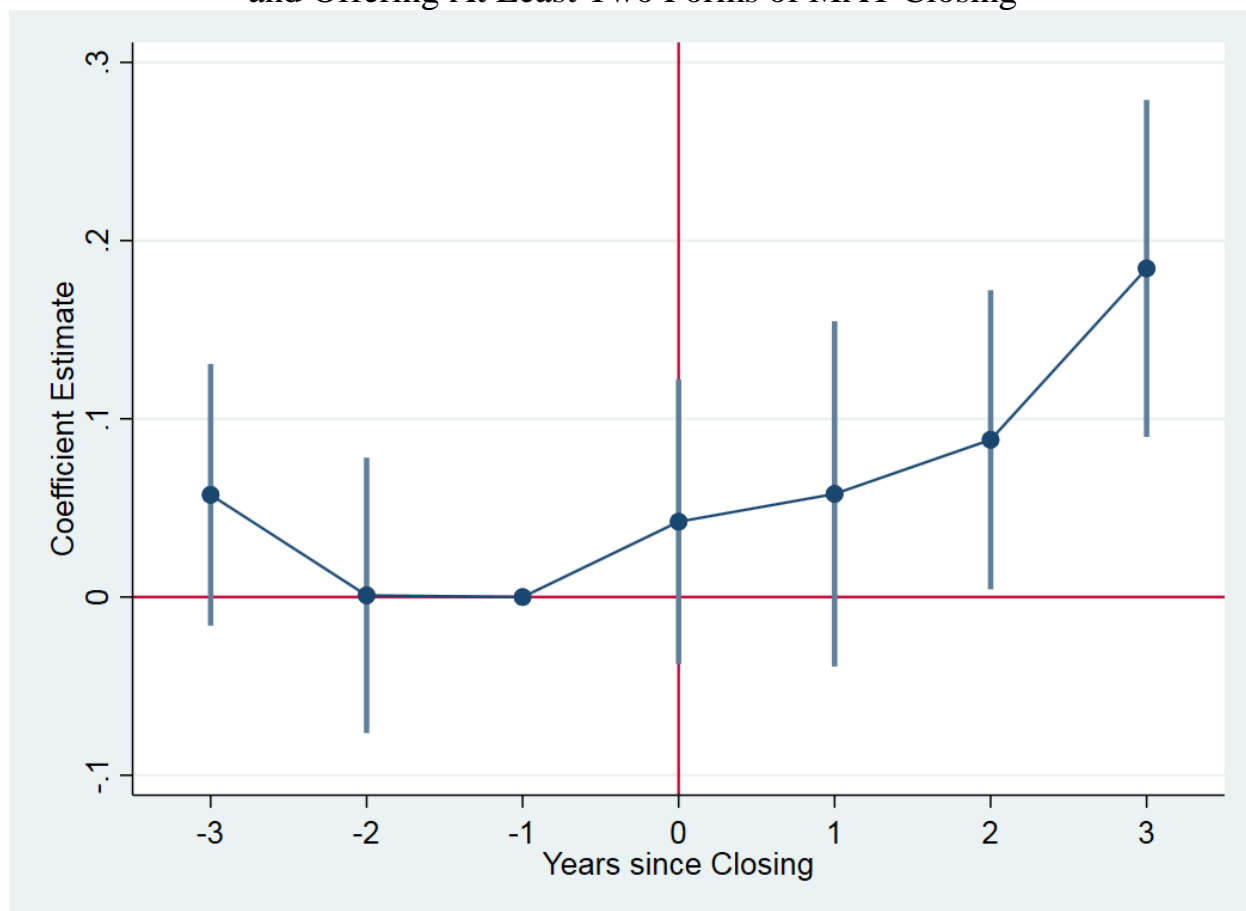
*Notes:* Dependent variable – inverse hyperbolic sine transformation of opioid related death rate per 100,000. Event study of counties with only one substance abuse treatment facility accepting Medicaid opening throughout 2005-2016. Controls include the fraction of the county population that are: white, black, female, ages 0-15, ages 16-34 and ages 35-64 years old, the unemployment rate and per capita income. Models include county FE, year FE and state by year FE.

Figure 11: Event Study – Impact of Substance Abuse Facility Accepting Medicaid and Offering Some MAT Closing



*Notes:* Dependent variable – inverse hyperbolic sine transformation of opioid related death rate per 100,000. Event study of counties with only one substance abuse treatment facility accepting Medicaid and offering some MAT closing throughout 2005-2016. Controls include the fraction of the county population that are: white, black, female, ages 0-15, ages 16-34 and ages 35-64 years old, the unemployment rate and per capita income. Models include county FE, year FE and state by year FE.

Figure 12: Event Study – Impact of Substance Abuse Facility Accepting Medicaid and Offering At Least Two Forms of MAT Closing



*Notes:* Dependent variable – inverse hyperbolic sine transformation of opioid related death rate per 100,000. Event study of counties with only one substance abuse treatment facility accepting Medicaid and offering at least two forms of MAT closing throughout 2005-2016. Controls include the fraction of the county population that are: white, black, female, ages 0-15, ages 16-34 and ages 35-64 years old, the unemployment rate and per capita income. Models include county FE, year FE and state by year FE.

## 9. Appendix

Table A1: Unweighted Summary Statistics

Variable	Mean	Std. Dev
Facilities Providing Substance Abuse Services	3.57	11.89
Substance Abuse Services Facilities Accepting Medicaid	1.99	5.85
Facilities Providing Some Medication Assisted Treatment	0.82	3.46
Facilities Providing Some Medication Assisted Treatment and Accepting Medicaid	0.53	2.54
Facilities Providing at Least Two Different Forms of Medication Assisted Treatment	0.54	2.60
Facilities Providing at Least Two Different Forms of Medication Assisted Treatment and Accepting Medicaid	0.16	1.04
All Opioids	7.39	26.83
All Opioids rate per 100k	6.01	11.13
Heroin (T40.1)	1.76	10.09
Heroin rate per 100k	0.78	2.58
Other Opioids (T40.2)	2.87	10.55
Other Opioids rate per 100k	2.82	5.89
Methadone (T40.3)	1.29	4.62
Methadone rate per 100k	1.33	7.12
Synthetic Opioids (T40.4)	1.33	8.32
Synthetic Opioids rate per 100k	1.19	3.66
Other/Unspecified Narcotics (T40.6)	0.77	6.95
Other/Unspecified Narcotics rate per 100k	0.44	2.21

*Notes:* Data - 2005-2016

Table A2  
Robustness

	Substance Abuse Facilities	SA Facilities Accepting Medicaid	Facilities Providing Some MAT	Facilities Providing MAT and Accepting Medicaid	Facilities Providing Two or More Forms of MAT	Facilities Providing Some MAT and Accepting Medicaid
<i>Panel A: Unweighted OLS</i>	0.000737 (0.00248)	0.000478 (0.00343)	-0.00751** (0.00363)	-0.0123** (0.00494)	-0.00277 (0.00196)	-0.0138** (0.00574)
<i>N</i>	33,197	33,197	33,197	33,197	33,197	33,197
<i>Mean</i>	6.01	6.01	6.01	6.01	6.01	6.01
<i>Panel B: Unweighted Poisson</i>	0.00114 (0.001)	0.0005 (0.00175)	-0.00193 (0.00209)	-0.00666*** (0.00258)	-0.000449 (0.00112)	-0.00292 (0.00275)
<i>N</i>	29,979	29,979	29,979	29,979	29,979	29,979
<i>Mean</i>	7.39	7.39	7.39	7.39	7.39	7.39

*Notes:* Dependent variable - Inverse Hyperbolic Sine transformation of opioid death rate per 100,000 for OLS model and count for Poisson model. Controls include the fraction of the county population that are: white, black, female, ages 0-15, ages 16-34 and ages 35-64 years old, the unemployment rate and per capita income. Models include county FE, year FE and state by year FE. Treatment facilities are a count variable: number in a county by year. These estimates are weighted by country population. Standard errors in parenthesis are adjusted for clustering at the county level. \* p<0.10, \*\* p<0.05, \*\*\* p<0.01



Table A3  
Reverse Causality

	Substance Abuse Facilities	SA Facilities Accepting Medicaid	Facilities Providing Some MAT	Facilities Providing MAT and Accepting Medicaid	Facilities Providing Two or More Forms of MAT	Facilities Providing Two plus forms MAT and Accepting Medicaid
<i>Panel A: One Year before Opening</i>						
Opioid Death Rate per 100,000	0.00341 (0.00630)	0.0160 (0.0112)	-0.00213 (0.00512)	-0.00164 (0.00276)	0.00777 (0.0161)	-0.00128 (0.00240)
<i>N</i>	33,191	33,191	33,191	33,191	33,191	33,191
<i>Panel B: Two Years before Opening</i>						
Opioid Death Rate per 100,000	-0.00531 (0.00590)	0.00814 (0.0106)	0.00313 (0.00778)	0.00796 (0.00708)	-0.0104 (0.0178)	0.00499 (0.00380)
<i>N</i>	30,172	30,172	30,172	30,172	30,172	30,172

*Notes:* Dependent variable - indicator variable for substance abuse facility openings. Controls include the fraction of the county population that are: white, black, female, ages 0-15, ages 16-34 and ages 35-64 years old, the unemployment rate and per capita income. Models include county FE, year FE and state by year FE. These estimates are weighted by country population. Standard errors in parenthesis are adjusted for clustering at the county level. \* p<0.10, \*\* p<0.05, \*\*\* p<0.01

Table A4  
County Level Demographics

	Substance Abuse Facilities	SA Facilities Accepting Medicaid	Facilities Providing Some MAT
Population Share Ages 16-34	-0.00000881 (0.0000119)	-0.0000450* (0.0000261)	-0.0000250 (0.0000204)
Population Share Female	0.00000515 (0.00000322)	0.00000676 (0.00000537)	-0.00000341 (0.00000602)
Population Share White	0.00000967 (0.0000233)	0.00000669 (0.0000460)	0.000113* (0.0000654)
Population Share Black	-0.0000138 (0.0000235)	-0.0000357 (0.0000480)	-0.000157*** (0.0000577)
<i>N</i>	33,197	33,197	33,197

*Notes:* Dependent variable - share of county population within demographics group. Controls include the unemployment rate and per capita income. Models include county FE, year FE and state by year FE. These estimates are weighted by county population. Standard errors in parenthesis are adjusted for clustering at the county level. \* p<0.10, \*\* p<0.05, \*\*\* p<0.01