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 (OUD) (Department of Health and Human Services, 2017). From 1999-2016, over 367,000 deaths have been attributed to opioid overdose (CDC, 2018).[1] Important questions remain regarding the effectiveness of treatment for OUD and whether sufficient levels of treatment are accessible. Further, among the population with OUD seeking treatment, often patients themselves do not know what type of treatment is most effective. 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 (MAT) and accepting Medicaid reduces the county level opioid related death rate by about 0.6 to 1 percent while one additional substance abuse facility of any other type does not have a statistically significant impact.

Swensen (2015) exploits county level variation in the number of substance abuse treatment facilities and finds that a 10 percent increase in the number of treatment facilities leads to a 2 percent 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. The American Society of Addiction Medicine (ASAM) recommends MAT to treat OUD (Grogan et al., 2016). MAT combines behavioral therapies and prescribed medications. MAT involves one

[1] Including IDC-10 Codes: T40.0, T40.1, T40.2, T40.3, T40.4 and T40.6

of three medications approved by the FDA to treat OUD: buprenorphine, methadone, or naltrexone. Methadone and buprenorphine, the most commonly prescribed OUD medications, suppress the body's cravings to use opioids and treat opioid withdrawal. Different OUD medications 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, most facilities did not offer these services as of 2016. 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 form of MAT (see figure 1a). 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 reported accepting Medicaid (Jones et al., 2018). Among adult Medicaid beneficiaries, an estimated 12 percent have a substance use disorder (SUD) (Wachino, 2015). Approximately one out of every five Americans is covered by Medicaid (Rudowitz and Garfield, 2018).

2. Literature Review

Many studies have found improvements in patient outcomes following admission to treatment for SUD (Darke et al., 1996; Stewart et al., 2002; Hossop et al., 2003; Lu and McGuire, 2002; Swensen, 2015). Darke et al. (1996) find that heroin users who sought treatment or were active in treatment faced a substantially lower risk of overdose. Stewart et al. (2002) find 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). 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). 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 county level crime rates including homicide, aggravated assault, robbery, auto theft, and burglary.

The opening or closing of a treatment facility impacts the availability of services to a given patient and can alter the cost of treatment to that patient. In 2015, 89 percent of all patients receiving treatment for a SUD received treatment in an outpatient setting (SAMHSA, 2017). This fact highlights the importance of the location of substance abuse treatment facilities and the potential mismatch between patient and facility with respect to services offered and insurance type accepted. Treatment facilities may be facing capacity constraints. Rapp et al. (2006) survey patients with SUD 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 be placed on a waiting list to receive treatment (Rapp et al., 2006).

2.1 SUD Treatment and Health Insurance

Cost can be a significant barrier to receiving treatment. White 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 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; the authors find that state parity legislation increased treatment admissions, 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-grand-fathered 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 Americans 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 though treatment facilities may already be constrained by capacity. 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 SUDs and generous health insurance benefits. Treatment centers bill insurance issuers thousands of dollars per service like urine screening or counseling session (Seville et al., 2017). These fraudulent treatment centers rely heavily on online searches and advertising and generally do not offer legitimate services that patients need. These fraudulent treatment centers have admitted patients that subsequently died of overdose (Seville et al., 2017).

2.2 Efficacy of Methadone and Buprenorphine

Methadone and buprenorphine have been thoroughly studied in the medical literature. Mattick et al. (2009) review 11 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). 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 31 different 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 6 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 those with OUD receiving some type of opioid replacement therapy compared to no replacement therapy. In a clinical trial for an extended release formulation of buprenorphine, after 24 weeks, about 40 percent of patients receiving the treatment were abstaining from other opioid use compared to only 5 percent 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 OUD, 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.

2.3 Access to Treatment and MAT

Barriers to receiving treatment include capacity constraints, distance and travel constraints and cost constraints (Gryczynski et al., 2011; Andrews et al., 2013; Rosenblum et al., 2011; Sigmon, 2014). Jones et al. (2015) compare rates of opioid misuse 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 to misuse 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 OUD from obtaining these medications, particularly in rural areas in which there are a limited number of prescribers (Blum et al., 2016). Due to these restrictions and other factors, access to MAT has not grown as quickly as the population of Americans struggling with OUD. Access to MAT is more likely problematic in rural counties than in urban counties. Stein et al. (2015) find 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, it is important to understand why treatment facilities may not

offer MAT. Beyond the limitations associated with physician waivers, Olsen (2015) offers possible explanations for the opposition to offering MAT in the treatment community. Several addiction 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 incentives may be contributing to a lack of patient access to MAT. Using an email survey of physicians, Huhn and Dunn (2017) identified concerns associated with prescribing buprenorphine that physicians acknowledged including: a lack of time for additional patients requiring MAT, a lack of belief in the use of agonist treatment and low reimbursement for time and services offered.

Following Swensen (2015) and Bondurant et al. (2018), I will conduct a number of ancillary tests to examine the validity of the research design. Of particular concern is the endogeneity of the opening/closing of treatment facilities and/or the endogeneity in choice of services offered. 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 percent and in 2013 the response rate was 94 percent (N-SSATS, 2018). The N-SSATS contains a directory of each responding treatment facility that includes county identifiers and indicates what services are offered and what payment types are accepted by the facility.

N-SSATS directories were scraped and compiled into datasets by the organization amfAR, the Foundation for AIDs research. Services offered and payment type accepted by treatment facilities are identified using facility codes. A treatment facility is classified as offering some form of MAT if any of the of the following facility codes appear: BMW (Buprenorphine Maintenance for Predetermined Time), BU (Buprenorphine Used in Treatment), BUM (Buprenorphine Maintenance), DB (Buprenorphine Detoxification), DM (Methadone Detoxification), METH (Methadone), MM (Methadone Maintenance), MMW (Methadone Maintenance for Predetermined Time), UBN (Prescribes/Administers Buprenorphine and/or Naltrexone), VTRL (Vivitrol, Injectable Naltrexone). A treatment facility is identified as accepting Medicaid if the facility code MD appears in the directory. Finally, this methodology is used to characterize facilities offering buprenorphine, methadone, multiple forms of MAT and facilities offering MAT and accepting Medicaid.

N-SSATS data is aggregated to the county, year level and merged 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 related 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.

I merge these data with a set of covariates. Demographic controls 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 the county unemployment rate obtained from the Bureau of Labor Statistics (BLS) Local Area Unemployment Statistics (LAUS) and county level per capita income obtained from the U.S. Bureau of Economic Analysis (BEA) regional data.

I consider additional outcomes obtained from the Substance Abuse and Mental Health Services Administration's Treatment Episode Data Set: Admissions (TEDS-A). The TEDS-A data contain records of admissions into treatment facilities. Following Maclean and Saloner (2019), I calculate the admissions rate per 100,000. 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). The use of methadone or buprenorphine is relatively well reported and is only missing in 4.3 percent of admissions records from 2010-2015 (SAMHSA, 2018). While health insurance status is also collected, from 2010-2015, insurance status is either missing or unknown for 56.8 percent of admissions (SAMHSA, 2018). Last, 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. I estimate the relationship between treatment facilities and the opioid related death rate using following equation:

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

$Facility_{c,t-1}$ is the number of treatment facilities in county *c* in year *t-1*. δ_C is the county fixed effect and ρ_T is the year fixed effect. $\theta_{c,t}$ represents the state by year fixed effect. The identifying variation used in this study is visible in figures 2a-c which show the counties throughout the U.S. that experienced one or more openings of a substance abuse treatment facility (figure 2a), one or more openings of a treatment facility offering MAT (figure 2b) and one or more openings of a facility accepting Medicaid (figure 2c). Whereas Swensen (2015) considers the impact of any treatment facility, I exploit variation across treatment facilities by measuring treatment facilities of different types as described in section 3. $Mortality_{c,t}$ is the opioid related death rate per 100,000 in county *c* in year *t*. These estimates are weighted by county population. Standard errors are adjusted for clustering at the county level. $X_{c,t}$ is a vector of controls including demographic controls and controls for economic conditions**.**

To further examine the validity of this 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 county for each five years before and after the facility/facilities opening. Some counties experienced multiple openings and/or closings throughout the sample period. For this reason, I estimate 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 existed. Second, I estimate the impact of the opening of a treatment facility in counties which experienced only a single opening throughout the sample period.

5. Results

In table 2, I examine the impact of substance abuse treatment facilities offering MAT on the opioid related death rate. The outcome variable, the opioid related death rate at the county year level, is transformed using the inverse hyperbolic sine function rather than the natural log function 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. The opening of one substance abuse facility offering MAT is estimated to reduce the county level opioid related death rate by about 0.2 to 0.6 percent. One additional substance abuse facility offering MAT represents a 10.6 percent increase compared to the existing mean capacity. The opening of one substance abuse facility offering MAT and accepting Medicaid is estimated to reduce the county level opioid related death rate by about 0.6 to 0.95 percent. The opening of one substance abuse facility offering two or more forms of MAT and accepting Medicaid has a similar estimated effect to the opening of one substance abuse facility offering MAT and accepting Medicaid. Whether a treatment facility

offers one or multiple forms of MAT, a facility opening has a larger negative impact on the county death rate if that facility also accepts Medicaid.

In table 3, I compare facilities offering buprenorphine and methadone. The opening of a treatment facility offering buprenorphine is estimated to be more impactful on the opioid related death rate compared to the opening of a treatment facility offering methadone. The opening of a treatment facilities offering buprenorphine is estimated to have a larger negative impact on the opioid related death rate if that facility also accepts Medicaid. The opening of a treatment facilities offering buprenorphine and accepting Medicaid leads to a reduction in the opioid related death rate of about 0.8 percent. In table 4, I compare the types of treatment facilities estimated to be the most impactful on the opioid related death rate to all other substance abuse treatment facilities not of that type. The opening of a treatment facility accepting Medicaid and offering buprenorphine, some form of MAT, or two or more forms of MAT leads to about a 0.8 to 1 percent reduction in the county level opioid related death rate. The opening of any treatment facility not of that type does not have a statistically significant impact on the county level opioid related death rate. The estimates are visible in figure 4. The opening of a treatment facility accepting Medicaid and offering MAT has a much larger negative impact on the opioid related death rate compared the opening of a treatment facility accepting Medicaid or offering MAT.

5.1 Analysis of Treatment Episode Data Set: Admissions

Next, I consider outcomes from the TEDS-A. The TEDS-A data does not have county identifiers. Rather, the TEDs-A contains identifiers for the state and core based statistical area (CBSA) of the treatment admission. First, I aggregate the TEDS-A and the N-SSATS to the state year level and merge the two data sets. In table 5, I examine admission by the primary substance abuse problem restricting the sample to admissions related to OUD. Facilities that offer two plus

forms of MAT and accept Medicaid had the largest impact on the opioid related admission rate. The opening of one such facility was estimated to increase the state level OUD admissions rate by about 0.5 per 100,000.

Second, I aggregate to the TEDS-A to the CBSA year level. Using the CBSA to FIPS County Crosswalk file from the National Bureau of Economic Research (NBER), I match treatment facilities with county identifiers to a CBSA. CBSA population estimates were obtained from the U.S. Census Bureau (2019). In panel A of table 6, 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 offering some form of MAT and accepting Medicaid have the largest effect on the admission involving MAT rate. The opening of such a treatment facility is estimated to increase the admission involving MAT rate by about 0.6 per 100,000.

5.2 Timing of Opening

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. The event study evidence, in general, alleviates concerns about the endogeneity of the opening of a treatment facility. 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 leading up to the opening, the opioid related death rate declines, most prominently 2-5 years after opening. I restrict the scope of the event studies to the opening of a substance abuse treatment facility that accepts Medicaid. Within counties with no previous treatment facility of that type experiencing

one or more openings (figure 6), again no trends appear in the years leading up to the opening. The opening(s) then lead to a decrease in the opioid related death rate.

Next, I apply the event study framework to the opening of treatment facilities offering MAT. In the years leading up to the opening of a treatment facility offering some MAT (figure 7) there are no visible pre-trends followed by an estimated negative impact on the opioid related death rate. Figure 8 examines the impact of the opening of a facility offering some MAT and accepting Medicaid. There are no visible trends prior to opening. A small decrease in the opioid death rate appears following the opening, however, confidence intervals are large and contain a zero-coefficient estimate. Figures 9 and 10 test the impact of the opening of a treatment facility offering two of more forms of MAT in counties with a single opening or no previous capacity. Throughout the event studies, coefficient estimates are close to zero in the years leading up to the opening of a treatment facility across facility types. The event studies do restrict the identifying variation, they offer evidence in support of the validity of the identification strategy used throughout this study.

I evaluate the timing of the opening of treatment facilities using lags and leads of the number of treatment facilities. Results in table A2 includes a measure of all treatment facilities in my sample. The estimates in table A2 show that there does not appear to be a relationship between the opioid related death rate and the number of treatment facilities in the future. There is a negative relationship between the number of treatment facilities and the subsequent death rate. Results in table A3 includes only treatment facilities offering MAT and accepting Medicaid. Again, there does not appear to be a relationship between the opioid related death rate a future treatment capacity.

5.3 Robustness, Simulations and Falsification Tests

In table A1, it appears that the primary results presented in this study are robust when estimated using alternate measures of the outcome variable, unweighted models and to different functional forms. These alternate specifications include the natural log transformation of the opioid related death rate (panel A)[2], unweighted OLS (panel B) and population weighted Poisson models (panel C).[3] To further assess the inference and contextualize estimates obtained in this study, I run a number of simulations and falsification tests. The measure of treatment access relies on the opening and closing of treatment facilities. The data includes 3,143 counties.[4] From 2005-2016, 1,910 of those counties experienced at least one treatment facility opening. 1,303 counties experienced at least one opening of a treatment facility accepting Medicaid. 610 counties experiences at least one opening of a treatment facility accepting Medicaid and offering two of more forms of MAT.

In each simulation, counties are randomly assigned into treatment and control groups. A treatment date is randomly drawn from a uniform distribution (between 2006 and 2016) for each treated county. I estimate equation 1 replacing the measure of treatment facilities with the randomly generated treat*post variable. The simulation is repeated 1,000 times. The number of treated counties is varied to reflect the different size of the treatment and control groups in my primary analysis (1,910 treated counties, 1,300 treated counties and 610 treated counties). In figures 11a-c, I present histograms of the 1,000 estimates of β obtained in these simulations. The distribution of coefficient estimates appears to follow a normal distribution with mean zero, regardless of the size of the treatment group.

[2] One is added to the opioid related death rate prior to the log transformation to avoid missing observations
[3] Poisson regressions are estimated using the ppmlhdfe Stata command developed by Correia et al. (2019) while OLS regressions are estimated using reghdfe Stata command developed by Correia (2017)
[4] Florida is excluded because of concerns about fraudulent treatment centers

I conduct a number of falsification tests to further consider the validity of the research design. While increased access to treatment for substance use disorder can have far reaching health benefits beyond reducing the risk of overdose, it is not expected to have an immediate short run effect on alternate mortality rates. In figures 12 a-c, I present the results from these tests. Using equation 1, I estimate the impact of treatment facilities on various cancer rates, dementia and other cause mortality. ICD-10 codes used for this analysis can be found in table A10. The falsification tests show that treatment facilities do not appear to have a short term impact of alternate cause mortality rates. Finally, I examine the potential for changes in the composition of the county population in response to the opening/closing of treatment facilities. In table A9, I move county demographic controls to the left-hand side and find that overall, the opening/closing of treatment facilities does not explain any compositional changes in the county population.

5.4 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 the sample consists of 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 fraud in the treatment industry in the media on a case by case basis but no published research of broader scope to date (Seville et al., 2017).

In table A4, I explore the heterogeneity of these effects by gender. The opening of a treatment facility offering some MAT and accepting Medicaid has the largest negative impact on the opioid related death rate of females. The opening of such a treatment facility has less of an impact of the male opioid related death rate. The population weighted mean male opioid related death rate is about twice that of the female opioid related death rate. In table A5, 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 MAT and accepting Medicaid. 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 A6, it appears that treatment facility openings have a larger negative impact in rural counties though the coefficient of interest is no longer significant. This may be explained by a lack of identifying variation as there are fewer openings in rural counties throughout the sample period.

5.5 Other Economic Outcomes

Given the economic cost of the opioid epidemic, changes in treatment capacity may impact local economic outcomes. In table A7, I consider the impact of treatment facilities 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 dataset 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. The opening of one such facility is estimated to increase the labor force participation rate by about 0.08-0.09 percent. In table A8, 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, the opening of a treatment facility appears to have a positive impact on median and mean county income.

6. Conclusion

In this study, I find that the opening of a substance abuse treatment facility has a negative impact on the opioid related death rate within the county of the opening. There is substantial heterogeneity when comparing different types of treatment facilities. The opening of a treatment facility offering at least some form of MAT and accepting Medicaid is estimated to reduce the county opioid related death rate by about 0.9 to 1.1 percent while the opening of any other type of treatment facility does not have a statistically significant impact. Treatment facilities accepting Medicaid and offering MAT were also found to have a larger positive impact on treatment admissions rates and on local economic outcomes.

Mental health parity legislation along with the ACA has increasing the prominence of public and private insurance in providing funding for treatment of SUD. Medicaid is the single largest payer for mental health services in the U.S. (Centers for Medicare and Medicaid Services, 2019). From the perspective of a patient seeking treatment for OUD, increasing treatment capacity can remove or reduce some of the barriers to receiving treatment that patient may face. These barriers could include cost related to distance/travel, insurance type mismatch or a lack of services available to treat OUD. Results presented in this paper suggest that the existing capacity

for treatment of OUD in the U.S. may not be sufficient. Specifically, this applies to Medicaid beneficiaries seeking treatment for OUD.

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8. Tables and Figure

Table 1
Summary Statistics

Variable	Mean	Std. Dev
Facilities Providing Substance Abuse Services	39.24	77.29
Facilities Providing Substance Abuse Services and 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
Facilities Providing Buprenorphine	4.58	9.24
Facilities Providing Buprenorphine and Accepting Medicaid	2.53	5.55
Facilities Providing Methadone	4.58	8.91
Facilities Providing Methadone and Accepting Medicaid	3.10	6.80
All Opioids Death rate per 100k	7.52	7.08
Fraction Ages 0-15	0.21	0.03
Fraction Ages 16-35	0.26	0.04
Fraction Ages 35-64	0.39	0.03
Fraction Female	0.51	0.01
Fraction White	0.79	0.15
Fraction 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
Impact of Treatment Facilities Offering MAT on Opioid Mortality Rate

	(1)	(2)	(3)	(4)
Facilities Providing Some MAT	-0.00629***	-0.00293	-0.00229	-0.00231
	(0.00125)	(0.00248)	(0.00252)	(0.00261)
Facilities Providing Some MAT and Accepting Medicaid	-0.00608*	-0.00945***	-0.00884***	-0.00892***
	(0.00318)	(0.00360)	(0.00336)	(0.00342)
Facilities Providing Two or More Forms of MAT	-0.00191**	-0.00137	-0.00115	-0.00112
	(0.000795)	(0.00117)	(0.00112)	(0.00113)
Facilities Providing Two or More forms of MAT and Accepting Medicaid	-0.00698*	-0.0112***	-0.00975**	-0.00958**
	(0.00388)	(0.00397)	(0.00401)	(0.00413)
County FE and Year FE	Yes	Yes	Yes	Yes
State by Year FE	No	Yes	Yes	Yes
Demographic Controls	No	No	Yes	Yes
Controls for Economic Conditions	No	No	No	Yes
N	33,798	33,769	33,769	33,197
Mean of Dependent Before Transformation	7.52	7.52	7.52	7.52

Notes: Dependent variable - Inverse Hyperbolic Sine transformation of opioid death rate per 100,000. Treatment facilities are a count variable per county per year by type of facility. 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 3
Impact of Treatment Facilities on Opioid Mortality Rate by Medication Offered

	(1)	(2)	(3)	(4)
Facilities Offering Buprenorphine	-0.00266	-0.00435***	-0.00410***	-0.00391***
	(0.00168)	(0.00123)	(0.00118)	(0.00126)
Facilities Offering Buprenorphine and Accepting Medicaid	-0.00768***	-0.00862***	-0.00810***	-0.00770***
	(0.00178)	(0.00147)	(0.00140)	(0.00146)
Facilities Offering Methadone	0.00383*	0.000103	-0.00124	-0.000976
	(0.00206)	(0.00218)	(0.00197)	(0.00196)
Facilities Offering Methadone and Accepting Medicaid	0.00198	0.000962	-0.000736	-0.000398
	(0.00329)	(0.00328)	(0.00308)	(0.00305)
County FE and Year FE	Yes	Yes	Yes	Yes
State by Year FE	No	Yes	Yes	Yes
Demographic Controls	No	No	Yes	Yes
Controls for Economic Conditions	No	No	No	Yes
N	33,809	33,769	33,769	33,204
Mean of Dependent Before Transformation	7.52	7.52	7.52	7.52

Notes: Dependent variable - Inverse Hyperbolic Sine transformation of opioid death rate per 100,000. Treatment facilities are a count variable per county per year by type of facility. 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 4
Comparing Treatment Facilities to all others not of the Type

	Facilities of that Type	All other Facilities Not of that Type
Panel A		
Facilities Offering Some MAT	-0.00892***	-0.000811
and Accepting Medicaid	(0.00342)	(0.00102)
Panel B		
Facilities Offering at least 2 Forms	-0.00958**	-0.000999
of MAT and Accepting Medicaid	(0.00413)	(0.000976)
Panel C		
Facilities Offering Buprenorphine	-0.00770***	-0.000652
and Accepting Medicaid	(0.00146)	(0.00112)
N	33,197	33,197
Mean	7.52	7.52

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 the natural log of per capita income. Treatment facilities are a count variable: number in a county by year. Models include county, year and state by year fixed effects. 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 5
Opioid Use Treatment Admissions Rate by Primary Substance Abuse Problem - State Year Level Data

	Substance Abuse Facilities	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
Panel A: All Opiates	-0.117	-0.0361	0.0750	0.192***	0.218*	0.486**
	(0.108)	(0.150)	(0.101)	(0.0620)	(0.110)	(0.213)
N	498	498	498	498	498	498
Mean	144.91	144.91	144.91	144.91	144.91	144.91
Panel B: Heroin	-0.0900	-0.0835	-0.00277	0.00196	0.129	0.335*
	(0.0925)	(0.102)	(0.0588)	(0.0650)	(0.0957)	(0.167)
N	493	493	493	493	493	493
Mean	100.63	100.63	100.63	100.63	100.63	100.63
Panel C: Other Opiates	-0.0285	0.0455	0.0747	0.182***	0.0858	0.144**
Excluding Methadone	(0.0356)	(0.0577)	(0.0775)	(0.0506)	(0.0652)	(0.0604)
N	497	497	497	497	497	497
Mean	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. Treatment facilities are a count variable per state per year by type of facility. Models include state and year fixed effects. 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 6

Opioid Use Disorder Treatment Admissions Rate - Core Based Statistical Area

	Substance Abuse Facilities	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
Panel A	-0.0829	-0.227**	0.409***	0.599***	0.158	0.289***
Admissions Involving MAT	(0.106)	(0.114)	(0.134)	(0.134)	(0.152)	(0.0368)
N	1,362	1,362	1,362	1,362	1,362	1,362
Mean	45.61	45.61	45.61	45.61	45.61	45.61
Panel B	-0.193	-0.283	0.120	0.114	0.0101	0.0632
Admissions for OUD	(0.149)	(0.186)	(0.238)	(0.350)	(0.200)	(0.123)
N	1,362	1,362	1,362	1,362	1,362	1,362
Mean	154.96	154.96	154.96	154.96	154.96	154.96

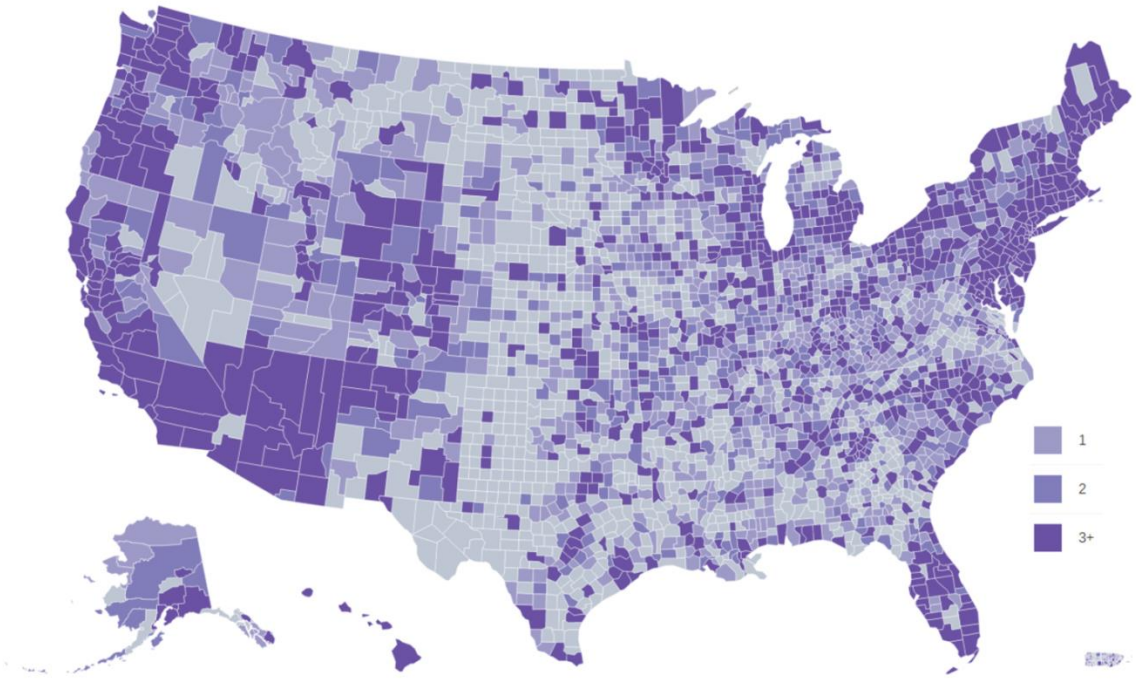
Notes: Dependent variable - treatment admission rate per 100,000 where primary substance abuse problem is opioid use. Treatment facilities are a count variable per CSBA per year by type of facility. Models include Core Based Statistical Area (CBSA) and year fixed effects. These estimates are weighted by CSBA population. Standard errors in parenthesis are adjusted for clustering at the CSBA level. * p<0.10, ** p<0.05, *** p<0.01

Table 7
Comparing Florida to the Rest of the U.S.

	Substance Abuse Facilities	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
Panel A: Florida	0.0162**	0.0260*	0.0281***	0.0511	0.0260***	0.0960*
	(0.00737)	(0.0153)	(0.00920)	(0.0348)	(0.00741)	(0.0526)
N	737	737	737	737	737	737
Mean	8.28	8.28	8.28	8.28	8.28	8.28
Panel B: Rest of U.S.	-0.00157**	-0.000350	-0.00231	-0.00892***	-0.00112	-0.00958**
	(0.000749)	(0.00143)	(0.00261)	(0.00342)	(0.00113)	(0.00413)
N	33,197	33,197	33,197	33,197	33,197	33,197
Mean	7.52	7.52	7.52	7.52	7.52	7.52

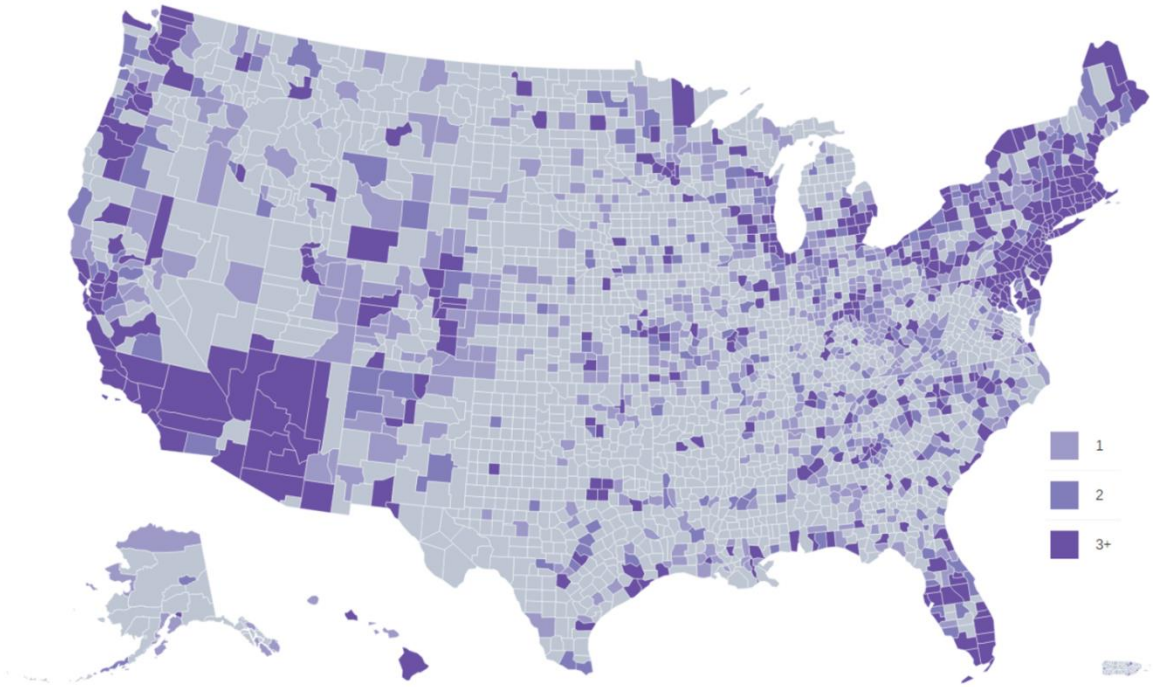
Notes: Dependent variable - Inverse Hyperbolic Sine transformation of opioid death rate per 100,000. Controls include the fraction of the county population that are: white, black, female, ages 0-15, ages 16-34 and ages 35-64 years old, the unemployment rate and log per capita income. Models include county FE and 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

Figure 1a: All Substance Abuse Facilities, 2016



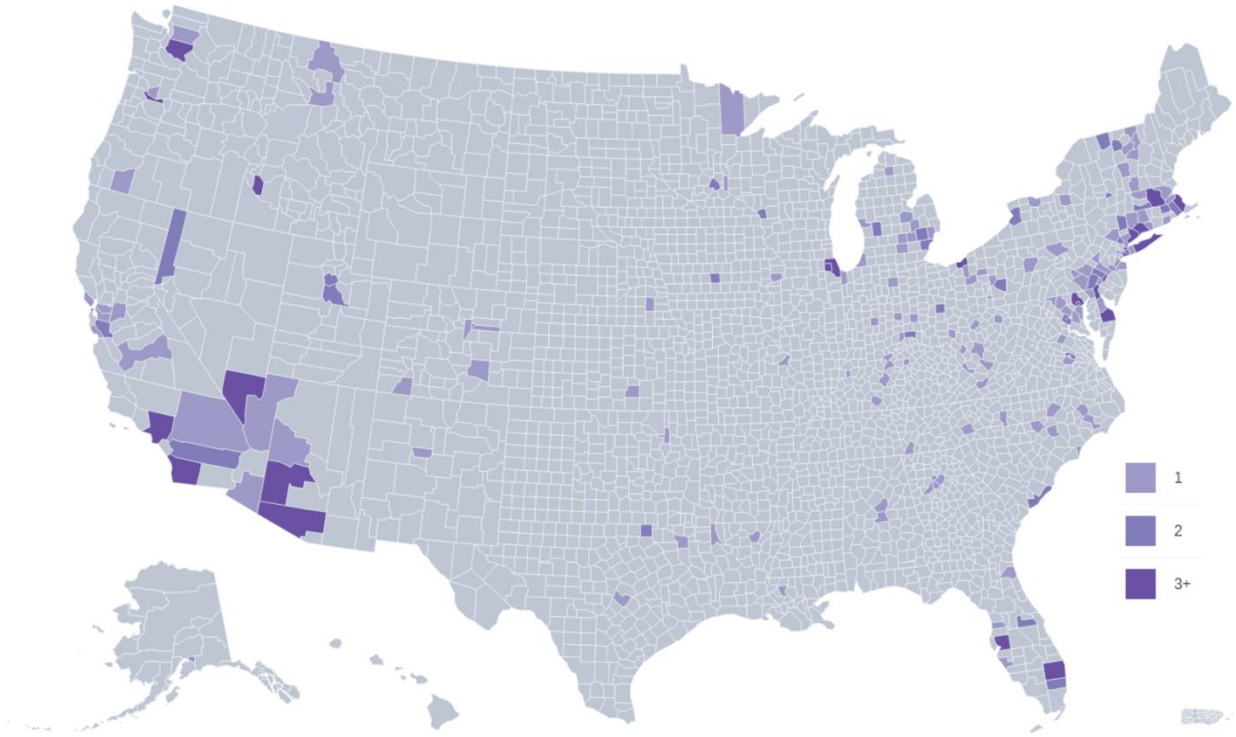
Source: Jones et al., 2018

Figure 1b: Substance Abuse Facilities Offering Some MAT, 2016



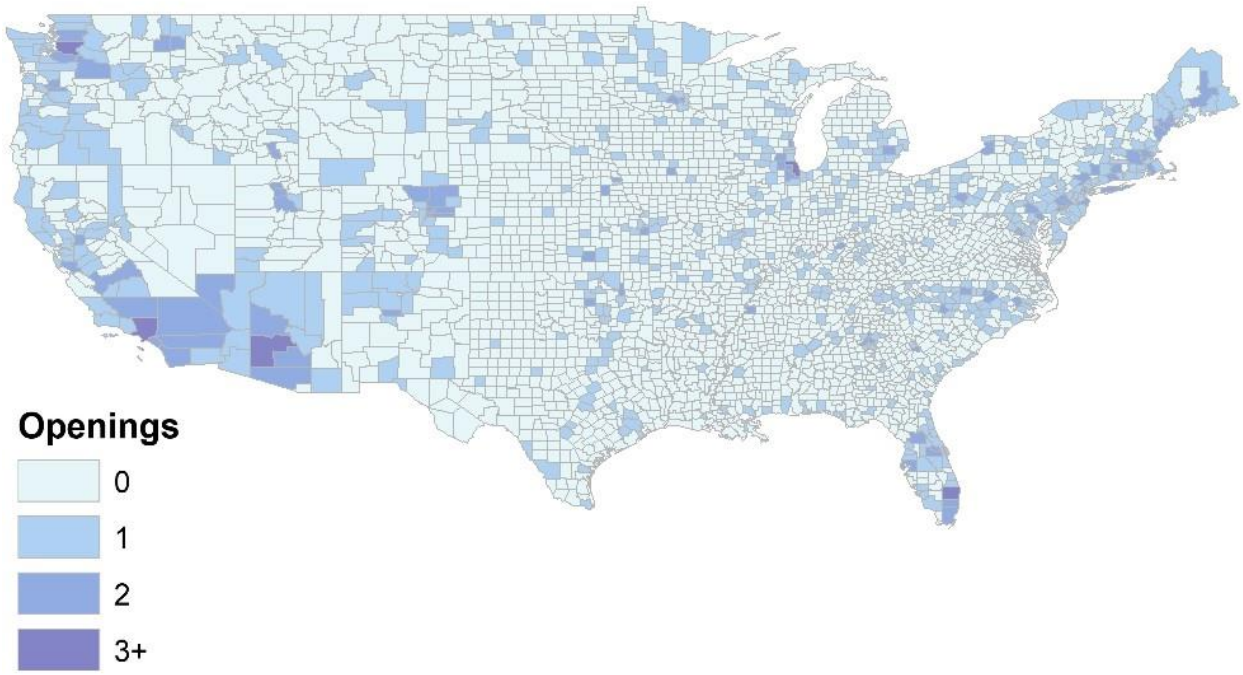
Source: Jones et al., 2018

Figure 1c: Substance Abuse Facilities Offering All Three Forms of Medication-Assisted Treatment, 2016



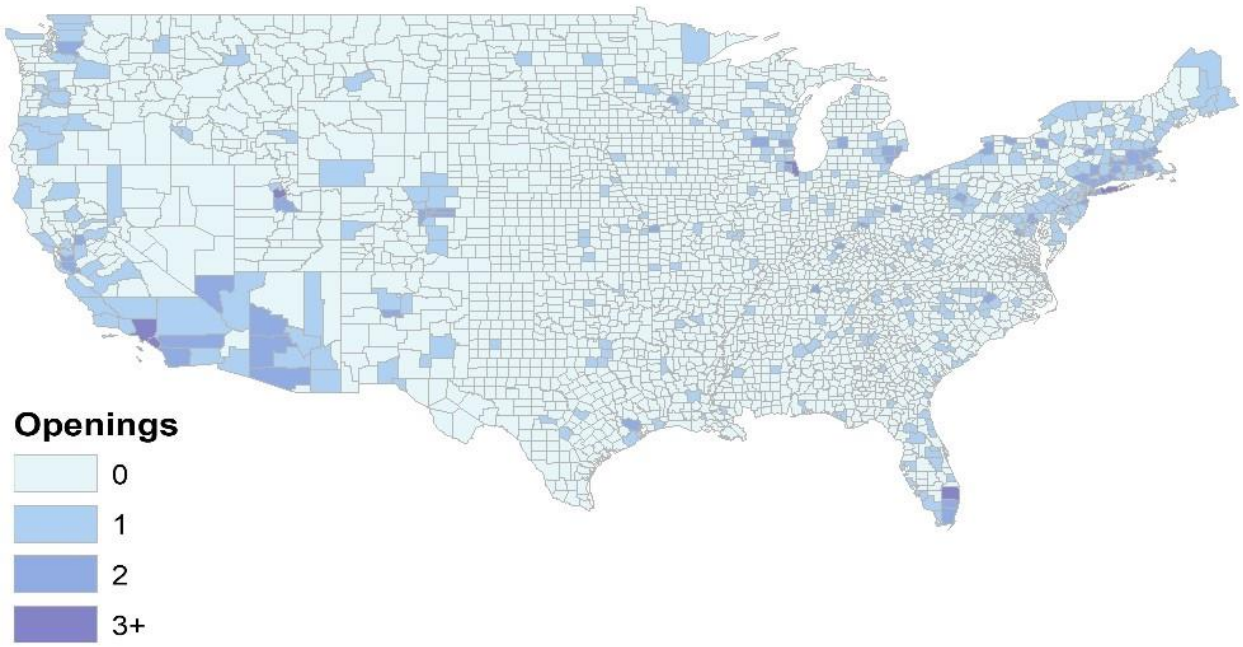
Source: Jones et al., 2018

Figure 2a: All Substance Abuse Facility Openings (2005-2016)



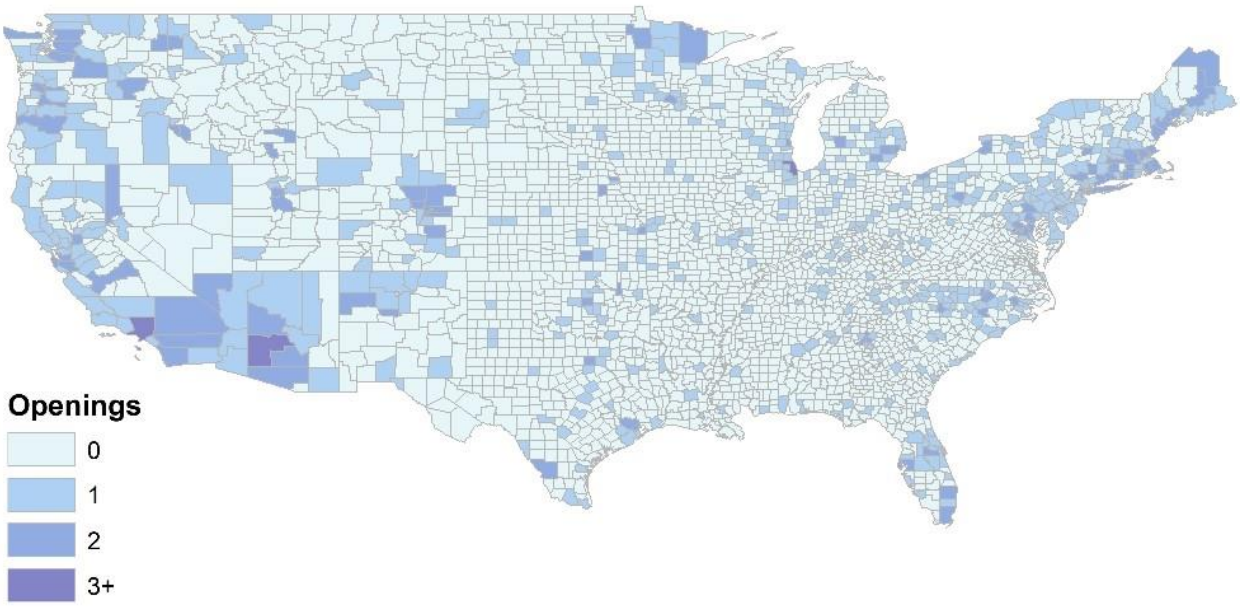
Notes: Data - SAMHSA N-SSATS Directories 2005-2016

Figure 2b: Substance Abuse Facilities offering Some MAT Openings (2005-2016)



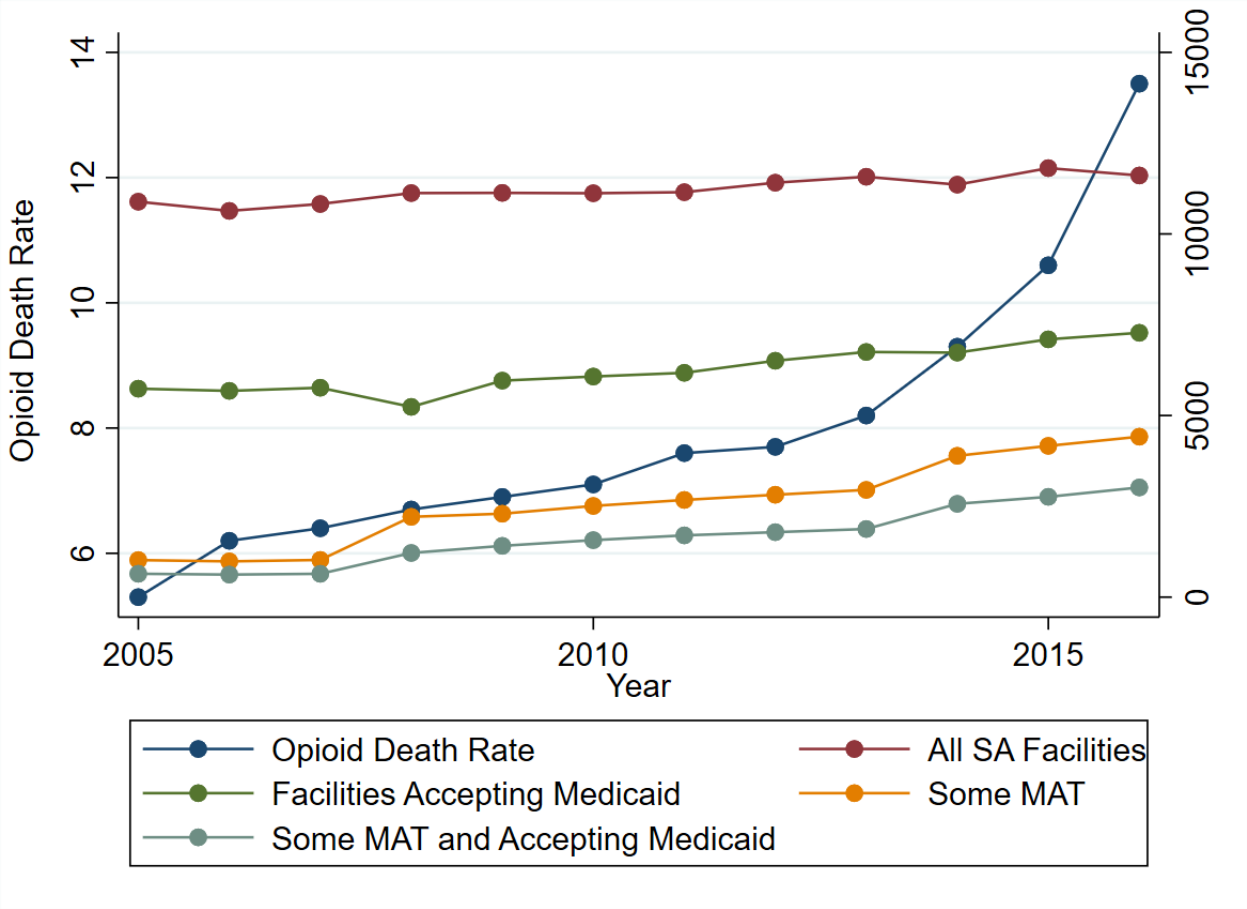
Notes: Data - SAMHSA N-SSATS Directories 2005-2016

Figure 2c: Substance Abuse Facilities accepting Medicaid Openings (2005-2016)



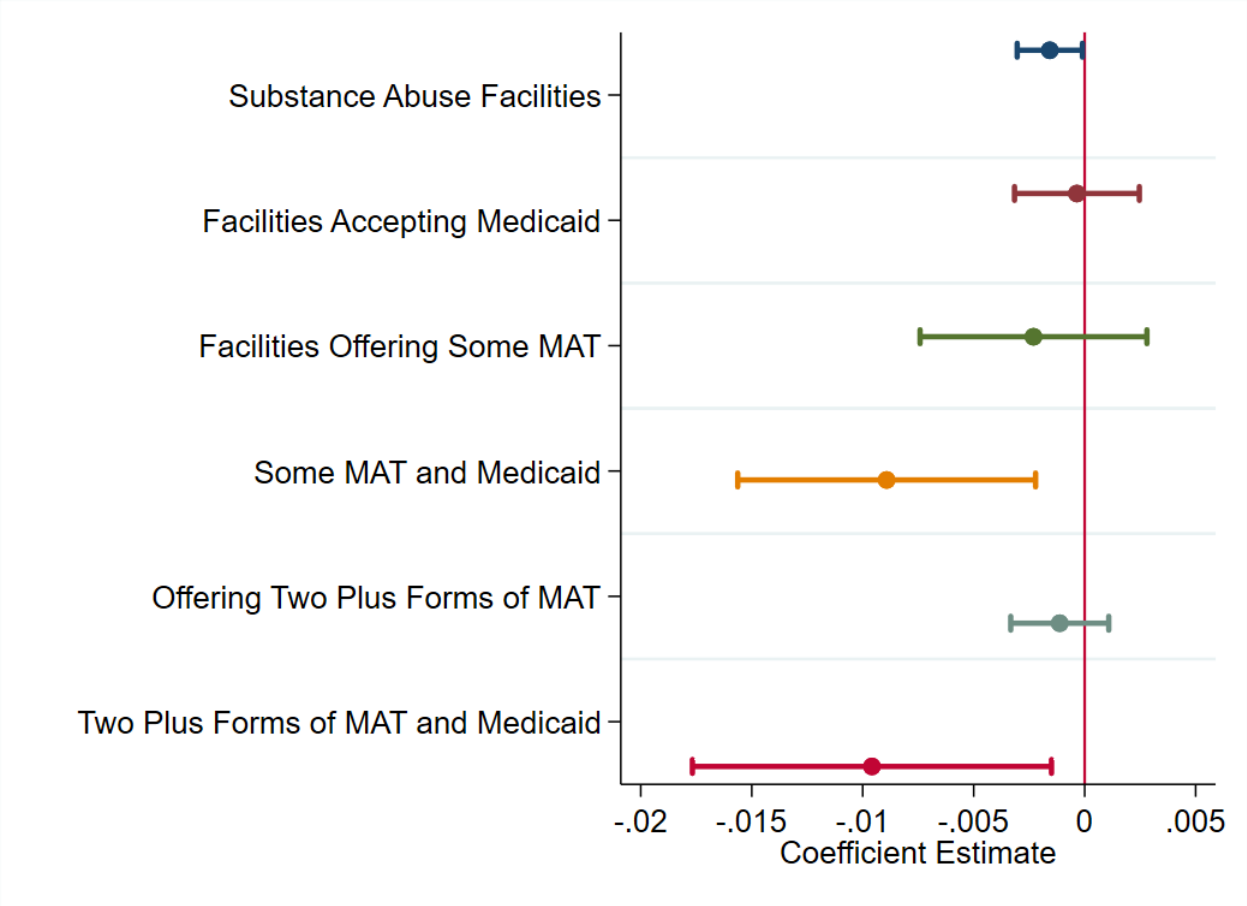
Notes: Data - SAMHSA N-SSATS Directories 2005-2016

Figure 3: Treatment Facilities by Type and Opioid Death Rate per 100,000



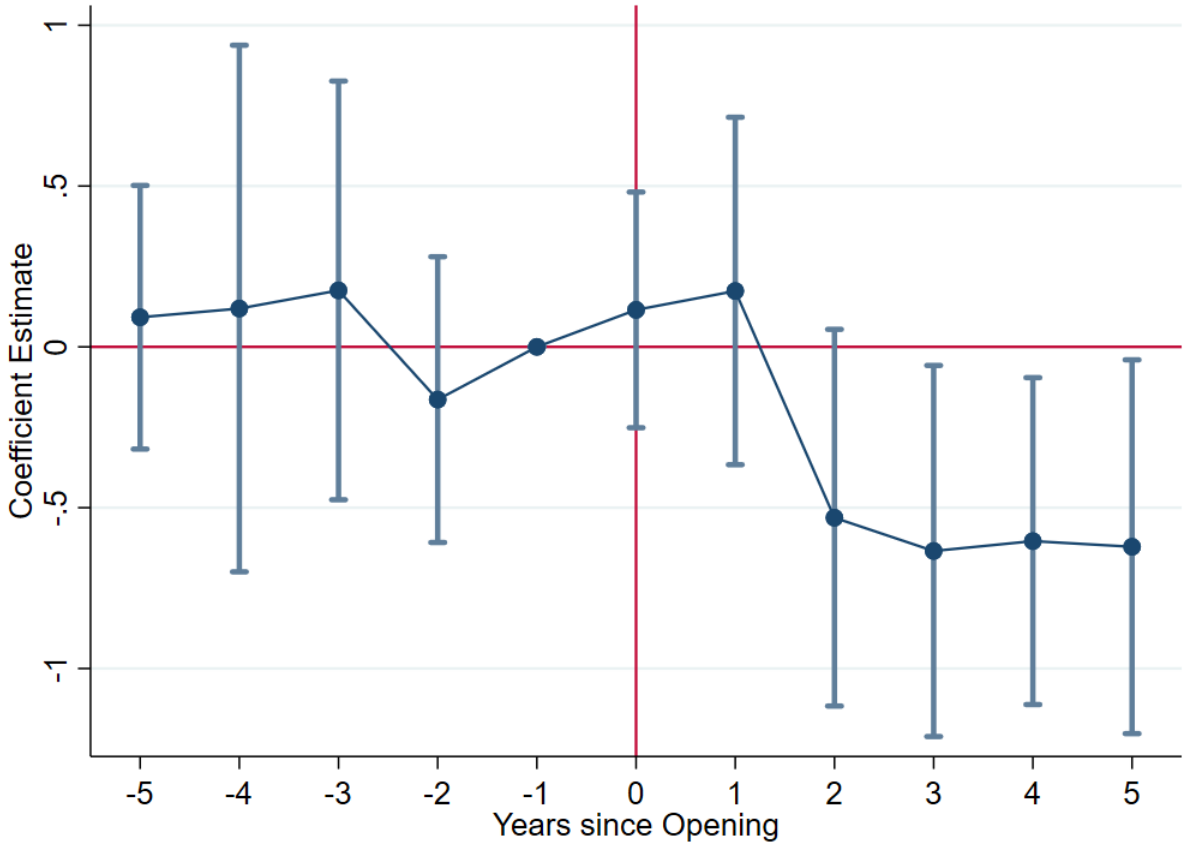
Notes: All SA Facilities refers to the any facility offering substance abuse treatment. Some MAT refers to the number of treatment facilities offering any of the three forms of medication assisted treatment: methadone, buprenorphine, and/or naltrexone. Opioid death rate on left vertical axis and number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

Figure 4: Coefficient Plot



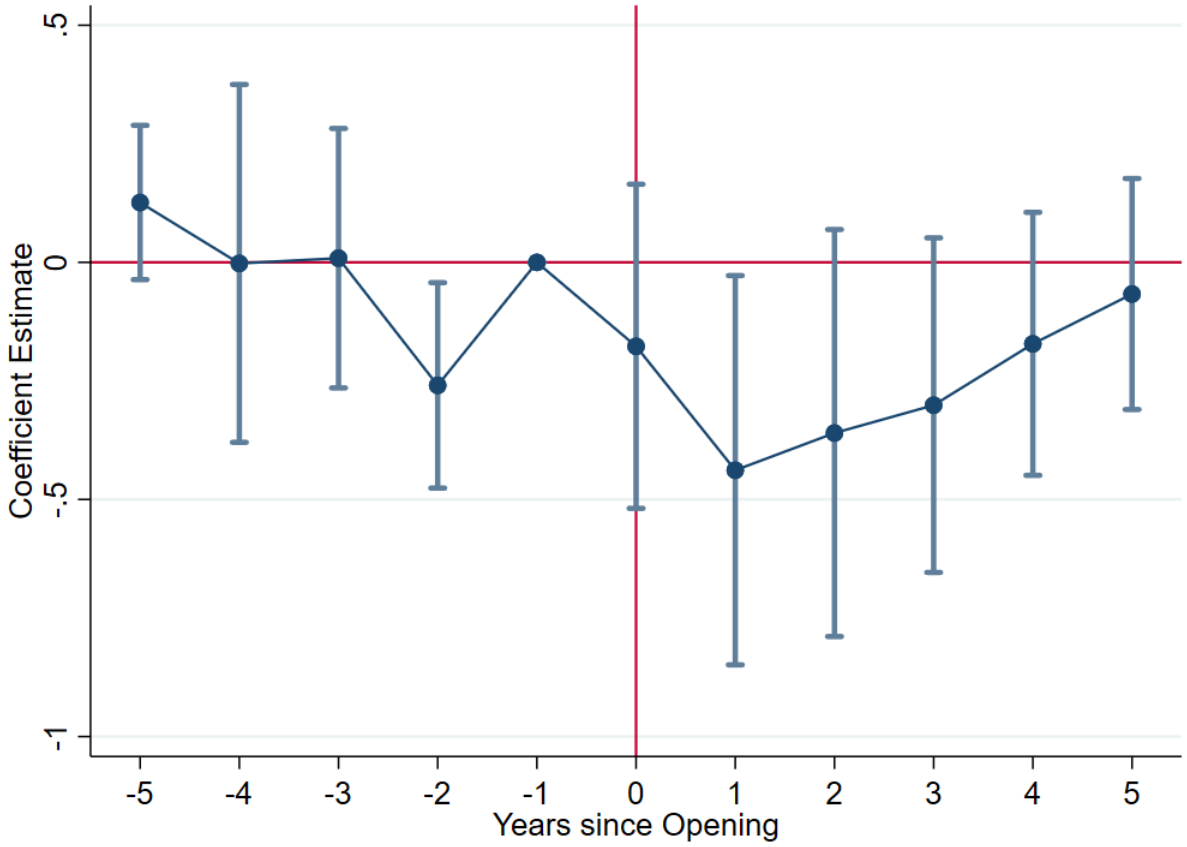
Notes: Dependent variable – inverse hyperbolic sine transformation of opioid related death rate per 100,000. Plot of coefficient estimate and 95% confidence interval. Controls include the fraction of the county population that are white, black, female, ages 0-15, ages 16-34 and ages 35-64 years old, the unemployment rate and the natural log of per capita income. Treatment facilities are a count variable per county per year by type of facility. Models include county, year and state by year fixed effects. These estimates are weighted by county population. Standard errors in parenthesis are adjusted for clustering at the county level.

Figure 5: Event Study – Impact of substance abuse facility opening



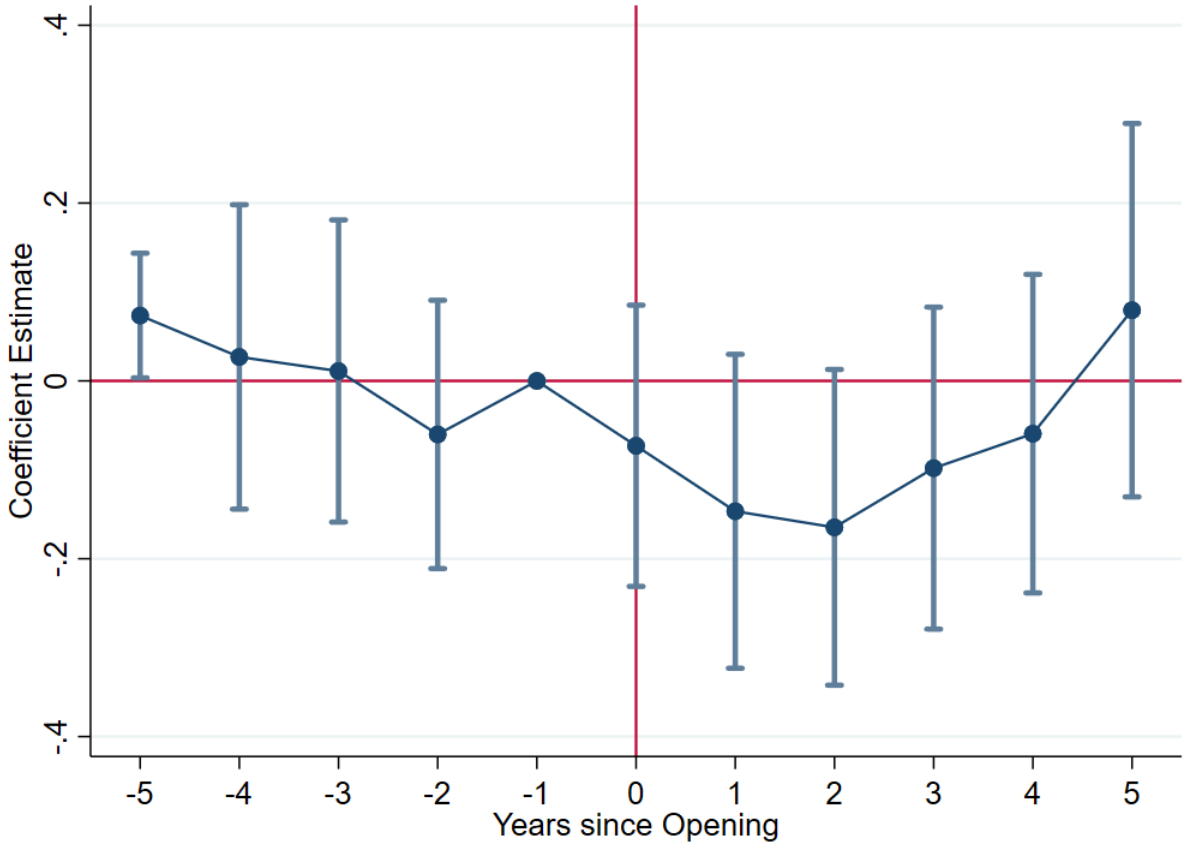
Notes: Dependent variable – inverse hyperbolic sine transformation of opioid related death rate per 100,000. Event study of counties with no substance abuse treatment facility with one or more opening throughout 2005-2016. Controls include the fraction of the county population that are white, black, female, ages 0-15, ages 16-34 and ages 35-64 years old, the unemployment rate and the natural log of per capita income. Models include county, year and state by year fixed effects. These estimates are weighted by county population. Standard errors in parenthesis are adjusted for clustering at the county level.

Figure 6: Event Study – Impact of substance abuse facility accepting Medicaid opening



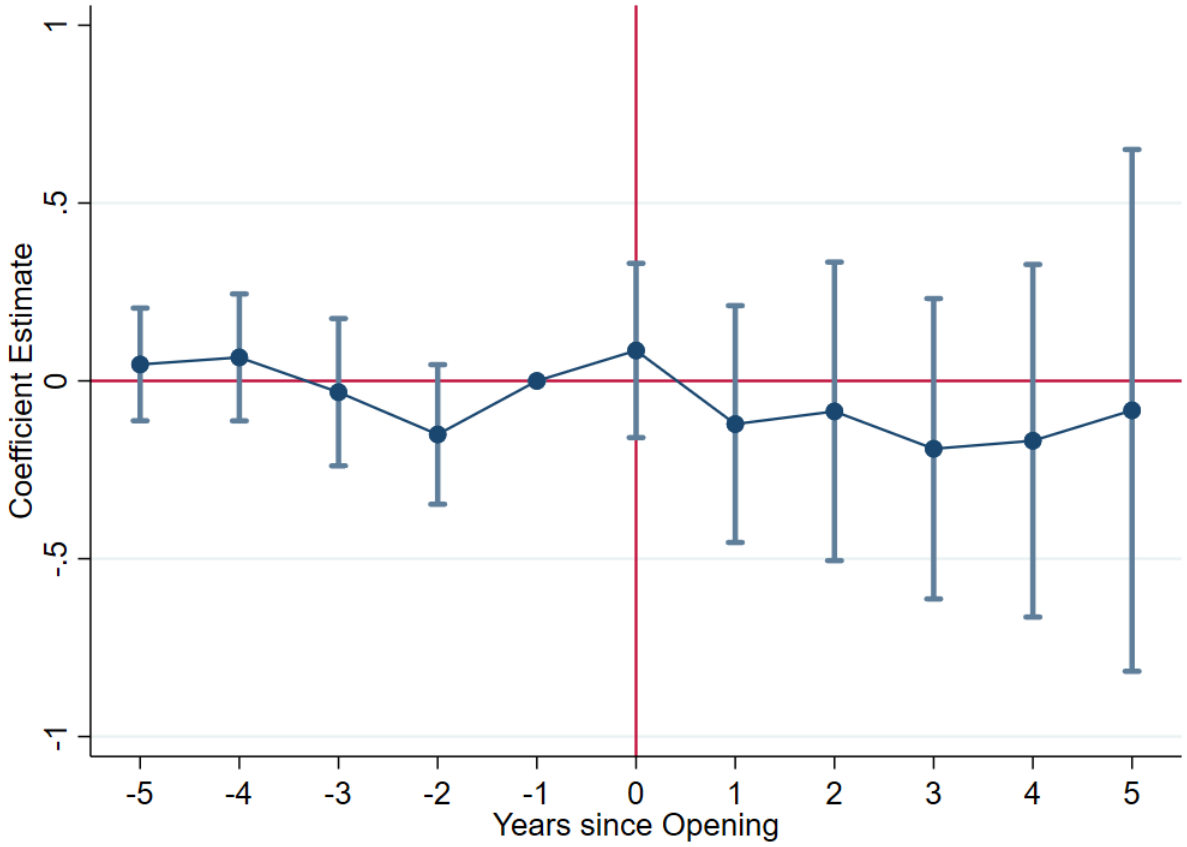
Notes: Dependent variable – inverse hyperbolic sine transformation of opioid related death rate per 100,000. Event study of counties with no substance abuse treatment facility accepting Medicaid with one or more opening throughout 2005-2016. Controls include the fraction of the county population that are white, black, female, ages 0-15, ages 16-34 and ages 35-64 years old, the unemployment rate and the natural log of per capita income. Models include county, year and state by year fixed effects. These estimates are weighted by county population. Standard errors in parenthesis are adjusted for clustering at the county level.

Figure 7: Event Study – Impact of substance abuse facility offering some MAT



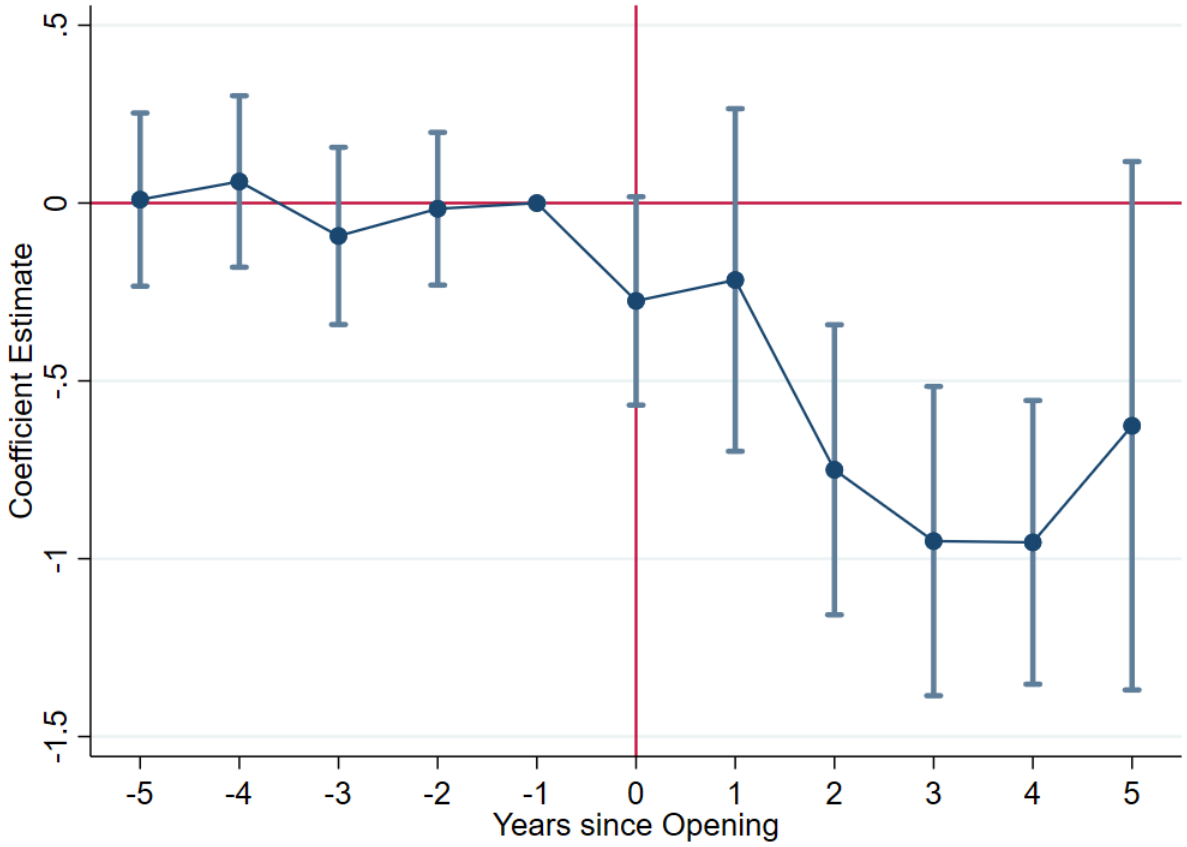
Notes: Dependent variable – inverse hyperbolic sine transformation of opioid related death rate per 100,000. Event study of counties with no substance abuse treatment facility offering MAT with one or more opening throughout 2005-2016. Controls include the fraction of the county population that are white, black, female, ages 0-15, ages 16-34 and ages 35-64 years old, the unemployment rate and the natural log of per capita income. Models include county, year and state by year fixed effects. These estimates are weighted by county population. Standard errors in parenthesis are adjusted for clustering at the county level.

Figure 8: Event Study – Impact of substance abuse facility offering some MAT and accepting Medicaid opening



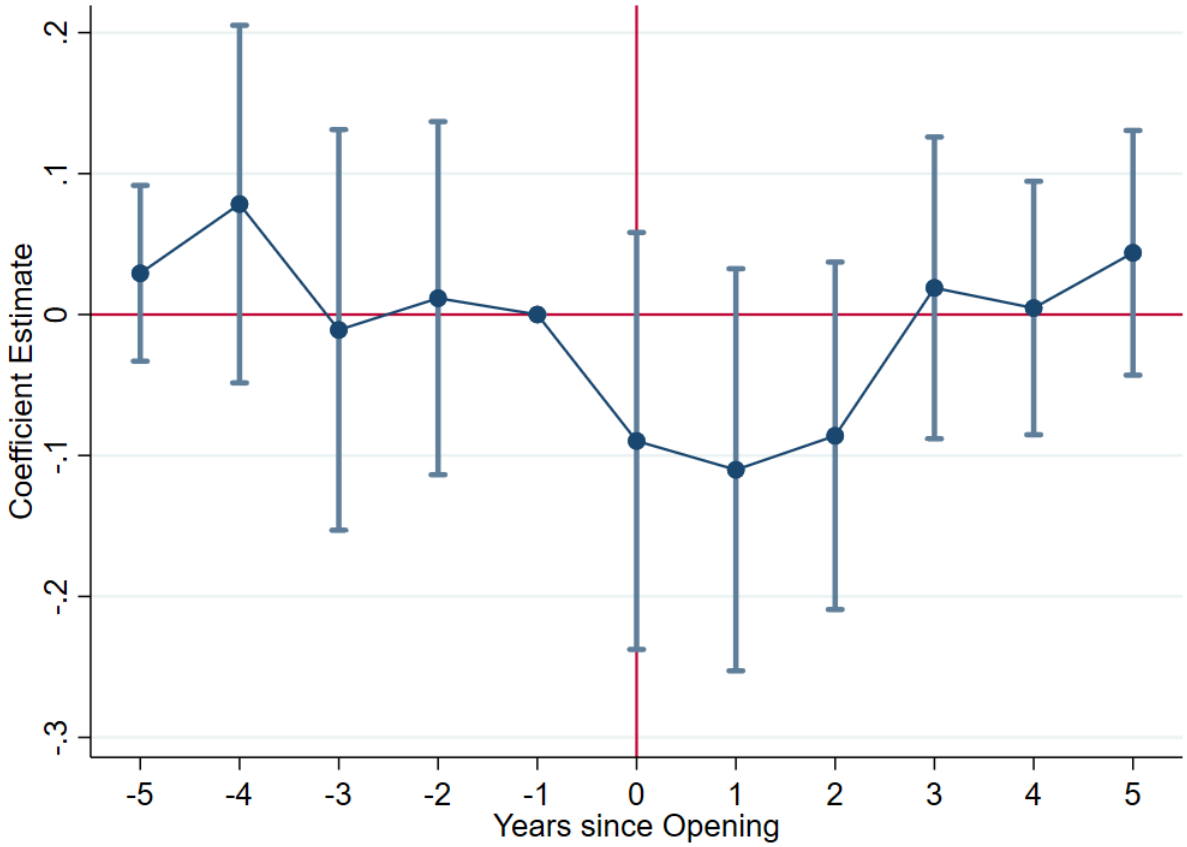
Notes: Dependent variable – inverse hyperbolic sine transformation of opioid related death rate per 100,000. Event study of counties with a single opening of a treatment facility offering MAT and accepting Medicaid throughout 2005-2016. Controls include the fraction of the county population that are white, black, female, ages 0-15, ages 16-34 and ages 35-64 years old, the unemployment rate and the natural log of per capita income. Models include county, year and state by year fixed effects. These estimates are weighted by county population. Standard errors in parenthesis are adjusted for clustering at the county level.

Figure 9: Event Study – Impact of substance abuse facility offering Two plus forms of MAT opening



Notes: Dependent variable – inverse hyperbolic sine transformation of opioid related death rate per 100,000. Event study of counties with a single opening of a treatment facility offering two plus forms of MAT 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 the natural log of per capita income. Models include county, year and state by year fixed effects. These estimates are weighted by county population. Standard errors in parenthesis are adjusted for clustering at the county level.

Figure 10: Event Study – Impact of substance abuse facility offering Two plus forms of 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 two plus forms of MAT 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 the natural log of per capita income. Models include county, year and state by year fixed effects. These estimates are weighted by county population. Standard errors in parenthesis are adjusted for clustering at the county level.

Figure 11a – Simulations, 1,910 treated counties

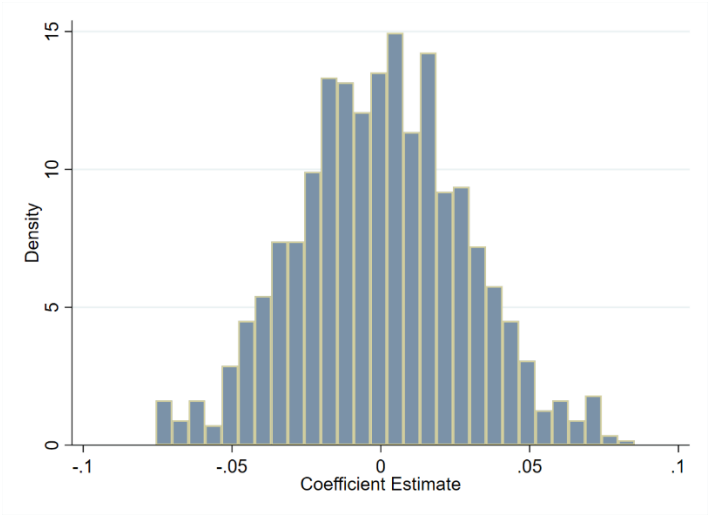


Figure 11b – Simulations, 1,300 treated counties

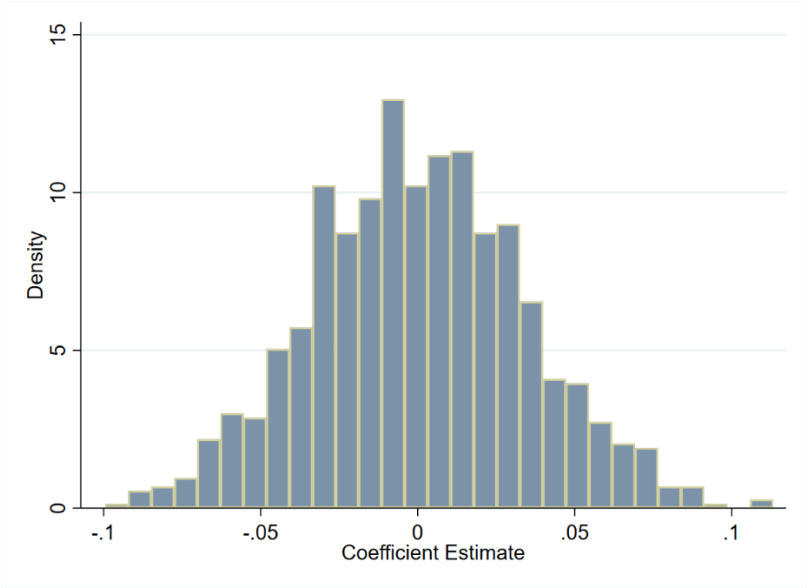
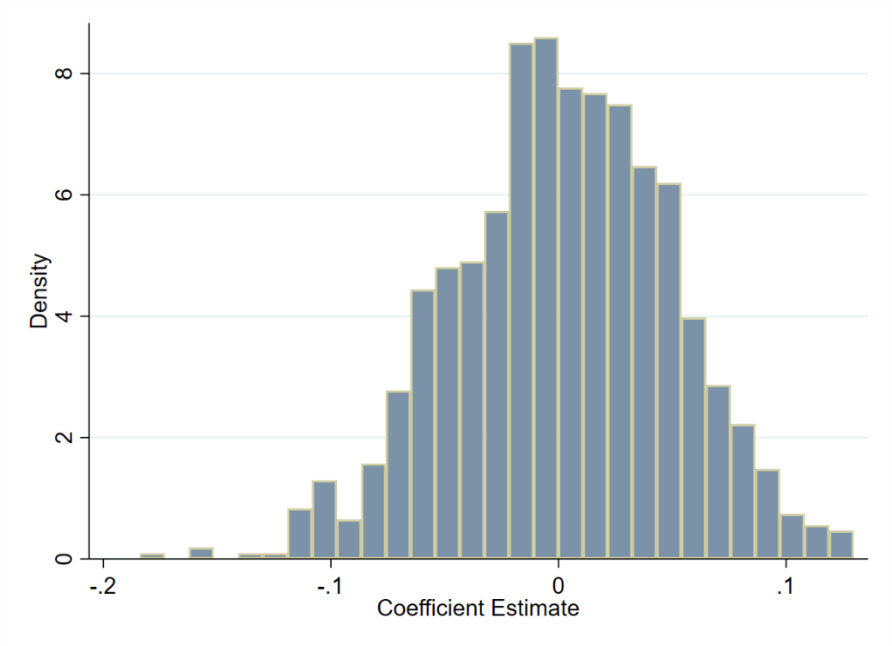


Figure 11c – Simulations 610 treated counties



Notes: Histogram of coefficient estimates obtained from 1,000 simulations. Figure 15a 1,910 counties randomly assigned into a treatment group. Year of treatment is randomly assigned using a uniform distribution Unif [2005, 2016]. Figure 15b 1,300 counties randomly assigned into a treatment group. Figure 15c 610 counties randomly assigned into a treatment group. Sample includes 3,143 counties. State of FL dropped from sample. 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 the natural log of per capita income. Models include county, year and state by year fixed effects. Estimates are weighted by county population. Standard errors in parenthesis are adjusted for clustering at the county level.

Figure 12a – Placebo Regressions – All Substance Abuse Treatment Facilities

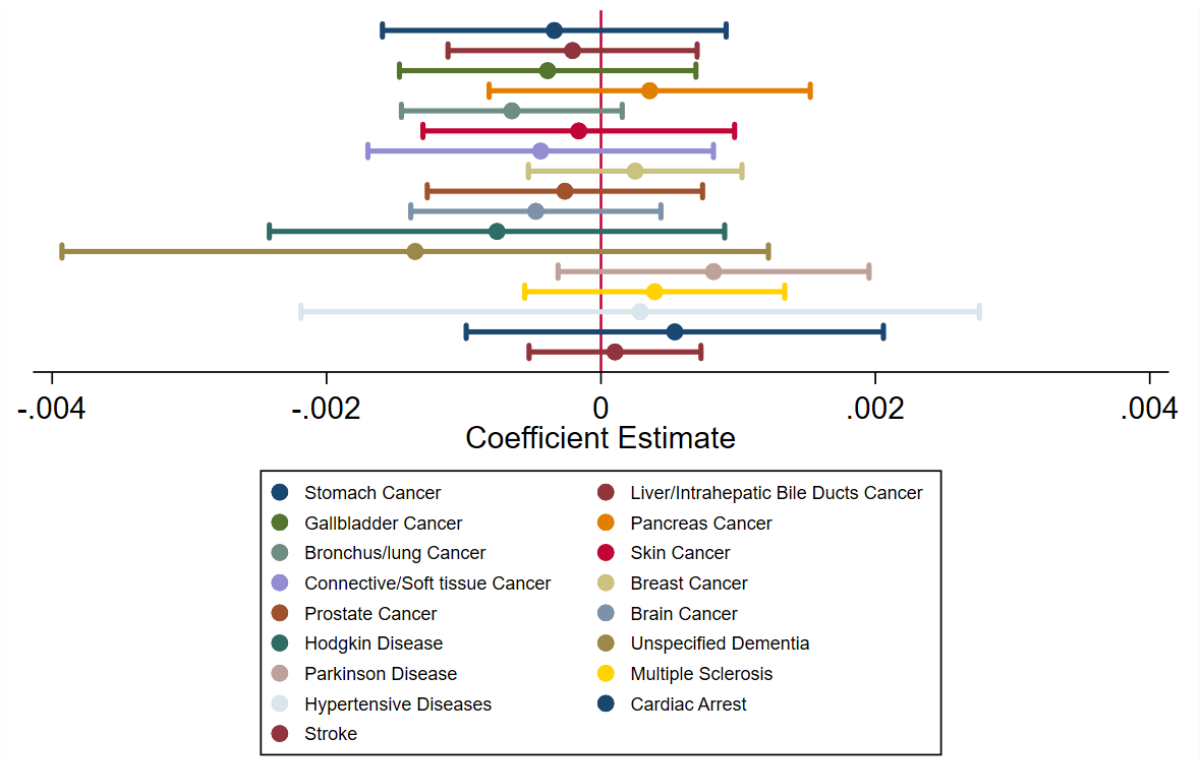


Figure 12b – Placebo Regressions: All Substance Abuse Treatment Facilities Accepting Medicaid

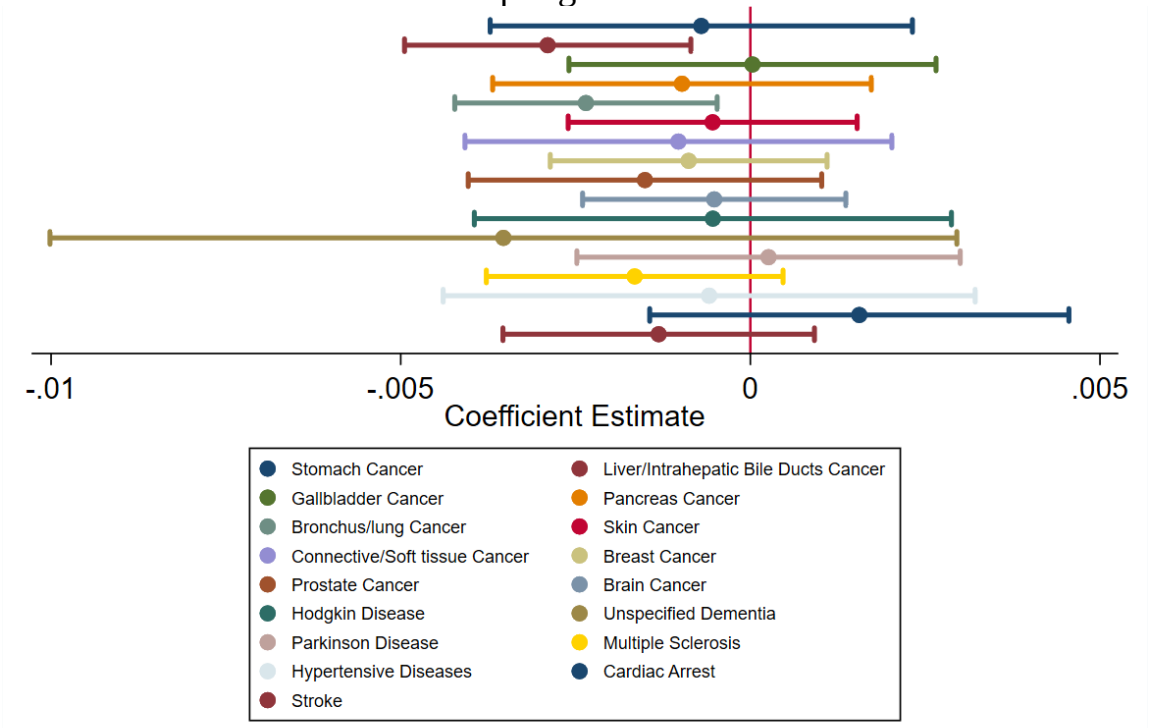
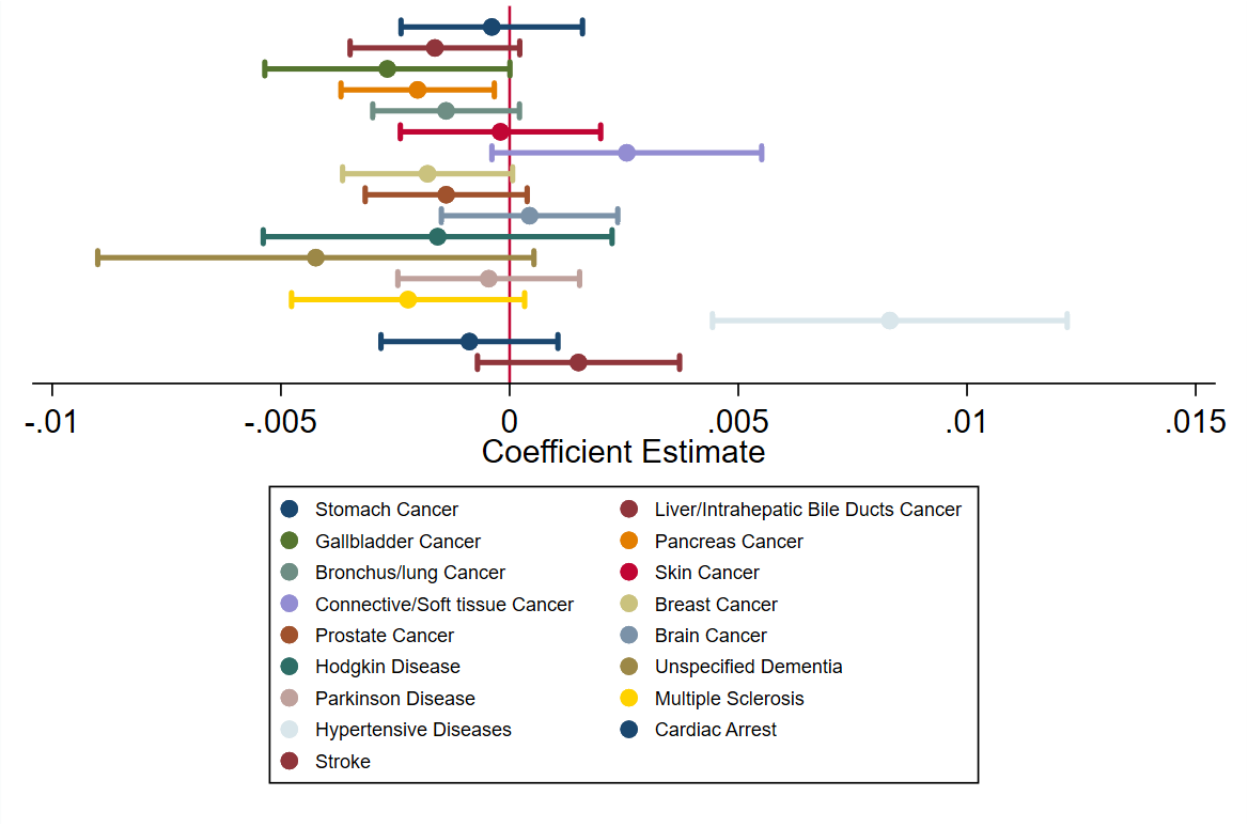


Figure 12c – Placebo Regressions: All Substance Abuse Treatment Facilities Offering Some MAT



Notes: Coefficient plot of estimated impact of substance abuse treatment facilities mortality rates due to other causes. Figure 16a – all substance abuse treatment facilities. Figure 16b – all substance abuse treatment facilities accepting Medicaid. Figure 16c – all substance abuse treatment facilities offering some MAT. 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 the natural log of per capita income. Models include county, year and state by year fixed effects. These estimates are weighted by county population. Standard errors in parenthesis are adjusted for clustering at the county level.

9. Appendix

Table A1
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 Two plus forms MAT and Accepting Medicaid
Panel A: Weighted OLS	-0.00117*	-0.0000921	-0.00154	-0.00661**	-0.000844	-0.00748**
Dependent LN(Death Rate + 1)	(0.000632)	(0.00124)	(0.00205)	(0.00284)	(0.000912)	(0.00344)
N	33,197	33,197	33,197	33,197	33,197	33,197
Mean	7.52	7.52	7.52	7.52	7.52	7.52
Panel B: Unweighted OLS	0.00192	0.00178	-0.00379	-0.00741	-0.00162	-0.0122**
Dependent IHS(Death Rate)	(0.00257)	(0.00336)	(0.00359)	(0.00501)	(0.00203)	(0.00587)
N	33,197	33,197	33,197	33,197	33,197	33,197
Mean	7.52	7.52	7.52	7.52	7.52	7.52
Panel C: Weighted Poisson	-0.00141**	-0.00103	0.00165	-0.00190	0.000241	-0.00452
Dependent Deaths	(0.000560)	(0.000892)	(0.00168)	(0.00238)	(0.000654)	(0.00349)
N	30,276	30,276	30,276	30,276	30,276	30,276
Mean	71.59	71.59	71.59	71.59	71.59	71.59

Notes: 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 county population. Standard errors in parenthesis are adjusted for clustering at the county level. * p<0.10, ** p<0.05, *** p<0.01

Table A2
Estimated effect of any Substance Use Facility Using Lags and Leads

	(1)	(2)	(3)	(4)
Number of Facilities (t-2)		0.00192		
		(0.00117)		
Number of Facilities (t-1)	-0.00157**	-0.00247**	0.00122	0.000333
	(0.000749)	(0.00112)	(0.00120)	(0.00130)
Number of Facilities (t)			-0.00288***	-0.000955
			(0.000943)	(0.00124)
Number of Facilities (t+1)				-0.000981
				(0.000985)
N	33,197	30,181	33,197	30,176
Mean	7.52	7.52	7.52	7.52

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 the natural log of per capita income. Treatment facilities are a count variable: number in a county by year. Models include county, year and state by year fixed effects. 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 A3

Estimated effect of Substance Use Facilities offering MAT and Accepting Medicaid Using Lags and Leads

	(1)	(2)	(3)	(4)
Number of Facilities (t-2)		0.000559		
		(0.00305)		
Number of Facilities (t-1)	-0.00892***	-0.00579	-0.00304	-0.00566**
	(0.00342)	(0.00406)	(0.00280)	(0.00278)
Number of Facilities (t)			-0.00811***	-0.00955***
			(0.00269)	(0.00241)
Number of Facilities (t+1)				0.000692
				(0.00309)
N	33,197	30,181	33,197	30,176
Mean	7.52	7.52	7.52	7.52

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 the natural log of per capita income. Treatment facilities are a count variable: number in a county by year. Models include county, year and state by year fixed effects. 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 A4
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
Panel A: Male	-0.00161**	-0.000336	-0.00369	-0.0112***	-0.00160	-0.0117***
	(0.000761)	(0.00159)	(0.00281)	(0.00379)	(0.00120)	(0.00415)
Mean	10.09	10.09	10.09	10.09	10.09	10.09
Panel B: Female	-0.00131	-0.000550	-0.0000794	-0.00543	-0.000351	-0.00818*
	(0.00104)	(0.00166)	(0.00258)	(0.00341)	(0.00125)	(0.00470)
Mean	5.15	5.15	5.15	5.15	5.15	5.15
N	33,197	33,197	33,197	33,197	33,197	33,197

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 county population. Standard errors in parenthesis are adjusted for clustering at the county level. * p<0.10, ** p<0.05, *** p<0.01

Table A5
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
Panel A: White	-0.00184**	-0.000502	-0.00217	-0.00795**	-0.00152	-0.00893**
	(0.000781)	(0.00153)	(0.00259)	(0.00357)	(0.00114)	(0.00406)
N	33,197	33,197	33,197	33,197	33,197	33,197
Mean	8.75	8.75	8.75	8.75	8.75	8.75
Panel B: Black	0.000425	-0.00127	0.000494	-0.00314	0.00176	-0.00500
	(0.00144)	(0.00223)	(0.00310)	(0.00487)	(0.00156)	(0.00573)
N	33,142	33,142	33,142	33,142	33,142	33,142
Mean	4.62	4.62	4.62	4.62	4.62	4.62
Panel C: Hispanic	0.000862	-0.000527	-0.00189	-0.00437	-0.000142	-0.00226
	(0.000926)	(0.00163)	(0.00135)	(0.00282)	(0.00127)	(0.00324)
N	31,973	31,973	31,973	31,973	31,973	31,973
Mean	3.86	3.86	3.86	3.86	3.86	3.86

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 county population. Standard errors in parenthesis are adjusted for clustering at the county level. * p<0.10, ** p<0.05, *** p<0.01

Table A6
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
Panel A: Urban	-0.00163*	-0.00116	-0.000795	-0.00640	-0.000922	-0.00591
	(0.000844)	(0.00150)	(0.00295)	(0.00405)	(0.00119)	(0.00552)
N	2,493	2,493	2,493	2,493	2,493	2,493
Mean	7.86	7.86	7.86	7.86	7.86	7.86
Panel B: Medium	0.00641	0.00539	-0.00398	-0.00812	0.00517	0.00726
	(0.00651)	(0.00788)	(0.0107)	(0.0127)	(0.00793)	(0.0193)
N	7,432	7,432	7,432	7,432	7,432	7,432
Mean	7.4	7.4	7.4	7.4	7.4	7.4
Panel C: Rural	0.00139	-0.0185	-0.00355	-0.00884	-0.0130	-0.0133
	(0.0158)	(0.0165)	(0.0284)	(0.0319)	(0.0317)	(0.0612)
N	23,126	23,126	23,126	23,126	23,126	23,126
Mean	6.22	6.22	6.22	6.22	6.22	6.22

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 county population. Standard errors in parenthesis are adjusted for clustering at the county level. * p<0.10, ** p<0.05, *** p<0.01

Table A7
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
Panel A: ACS	0.00513*	0.0177***	0.0409***	0.0819***	0.0105***	0.0853***
	(0.0000262)	(0.0000564)	(0.0000620)	(0.000127)	(0.0000247)	(0.000203)
N	8,307	8,307	8,307	8,307	8,307	8,307
Mean	0.66	0.66	0.66	0.66	0.66	0.66
Panel B: BLS	0.00195	0.0230*	0.0190	0.0799***	0.000889	0.0921***
and NHCS	(0.0000621)	(0.000133)	(0.000140)	(0.000255)	(0.0000575)	(0.000327)
N	33,769	33,769	33,769	33,769	33,769	33,769
Mean	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, female, ages 0-15, ages 16-34 and ages 35-64 years old, the unemployment rate and the natural log of per capita income. Treatment facilities are a count variable per county per year by type of facility. Models include county, year and state by year fixed effects. 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 A8
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
Panel A: Log Median	0.0000202	0.0000219	0.000104	-0.000225	0.000162*	0.000595
Household Income	(0.0000826)	(0.000166)	(0.000303)	(0.000362)	(0.0000876)	(0.000447)
Mean	61,585	61,585	61,585	61,585	61,585	61,585
Panel B: Log Median	0.000267**	0.000525**	0.000417	0.000754	0.000273**	0.000551
Non-Family Income	(0.000107)	(0.000260)	(0.000283)	(0.000549)	(0.000135)	(0.000623)
Mean	38,220	38,220	38,220	38,220	38,220	38,220
Panel C: Log Mean	0.000122*	0.000214*	-0.000166	-0.000346	-0.0000295	0.000174
Household Income	(0.0000646)	(0.000127)	(0.000238)	(0.000278)	(0.0000604)	(0.000438)
	82,321	82,321	82,321	82,321	82,321	82,321
Panel D: Log Mean	0.000255***	0.000423*	0.0000453	0.000204	-0.0000600	0.000207
Non-Family Income	(0.0000980)	(0.000230)	(0.000218)	(0.000374)	(0.000113)	(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 white, black, female, ages 0-15, ages 16-34 and ages 35-64 years old, the unemployment rate and the natural log of per capita income. Treatment facilities are a count variable per county per year by type of facility. Models include county, year and state by year fixed effects. 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 A9
Estimates of Changes in County Population Composition

	Substance Abuse Facilities	SA Facilities Accepting Medicaid	Facilities Providing Some MAT
Population Share Ages 16-34	-0.00000881	-0.0000450*	-0.0000250
	(0.0000119)	(0.0000261)	(0.0000204)
Population Share Female	0.00000515	0.00000676	-0.00000341
	(0.00000322)	(0.00000537)	(0.00000602)
Population Share White	0.00000967	0.00000669	0.000113*
	(0.0000233)	(0.0000460)	(0.0000654)
Population Share Black	-0.0000138	-0.0000357	-0.000157***
	(0.0000235)	(0.0000480)	(0.0000577)
N	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, year and state by year fixed effects. 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 A10
ICD-10 Codes Used for Placebo Analysis

Cause of Death	ICD-10 Codes
Malignant neoplasm of stomach	C16
Malignant neoplasm of liver and intrahepatic bile ducts	C22
Malignant neoplasm of gallbladder	C23
malignant neoplasm of pancreas	C25
Malignant neoplasm of bronchus and lung	C34
Melanoma and other malignant neoplasms of skin	C43-C44
Malignant neoplasm of other connective and soft tissue	C49
Malignant neoplasm of breast	C50
Malignant neoplasm of prostate	C61
Malignant neoplasm of brain	C71
Hodgkin Disease	C81
Unspecified Dementia	F03
Parkinson Disease	G20
Multiple Sclerosis	G35
Cardiac Arrest	I46
Stroke	I64

Notes: ICD-10 codes used to identify cause of death in falsification tests