Closing the Opioid Use Disorder Treatment Gap: Expanding Nurse Practitioners' Prescriptive Authority

By Lance Gui*

10/29/2025

Buprenorphine, like nicotine gum for quitting smoking, provides a safe treatment for opioid withdrawal, yet access remains limited. The 2016 Comprehensive Addiction and Recovery Act (CARA) enabled Nurse Practitioners (NPs) to prescribe buprenorphine. Leveraging pre-existing state-level NP prescribing authority and comparing pre- and post-CARA periods, I find that allowing NPs to prescribe buprenorphine independently expands the pool of active buprenorphine prescribers, increases buprenorphine dispensation, and reduces opioid-related mortality by over 20%, without replacing specialized treatment. Gains were concentrated in underserved counties, with limited effects elsewhere. Finally, there is suggestive evidence of increased diversion into the secondary market.

JEL: I14, I18, J44

Keywords: opioid epidemic, demand-side policy, nurse practitioners

* gui@arizona.edu. I am deeply grateful to Mo Xiao for her invaluable mentorship and guidance throughout this project. I extend my sincere thanks to Christian Cox, Hidehiko Ichimura, and Matthijs Wildenbeest for their thoughtful and detailed feedback. I also appreciate the insightful discussions with Susan Bratton, M.D., Mark Grant, M.D., and Lynn Webster, M.D., whose expertise was instrumental in ensuring the accuracy of the medical contexts presented in this paper and grounding the paper in reality. Additionally, I am thankful for the constructive comments and suggestions from Ami Ichikawa, Aljoscha Janssen, Haizhen Lin, Molly Schnell, Austin Smith, Yi Zhang, and seminar participants at the University of Arizona. All remaining errors are my own.

Conflict of Interests: I declare that I have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

I. Introduction

Opioid use disorder (OUD) remains a leading public health concern in the United States, contributing to three-quarters of all overdose deaths. Synthetic opioids like fentanyl are now the leading cause of death for Americans aged 18 to 45.[1] While medications such as buprenorphine are shown to reduce opioid misuse and overdose risk (Connery 2015; Timko et al. 2016; Ma et al. 2019), a substantial treatment gap persists. Recent estimates suggest that 87% of individuals who could benefit from medication for OUD remain untreated (Krawczyk et al., 2022).

A key contributor to this gap is the limited availability of qualified prescribers. In 2016, nearly one-third of Americans lived in counties without a federally designated opioid treatment program (OTP), and fewer than 10% of primary care physicians were authorized to prescribe buprenorphine (McBain et al., 2020). To address provider shortages, the Comprehensive Addiction and Recovery Act (CARA) of 2016 expanded prescribing authority to Nurse Practitioners (NPs), who comprise approximately 20% of the primary care workforce.[2]

This policy change raises a number of questions. Did expanding buprenorphine prescribing authority to NPs meaningfully increase access to treatment? Did it improve health outcomes? And through what mechanisms did these improvements occur? I study these questions using a difference-in-differences (DiD) framework that exploits variation introduced by CARA, which authorized NPs to prescribe buprenorphine for the first time. Crucially, the effect of this federal reform depends on whether a state permits NPs to prescribe independently. In full-practice states, NPs were able to prescribe buprenorphine without physician oversight following CARA's enactment. In contrast, NPs in restricted-practice states remained subject to supervision or collaboration requirements, limiting the practical impact of the federal reform. I leverage the interaction between federal and state policy, comparing outcomes before and after CARA across states with differing scope-of-practice laws. This design isolates the effect of allowing NPs to prescribe buprenorphine independently, referred to throughout as "the policy."

I begin by examining whether the policy led to greater treatment access. Using Medicare Part D data, I find that NP prescribing of buprenorphine increased substantially, representing

[1] National Center for Health Statistics, Multiple Cause of Death via CDC WONDER, Accessed: 09/07/2024
[2] Primary care is defined here as family practice, internal medicine, and general practice physicians, as well as NPs.

an expansion equivalent to 27% of all buprenorphine prescribers prior to CARA by 2019. Automation of Reports and Consolidated Orders System (ARCOS), which tracks the distribution of controlled substances, indicates a 26% increase in buprenorphine dispensation attributable to the policy. This expansion led to a 22% reduction in opioid-related mortality, based on data from the National Center for Health Statistics. To my knowledge, this is the first study to document population-level health effects of buprenorphine treatment outside controlled clinical settings.

The decline in mortality appears to operate through two primary channels. First, the policy expanded the prescriber pool by both enabling NPs to enter the buprenorphine market and encouraging participation by other primary care providers. The policy led to a 47% increase in the number of active buprenorphine prescribers per capita, including NPs, while the average number of prescriptions per provider declined. This pattern points to an extensive margin response. Importantly, the policy increased the total supply of prescribers rather than reallocating prescribing activity from specialists to primary care providers. There is no evidence that the policy reduced prescribing by psychiatrists or addiction medicine specialists, and it did not displace care provided through OTPs. Second, the policy helped narrow geographic disparities in access to treatment. Opioid-related mortality fell by approximately 30% in counties lacking access. In contrast, counties with prior access experienced no statistically significant change in mortality, despite increases in dispensation across both groups. This asymmetry suggests that expanding NP prescribing authority can be an especially effective tool in underserved areas, where newly active prescribers help fill gaps in care. In contrast, adding more prescribers in already well-served areas appears to yield limited marginal benefits.

As buprenorphine prescribing expanded, an important concern is whether easier access also made the drug more available outside of treatment settings. This worry reflects the history of the opioid crisis, which was fueled in part by widespread availability of prescription opioids (Alpert, Powell and Pacula 2018; Currie and Schwandt 2021; Alpert et al. 2022). Evidence from StreetRx, a platform that tracks self-reported illicit drug transactions, shows that street prices for buprenorphine dropped sharply after the policy change. At the same time, survey data from the National Survey on Drug Use and Health (NSDUH) show no decline in self-reported

misuse of prescription opioids. These analyses can only be conducted at the state level. Because state-level results are likely driven by large, high-access counties, they suggest why counties with greater baseline buprenorphine access saw increased use without corresponding reductions in mortality, in contrast to underserved areas.

I do not estimate the overall treatment effect of CARA. Instead, I focus on a single provision: granting NPs the authority to prescribe buprenorphine independently. This empirical strategy isolates the causal effect of this policy change. The design is not sensitive to contemporaneous federal policies, such as grant allocations to states, provided that states respond uniformly to such changes. Nor is it confounded by other state-level initiatives, such as expanding over-the-counter access to naloxone, since the overlap with NP full-practice authority is limited. I later present evidence showing that the observed effects are not driven by other aspects of CARA or by unrelated federal or state reforms. This distinction is crucial in an era of numerous federal and state reforms, as it allows me to credibly identify the effect of expanded treatment access through NP prescribing authority.

This policy appears particularly effective compared with other demand-side interventions.[3] Prior to the policy, 62% of all counties had no access to buprenorphine. Its effectiveness likely stems from alleviating this critical constraint, particularly in small and rural communities. Policymakers have continued to relax prescribing requirements in subsequent years. The 2023 Omnibus Bill further expanded prescribing rights to all DEA-registered providers, eliminating waiver requirements entirely. The evidence in this paper suggests that the marginal returns to adding prescribers are diminishing. Such diminishing returns are already evident in counties with high baseline access, where additional prescribing capacity has not translated into lower mortality. These findings underscore that expanding prescribing authority is only one component of an effective policy response. To translate access into improved treatment outcomes, policymakers must design complementary interventions that strengthen patient engagement and address diversion risks. Without appropriate safeguards, the same accessibility that enables treatment could also increase opportunities for misuse.

[3]For example, Abouk, Pacula and Powell (2019) find that pharmacist naloxone access reduced mortality by 0.03 per 100,000, while the policy studied here reduced mortality by more than 2 per 100,000. Medicaid expansion has shown little impact on opioid mortality (Averett, Smith and Wang, 2019; Abouk et al., 2021).

***Literature*:** First, this is the first paper to evaluate the effectiveness of medications for OUD at the population level. Existing evidence largely comes from cohort studies (e.g., Degenhardt et al. 2014; Larochelle et al. 2018; Dever et al. 2024) and meta-analyses (e.g., Ma et al. 2019; Sordo et al. 2017), which consistently find that buprenorphine reduces mortality by roughly 50% among individuals with OUD. However, these studies are typically limited to select subpopulations, such as patients admitted for non-fatal overdose, and may be subject to selection bias. By contrast, I use a quasi-experimental design that captures a broader and more representative population. I find that expanding buprenorphine access reduces opioid-related mortality by 22% at the county level.

Second, this paper contributes to the literature on the health effects of NPs' scope of practice. Traczynski and Udalova (2018) document that NP autonomy improves access to primary care and reduces emergency room utilization. Alexander and Schnell (2019) find that granting NPs authority to prescribe unscheduled medications leads to improvements in mental health. More recent work uses the staggered adoption of NP scope-of-practice laws to study broader effects on access and prescribing behavior (e.g., Currie, Li and Schnell 2023). This paper extends this literature by focusing on the novel and policy-relevant outcomes of buprenorphine prescribing and subsequent opioid-related mortality. I use an alternative strategy that combines two policy variations: CARA's 2016 authorization of NP buprenorphine prescribing and state-level practice restrictions. This approach isolates the causal effect of allowing NPs to prescribe independently. The results show that this expansion increased the number of active buprenorphine prescribers, improved access to treatment, and led to meaningful reductions in opioid-related mortality.

Third, this is the first paper in the economics literature to evaluate the impact of CARA on treatment expansion, contributing to a broader policy discussion around the opioid crisis. While prior work has predominantly focused on supply-side measures, such as the 2010 OxyContin reformulation (Severtson et al., 2013; Alpert, Powell and Pacula, 2018; Evans, Lieber and Power, 2019), the implementation of prescription drug monitoring programs (Mallatt, 2018, 2022), and DEA enforcement targeting rogue distributors (Donahoe, 2023; Gui, Qin and Xiao, 2024; Soliman, 2025). These policies have often reduced access to prescription opioids without improving health outcomes, and in some cases, have led to substitution into illicit markets. In contrast,

recent policy discussions have turned toward demand-side responses, including harm reduction strategies and expanded access to treatment. One area of recent focus has been naloxone access laws, which show mixed evidence: while some studies report mortality reductions (Abouk, Pacula and Powell, 2019; Rees et al., 2019), others find no mortality effect but increased emergency department visits (Doleac and Mukherjee, 2022). This paper raises similar concerns about buprenorphine, namely, potential diversion as evidenced by declining secondary market prices. However, unlike naloxone, which is administered reactively, buprenorphine can substitute for more dangerous opioids in daily use. The findings show that expanded buprenorphine access reduces opioid-related mortality, suggesting it may offer broader population health benefits than harm reduction policies alone.

The remainder of the paper is structured as follows. Section II describes the data sources and construction of key variables. Section III outlines the empirical strategy, including the DiD design and associated identification challenges. Section IV presents the main findings on the effects of granting NPs independent authority to prescribe buprenorphine. Section V explores the mechanisms underlying these effects, including patterns of prescriber entry and differential mortality reduction. Section VI examines potential unintended consequences, including evidence of diversion to the secondary market. Section VII reports a series of robustness checks. Section VIII discusses implications for the regulation of OUD treatment and offers policy recommendations. Section IX concludes.

II. Data

This analysis draws on three primary data sources to examine how granting NPs the authority to independently prescribe buprenorphine affects treatment availability, shipments to pharmacies, and opioid-related mortality between 2012 and 2019. States are classified based on the extent of NP scope-of-practice authority following McMichael and Markowitz (2023), distinguishing between full-practice states, where NPs may prescribe without physician oversight, and restricted-practice states, where such independence is prohibited. Key features of the data are summarized below; additional institutional details are provided in Appendix A.

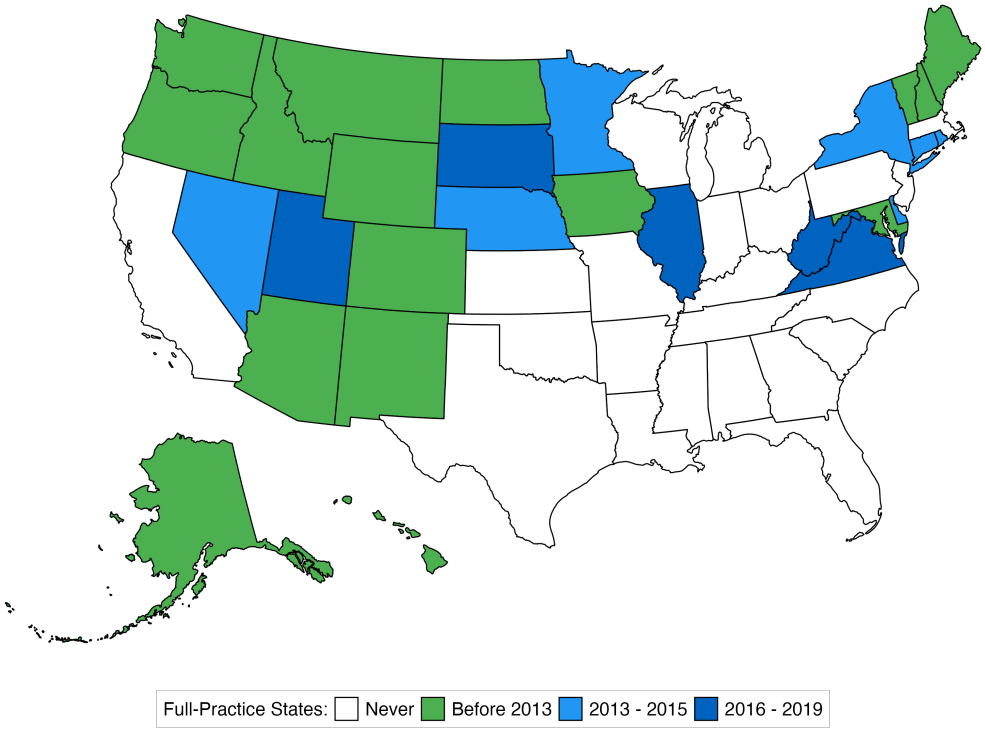


Figure 1. State Scope-of-Practice Law Status

Note: The term "full-practice states" denotes jurisdictions where NPs are authorized to prescribe controlled substances independently, without requiring supervision or collaboration with physicians. In essence, an NP's ability to prescribe is not contingent upon a doctor's oversight.

A. Scope-of-Practice State-level Regulation

Scope-of-practice laws for NPs differ significantly across states, with substantial variation in the specific language of the regulations. Following the classification by McMichael and Markowitz (2023), I categorize states as either full-practice or restricted-practice based on whether NPs can establish independent practices without physician collaboration or supervision. Figure 1 illustrates the adoption of full-practice authority for NPs by episodes. Before 2013, 17 states, including the District of Columbia, allowed NPs to prescribe Schedule II-V controlled substances independently. Between 2013 and 2019, an additional 12 states transitioned to full-practice status, reflecting a nationwide expansion of NP prescriptive authority. However, several states,

particularly in the South and large states like California, Texas, and Florida, continue to impose restrictions on NP independence.

Although states differ in scope-of-practice laws and geography, the composition of primary care providers is broadly similar across those with and without full practice authority. Table D1 reports 2015 provider counts for general practice physicians (including family practice) and NPs per 100,000 residents in each group.[4] At the state level, the supply of NPs and general practice physicians does not differ meaningfully between full-practice and restricted-practice states. This finding is consistent with Alexander and Schnell (2019), who show that adoption of full-practice authority reflects political and institutional factors rather than underlying healthcare needs. While state-level comparisons indicate broad similarity, more localized imbalances could still bias estimates. To address this possibility, the main analysis uses a synthetic DiD approach that reweights counties to ensure comparability in pre-treatment characteristics and trends.

B. Access to OUD Treatment

This analysis draws on two primary datasets to measure local access to OUD treatment: (1) the Drug Enforcement Administration's Automation of Reports and Consolidated Orders System (ARCOS), and (2) the Medicare Part D Provider and Drug dataset. These sources allow me to identify both methadone-dispensing OTPs and buprenorphine prescribers at the county level in 2013, prior to the policy change.

ARCOS is a national surveillance system established under the Controlled Substances Act of 1971. It tracks shipments of controlled substances from manufacturers and distributors to retail-level facilities, including hospitals, pharmacies, and OTPs. The dataset records the date, quantity, dosage, and National Drug Code for each shipment, as well as the identities of the sending and receiving entities. I use ARCOS to identify OTPs that received methadone for OUD treatment, defined by the presence of detoxification or maintenance service codes associated with the receiving entity and methadone-specific NDCs.[5] In parallel, I use Medicare Part D data to identify prescribers of buprenorphine-naloxone—the dominant formulation for outpatient

[4]Provider data are from June 9, 2015, retrieved via the Wayback Machine archive of the NPPES NPI registry: Wayback Machine. Accessed: 10/20/2024

[5]This excludes methadone formulations primarily indicated for pain.

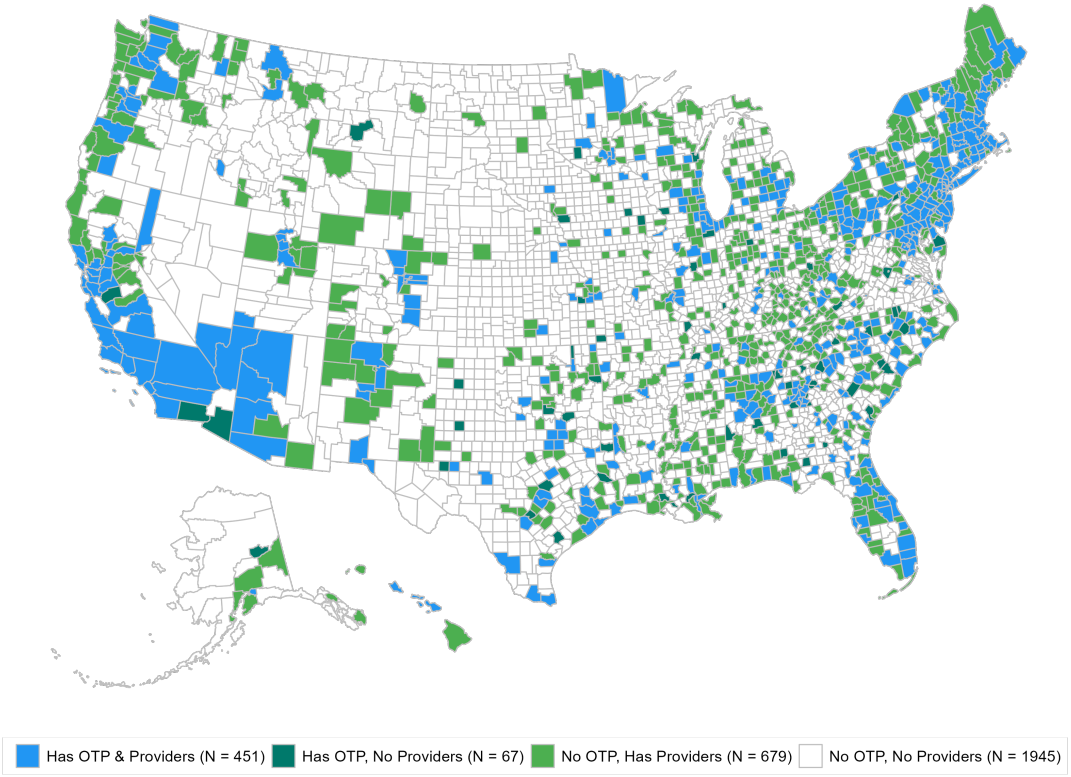


Figure 2. Geographic Distribution of OUD Treatment Access in 2013

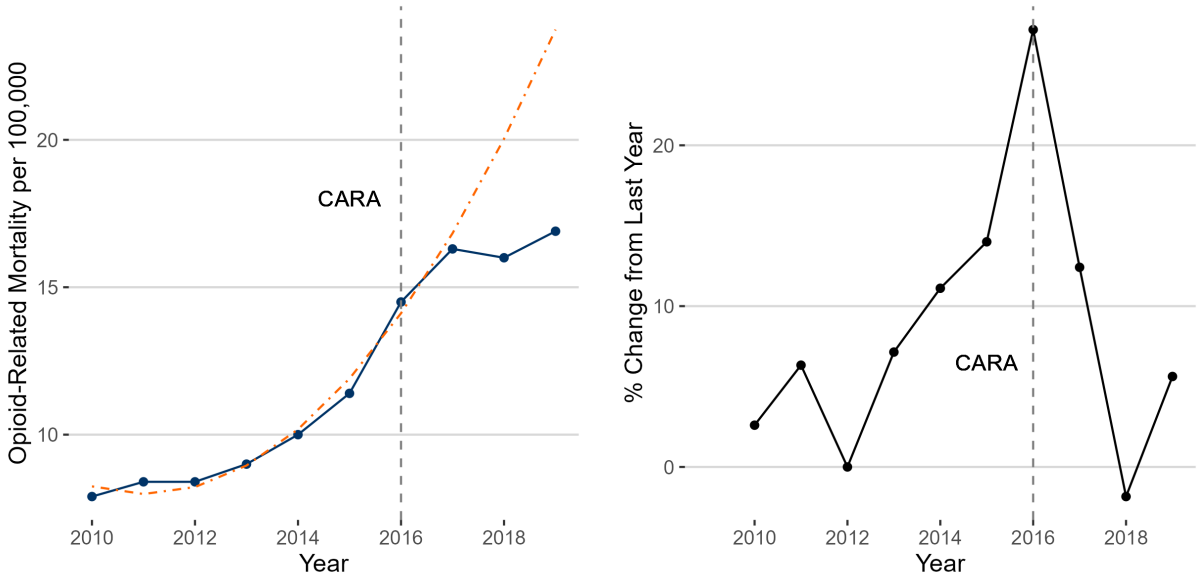
Note: Access to OTPs is identified through ARCOS data if the facility is listed for maintenance or detoxification services and received methadone shipments for OUD, as indicated by National Drug Codes. Provider access is measured by the presence of Medicare Part D prescribers who issued prescriptions for buprenorphine-naloxone, the most common buprenorphine formulation used in OUD treatment.

treatment. This dataset reports, for each provider-drug pair, the number of claims and total spending. Prescribers with 10 or fewer claims are excluded. Although Medicare represents only a subset of buprenorphine prescribers, I show in Appendix B that the number of Medicare buprenorphine prescribers in a county strongly predicts the total number of authorized providers based on DEA public request records.

Using these two sources, I classify OUD treatment access as follows: a county is considered to have access if it contains at least one methadone-dispensing OTP or one Medicare Part D buprenorphine-naloxone prescriber. Figure 2 maps access across the United States in 2013. Approximately 62% of counties lacked both an OTP and a Medicare buprenorphine prescriber.

About 13% of the U.S. population resided in such counties, while 31% lived in counties without OTP access. These gaps are especially acute in rural areas, including in regions heavily affected by the opioid crisis, such as Appalachia.

C. Health Outcomes



(a) Opioid-Related Mortality Rate

(b) Percentage Change in Mortality

Figure 3. National Trends in Opioid-Related Mortality

Note: The figures depict opioid-related mortality per 100,000 people, sourced from the National Vital Statistics System using codes T40.0–T40.4, as well as X42, X62, and Y12. The dashed orange line in Subfigure 3a represents a polynomial fit for the pre-2016 trend (2010–2016). Subfigure 3b shows the percentage change from the previous year, calculated as $(Y_t - Y_{t-1})/Y_{t-1}$.

The health outcome I focus on is opioid-related mortality. The opioid-related mortality data are from the restricted National Vital Statistics System for the years 2012 to 2019. This dataset provides granular details on the date and location (down to the county level) of all deaths in the United States, along with their causes. Following standard practice in opioid research, I use multiple cause-of-death codes to identify fatal drug overdoses involving opioids, specifically T40.0–T40.4, X42, X62, and Y12.

Figure 3a shows the overall trend in opioid-related mortality rates, while Figure 3b highlights the annual percentage changes. Notably, between 2016 and 2017, the United States saw its first decline in opioid-related deaths per capita in 25 years, and this trend remained relatively stable until the onset of the COVID-19 pandemic. This stabilization, following years of exponential growth, suggests a significant shift occurred in 2016.

This stylized fact motivates the broader question of what occurred during this period to explain the change, and in particular whether the national trend differed across states in ways that policymakers can learn from. This paper focuses on one key difference that could drive divergent mortality trends: whether states allowed NPs to prescribe buprenorphine independently. The paper does not attempt to explain why mortality declined nationally, since multiple federal and state policies were enacted in 2016—for example, the CDC's opioid prescribing guidelines and Arizona's over-the-counter naloxone law—making it difficult to attribute the change to a single cause. Instead, I compare states with restricted practice authority to those with full practice authority. Using mortality as an illustrative outcome, this comparison isolates the additional reduction observed in full-practice states, which I interpret as the effect of granting NPs independent authority to prescribe buprenorphine.

III. Empirical framework

A. Event Study Difference-in-Differences

To estimate the impact of granting NPs independent prescribing authority for buprenorphine, I use an event-study DiD framework that exploits the timing of CARA as policy variation. CARA was enacted on July 22, 2016, marking the start of the post-policy period. By November 17, 2016, NPs were authorized to begin the required 24 hours of training, typically offered online, to qualify for prescribing buprenorphine for OUD, following a process similar to physicians.[6] On February 27, 2017, NPs were formally permitted to prescribe buprenorphine.[7]

[6]The key difference is that NPs were required to complete 24 hours of approved training, compared with 8 hours for physicians. Medication for Substance Use Disorder Training.

[7]Consistent with this timeline, NP prescribing first appears in pharmacy claims data in July 2017, according to the Medicaid and CHIP Payment and Access Commission: MACPAC Report on Buprenorphine Prescribing. Similar evidence appears in DEA waiver counts by October 2017, although no data are available prior to that date: DEA Qualifying Practitioners by State [Accessed: 10/12/2025].

Although implementation lagged enactment, evidence points to behavioral responses beginning at the time of enactment. In particular, primary care physicians began prescribing buprenorphine in 2016, before NPs could enter, a mechanism discussed in detail later.[8] I therefore align treatment with the 2016 enactment date and use 2015 as the baseline ($k = 2015$).

The treatment group consists of states with full-practice authority, in which NPs could prescribe independently following CARA. The control group includes states with restricted-practice authority, where NPs remained subject to physician oversight. The main outcome variable, Y_{it}, is measured at the county-year or state-year level. I examine several outcomes, such as the number of NPs actively prescribing buprenorphine, per capita buprenorphine dispensation, and per capita opioid-related mortality. The sample is restricted to the years 2012–2019 and excludes states that modified NP scope-of-practice laws during this period. The estimating equation is given by:

$$Y_{it} = \sum_{k \neq 2015} \tau_k^{did} \times Treat_i + X_{it}\delta + \phi_i + \psi_t + \epsilon_{it} \tag{1}$$

Here, τ_k^{did} captures the year-specific treatment effect relative to 2015. The vector X_{it} includes demographic and socioeconomic controls (e.g., age, gender, race, income, educational attainment, poverty, and unemployment rates), as well as state-level policies that may influence opioid-related outcomes. These policies include: (i) naloxone access laws, which enhance public access to the opioid overdose reversal drug; (ii) involuntary commitment laws for substance use, which allow courts to mandate treatment for individuals arrested for drug-related offenses; (iii) informed consent laws requiring disclosure of risks before opioid prescribing; (iv) limits on opioid prescribing duration or dosage; (v) prescription drug monitoring programs, which track controlled substance prescriptions; and (vi) Medicaid expansion under the Affordable Care Act. Additionally, ϕ_i and ψ_t represent unit- and year-fixed effects, respectively.

[8] Anticipatory responses to policy changes are common in health care (e.g., Medicare Part D; Alpert, 2016), and opioid policies often exhibit effects at announcement rather than implementation (e.g., Sedney et al., 2021). Consistent with competitive pressure from expected NP entry, physicians have been shown to adjust prescribing in advance (Currie, Li and Schnell, 2023).

B. *Event Study Synthetic Difference-in-Differences*

To improve comparability between treated and control counties, I implement the synthetic DiD estimator developed by Arkhangelsky et al. (2021) and adapt it to an event study framework. This approach reweights control units so that their pre-treatment outcome trajectories more closely resemble those of the treated units, helping to address violations of the parallel trends assumption. For example, if average treated counties experienced a gradual rise in buprenorphine dispensation before the policy, the estimator assigns greater weight to control counties with similar upward trends rather than averaging over all control counties, many of which may have flat or declining trends. This targeted weighting reduces the influence of dissimilar units and improves the credibility of the estimated policy effect.

I begin by residualizing the outcome with respect to covariates and fixed effects, thereby controlling for these factors to align with the design in Equation 1. I then estimate treatment effects by tracking how treated units deviate from their synthetic controls over time. This framework produces a set of year-specific estimates, τ_t^{sdid}, which are directly comparable to the coefficients from the event study specification in Equation 1.

The procedure begins by estimating a two-way fixed effects regression:

$$Y_{it} = X_{it}\beta + \delta_i + \gamma_t + u_{it}, \tag{2}$$

and then constructing residualized outcomes:[9]

$$\tilde{Y}_{it} = Y_{it} - X_{it}\hat{\beta} - \hat{\delta}_i - \hat{\gamma}_t \tag{3}$$

Let N index all units, with N_{tr} treated units and $N_{co} = N - N_{tr}$ controls. Unit weights $\hat{\omega}_i$ are chosen to minimize pre-treatment imbalances such that: $\sum_{i=1}^{N_{co}} \hat{\omega}_i \tilde{Y}_{it} \approx N_{tr}^{-1} \sum_{i=N_{co}+1}^{N} \tilde{Y}_{it}$ for all $t \leq T_{pre}$. Time weights $\hat{\lambda}_t$ are also estimated to balance pre- and post-treatment periods. Details of the weight estimation procedure are provided in Appendix C, which follows the steps

[9]This approach deviates slightly from the original method proposed in Arkhangelsky et al. (2021), which regresses Y directly on covariates without fixed effects. However, based on findings by Kranz (2023), I opt for residualization with fixed effects.

outlined in Arkhangelsky et al. (2021).

The synthetic control outcome for treated unit j in year t is defined as $\tilde{Y}_{jt}^{co} = \sum_{i=1}^{N_{co}} \hat{\omega}_i \tilde{Y}_{it}$, and the event study estimate is computed as:

$$\tau_t^{sdid} = \left(\bar{\tilde{Y}}_t^{tr} - \bar{\tilde{Y}}_t^{co}\right) - \left(\bar{\tilde{Y}}_{baseline}^{tr} - \bar{\tilde{Y}}_{baseline}^{co}\right) \tag{4}$$

In the standard DiD approach, the baseline is typically fixed, often the year prior to treatment. In Equation 1, 2015 serves as the baseline. However, in the synthetic DiD approach, pre-treatment weights are optimally chosen as $\hat{\lambda}_t$, which implies a data-driven baseline constructed from the pre-treatment period.[10]

$$\bar{\tilde{Y}}_{baseline}^{tr} = \sum_{t=1}^{T_{pre}} \hat{\lambda}_t \bar{\tilde{Y}}_t^{tr}, \quad \text{and} \quad \bar{\tilde{Y}}_{baseline}^{co} = \sum_{t=1}^{T_{pre}} \hat{\lambda}_t \bar{\tilde{Y}}_t^{co} \tag{5}$$

Lastly, the confidence intervals for τ_t^{sdid} are constructed using bootstrap methods, by re-sampling treated units with replacement for 1,000 iterations and recalculating the estimates, essentially equivalent to standard errors clustered at the treatment unit level.

C. Interpretation of the Treatment

Figure 4 shows how CARA interacts with state-level NP regulations to generate treatment variation. In restricted-practice states, NPs may prescribe buprenorphine only under physician supervision and can obtain a waiver only if their supervising physician also holds one. This arrangement may expand prescribing capacity within existing practices, but it does not increase the number of treatment locations. In contrast, in full-practice states, CARA allows NPs to obtain waivers and prescribe independently. Even if the total number of NPs receiving waivers

[10] Unit weights $\hat{\omega}_i$ remain fixed across post-treatment periods, as they are determined solely by pre-treatment fit. However, the event study framework raises the question of whether time weights should vary across post-treatment years. To assess this, I recalculate time weights separately for each post-treatment period by iteratively including one additional post-treatment year in the pre-treatment set used to generate $\hat{\lambda}_t$. This alternative weighting scheme yields results nearly identical to the baseline specification, indicating that the estimated effects are not sensitive to how time weights are constructed.

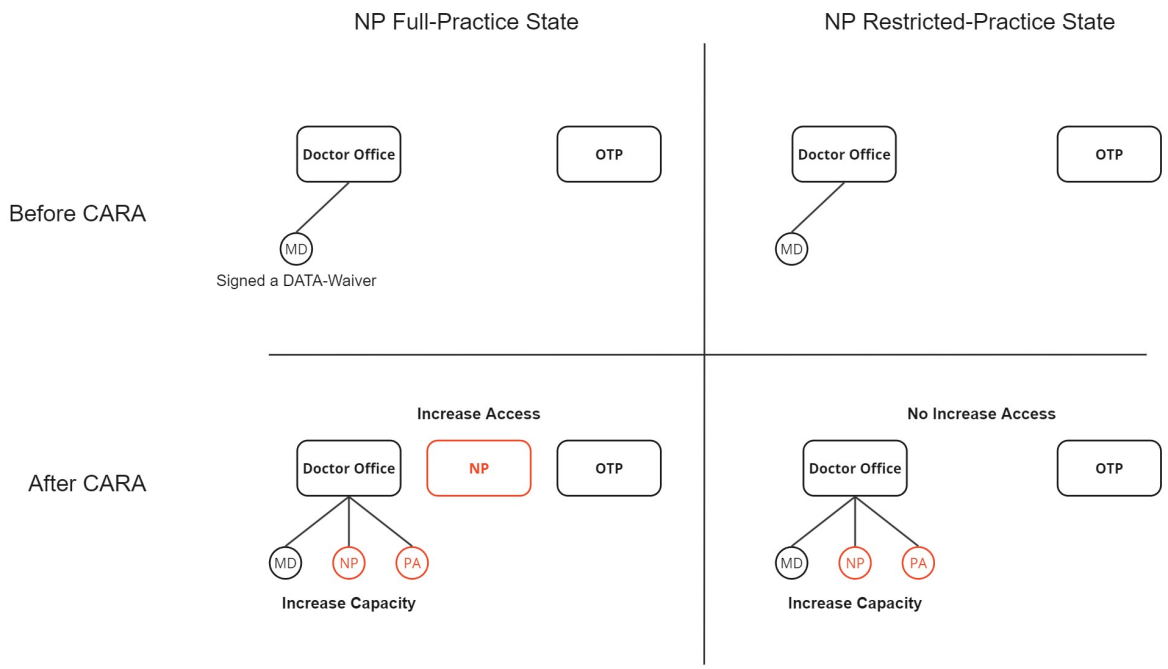


Figure 4. CARA and Scope-of-Practice Laws Interaction

Note: The figure illustrates how the 2016 CARA policy change interacted with state-level NP scope-of-practice laws to affect buprenorphine access. It is organized into four quadrants defined by state practice authority (full vs. restricted) and time period (pre- vs. post-CARA). Before CARA, NPs in both state types could not prescribe buprenorphine independently, so access depended on waivered physicians and opioid treatment programs. After CARA, NPs in full-practice states gained the ability to prescribe independently, leading to increased access. In restricted-practice states, NPs remained unable to prescribe without physician oversight, limiting the expansion of treatment sites. However, because NPs working under physician supervision could also obtain waivers after CARA, some increase in prescribing capacity occurred in both groups of states.

increased by a similar magnitude across states, independent prescribing inherently expands the number of dispensing sites, leading to greater buprenorphine availability in full-practice states.

Institutional differences also shape NP incentives. Independent NPs, who must build and maintain their own patient panels, have stronger incentives to offer buprenorphine as a way to attract and retain patients. By contrast, in restricted-practice states, NPs cannot prescribe buprenorphine if their supervising physician lacks a waiver, even if they wish to do so. I therefore expect greater uptake of buprenorphine prescribing among NPs in full-practice states. These institutional differences imply a larger expansion of buprenorphine use in full-practice states relative to restricted-practice states. This setting provides a useful environment to test whether

expanded buprenorphine access generates meaningful health impacts outside of clinical trial contexts.

D. Identification Assumptions

The primary threat to identification in a DiD framework is the potential violation of the parallel trends assumption. This assumption requires that, in the absence of treatment, trends in outcomes would have evolved similarly across treated and control states, conditional on observables. In this setting, the assumption holds if restricted-practice states serve as credible counterfactuals for full-practice states after the enactment of CARA.

Several features of the institutional environment support this assumption. First, while state scope-of-practice laws govern whether NPs may prescribe independently, federal laws determine whether they may prescribe buprenorphine for OUD. Prior to CARA, state-level scope-of-practice reforms could not have directly affected buprenorphine-based OUD treatment access, limiting concerns that such reforms were endogenous responses to the opioid crisis. In Table D3, I assess this empirically by estimating whether lagged opioid-related mortality predicts adoption of full-practice authority. I find no evidence that prior mortality trends predict the timing of adoption. This is consistent with Alexander and Schnell (2019), who show that scope-of-practice expansions were driven primarily by state political dynamics rather than local health conditions.

Second, I address the concern that the timing of NP prescribing authority may coincide with other state-level policy changes. While the main regressions control for a broad set of contemporaneous laws, Pei, Pischke and Schwandt (2019) recommends conducting balancing regressions to assess whether treatment timing is systematically correlated with other policy adoptions. Following this approach, I estimate a series of regressions using each policy variable as the dependent variable and test for correlation with the timing of NP prescribing authority. As shown in Table D2, the timing of expanded NP authority is not systematically associated with any other policy except Medicaid expansion. However, prior research finds that Medicaid expansion had little impact on opioid-related mortality (Averett, Smith and Wang, 2019; Abouk et al., 2021), indicating that this overlap is unlikely to meaningfully bias the estimates.

Third, a related concern is that states granting NPs independent prescribing authority may

have responded differently to federal policy changes. CARA included grant funding to states, but these funds were not disbursed until late 2017, well after the initial effects observed in my data. States also allocated CARA funds in broadly similar ways, primarily to support treatment expansion (Murrin, 2020). Another provision of CARA increased the patient cap for buprenorphine prescribers from 100 to 275 in 2016.[11] However, the literature consistently finds that most waivered physicians treated far below their patient limits during this period (Stein et al., 2016; Thomas et al., 2017; Andrilla, Coulthard and Patterson, 2018), suggesting that this provision is unlikely to confound the results.

Fourth, I exclude from the main analysis states that transitioned to full-practice authority after the baseline year (2015)—specifically, Illinois, South Dakota, and Virginia—to maintain a clean separation between treated and control groups. I also exclude states that adopted full-practice authority between 2012 and 2015 (Connecticut, Delaware, Minnesota, Nevada, New York, and Rhode Island). While these states transitioned prior to CARA, NPs may not have had sufficient time to establish independent practices before the federal expansion took effect. Including them could conflate early adoption effects with the treatment effect of interest. As a robustness check, I include these states as treated units and find that results remain consistent.

Finally, even if the standard parallel trends assumption is violated, the synthetic DiD estimator remains valid under weaker assumptions. Unlike the standard approach, synthetic DiD is more flexible: it requires only that the reweighted control group forms a valid synthetic counterfactual for the treated units. When pre-treatment trends are similar, both estimators yield comparable results. However, when parallel trends are unlikely to hold, synthetic DiD can still produce consistent estimates. In later parts of the analysis, standard estimation suggests a violation of the parallel trends assumption, with pre-treatment estimates that are statistically significant and deviate from zero. In contrast, synthetic DiD produces pre-treatment estimates that are close to zero and statistically insignificant.

[11] Under the Drug Addiction Treatment Act of 2000, waivered physicians could treat up to 30 patients in the first year and, after one year, notify to increase the cap to 100. In July 2016, HHS finalized a rule allowing certain physicians who had held the 100-patient cap for at least one year and met additional criteria (e.g., addiction credentialing or practicing in a "qualified practice setting") to increase to 275. CARA (2016) subsequently authorized NPs, with the same 30-patient first-year cap and eligibility to increase to 100 after one year (24 hours of required training under CARA). Eligibility for the 275-patient cap was later extended to "qualifying other practitioners" (including NPs) by the SUPPORT Act (2018). Thus, during 2016–2018 NPs could move from 30 to 100 but not to 275; from 2019 onward they could reach 275 under the same criteria as physicians.

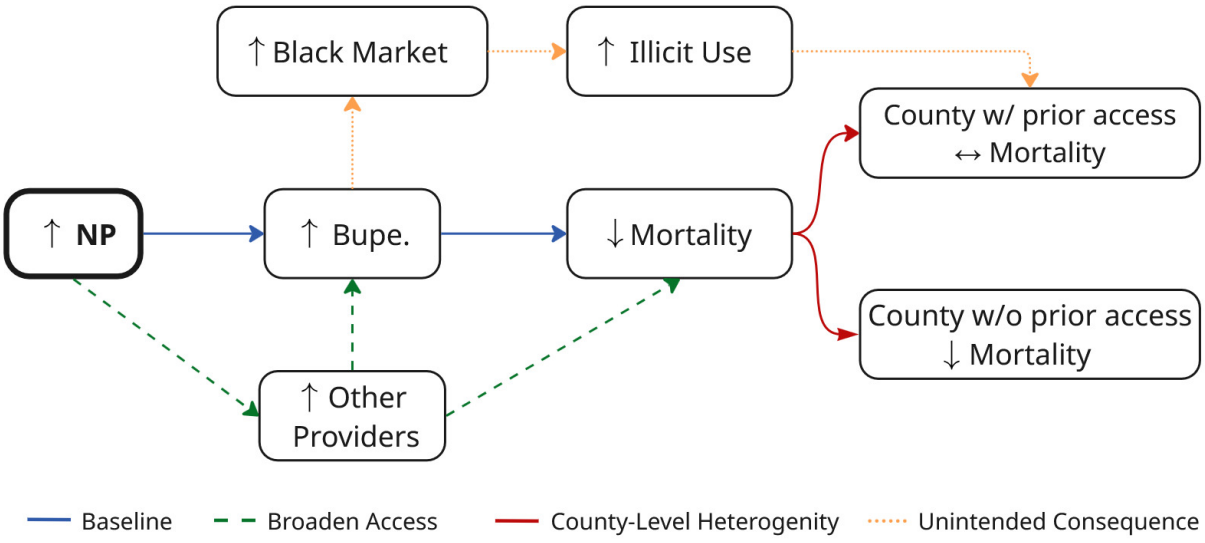


Figure 5. Illustration of Treatment Channels

Note: The flow chart reads from left to right and illustrates the hypothesized channels through which granting NPs independent prescribing authority affects opioid-related mortality. The baseline channel links the policy to increased NP entry, higher buprenorphine dispensation, and ultimately lower mortality. Additional channels include potential changes in prescribing behavior among non-NP providers, county-level heterogeneity in effects, and unintended consequences such as diversion.

IV. Main Results

Before turning to the results, Figure 5 provides an overview of how granting NPs independent prescribing authority affects the outcomes of interest. In Section IV, I present the core findings: the policy induces NP entry into buprenorphine prescribing, which increases overall dispensation and, in turn, reduces opioid-related mortality. Section V then explores the mechanisms behind these effects, including whether the policy broadened access by encouraging other non-NP providers to prescribe. I also examine heterogeneity at the county level. Counties with limited pre-policy access experience the largest mortality reductions, whereas counties with high baseline access show little to no effect. Finally, in Section VI, I investigate potential unintended consequences that may explain the absence of benefits in high-access counties. In particular, I present evidence consistent with diversion: illicit buprenorphine prices fell, and survey-based measures of misuse did not decline and in some cases increased following the policy.

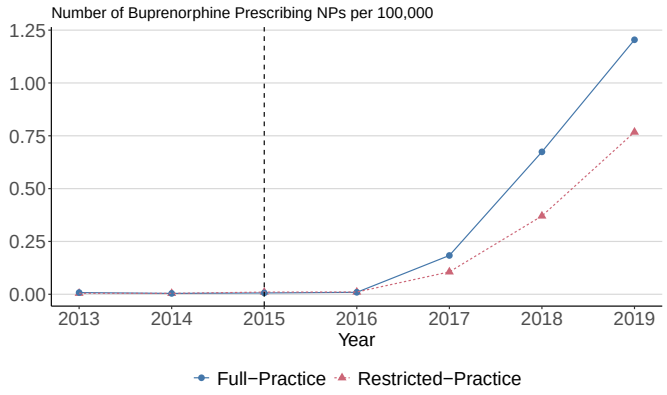
A. Growth in NP Buprenorphine Prescribing

Figure 6a shows the annual average number of NPs prescribing buprenorphine per 100,000 people in full-practice and restricted-practice counties.[12] Prior to 2016, NPs were generally not authorized to prescribe buprenorphine, aside from narrow exceptions.[13] Following the passage of CARA, NP prescribing increased in both groups of counties, but the increase was significantly larger in full-practice counties. This divergence is consistent with regulatory constraints: in restricted-practice counties, NPs must prescribe under physician supervision, which may limit both access and incentives to enter the market. In contrast, NP autonomy in full-practice states likely encouraged independent prescribing. Figure 6b presents DiD estimates of the policy effect using Equation 1, while Figure 6c implements the same specification using the synthetic DiD estimator (Equation 4). Estimates from both approaches are similar, though the synthetic DiD is preferred for its greater robustness to violations of the parallel trends assumption. The results indicate that allowing NPs to prescribe buprenorphine independently led to an increase of 0.41 NPs per 100,000 residents by 2019. For context, the average number of active buprenorphine prescribers in full-practice counties in 2015 was 1.53 per 100,000 people, implying a 27% increase in provider availability over the four-year period.

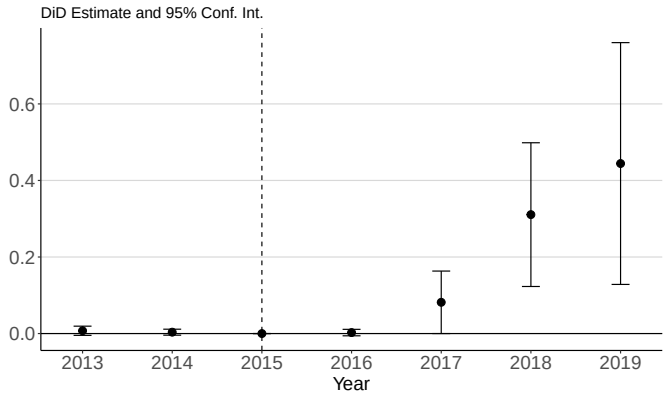
An important question is whether these findings based on Medicare Part D data generalize to the broader provider population. First, the Medicare-based results serve as a robustness check for the broader analysis in the next subsection, which uses shipment data to capture overall dispensation. This observed increase primarily reflects new provider entry rather than intensified prescribing by existing providers. Second, concerns about selection bias in the Medicare data are likely minimal in this context. Although the Medicare population is older, buprenorphine supply is not age-targeted: providers willing to prescribe to Medicare beneficiaries are generally not restricted to that demographic. In fact, relying solely on the Medicare population is unlikely to be financially viable for buprenorphine prescribers, as younger patients comprise the bulk of OUD

[12] Most of my analysis spans the years 2012 to 2019 in order to include a longer pre-treatment period, which strengthens the credibility of the results by providing a better assessment of pre-trends. However, due to limitations in the Medicare Part D dataset—which is only available from 2013 onward—analyses that rely on Medicare Part D data are restricted to the 2013–2019 period.

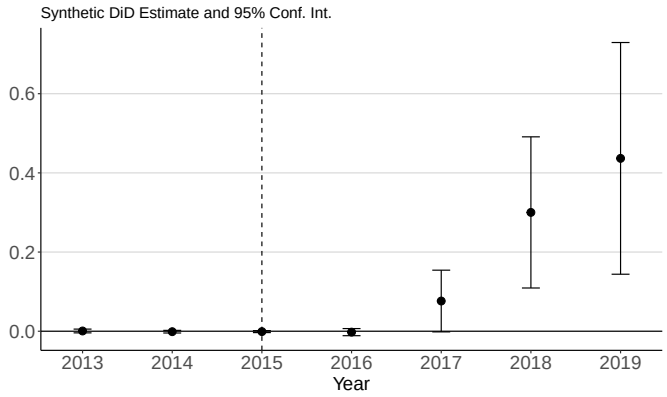
[13] In some cases, NPs could petition to prescribe controlled substances in areas with physician shortages, though such waivers were rare and difficult to obtain.



(a) Mean Trends



(b) Dynamic DiD Results



(c) Dynamic Synthetic DiD Results

Figure 6. Effect on the Number of Buprenorphine Prescribing NPs

Note: This figure examines the number of NPs per 100,000 people across counties. Panel (a) shows raw trends in the county-level average number of NPs from 2013 to 2019, comparing full-practice and restricted-practice states. Panel (b) presents event-study estimates from Equation 1, with 95% confidence intervals and county-clustered standard errors. Panel (c) displays estimates from the synthetic DiD specification in Equation 4, with confidence intervals computed via bootstrap resampling.

cases. Moreover, Medicare Part D data capture roughly two-thirds of all active buprenorphine prescribers nationally, and prescriber counts from this source are strongly correlated with overall provider availability at the county level (Appendix B).

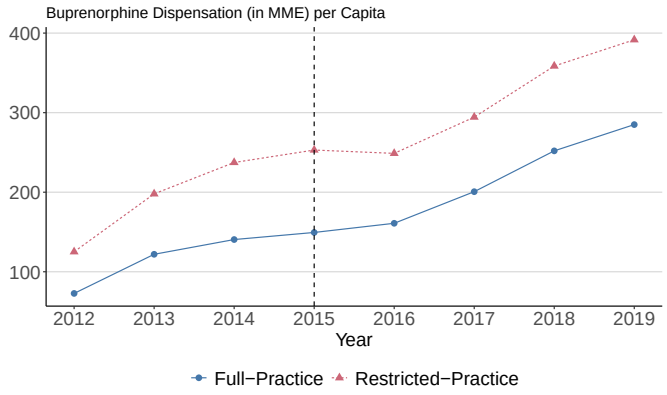
B. Buprenorphine Dispensation Expansion

The previous subsection showed that allowing NPs to prescribe independently led to a substantial increase in the number of buprenorphine prescribing NPs. I now examine whether this expansion in prescriber supply resulted in greater buprenorphine use, as measured by the volume of buprenorphine dispensed per capita.

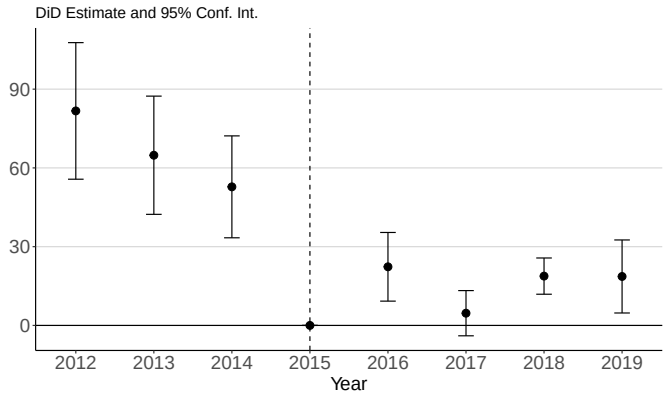
Figure 7a plots per capita buprenorphine dispensation, measured in morphine milligram equivalents (MME),[14] across full-practice and restricted-practice counties. Prior to 2015, restricted-practice counties had higher average levels of buprenorphine dispensing. This gap narrowed in the years following CARA. To quantify these changes, Figure 7b shows DiD estimates based on Equation 1, and Figure 7c presents synthetic DiD estimates based on Equation 4. By 2019, the synthetic DiD estimates imply that buprenorphine dispensation in treated counties was 26% higher than in 2015, corresponding to an increase from 149.48 to 188.58 MME per capita (39.10 MME per capita). Averaging across the post-policy period (2016–2019), the estimated treatment effect corresponds to an increase of 23.71 MME per capita relative to 2015. Taking a typical treated county with an average population of 80,068, this additional volume corresponds to about 3,955 patient-months of treatment at a 16 MME/day buprenorphine maintenance dose, the most common daily regimen. In other words, the increase is enough to provide one month of treatment to roughly 5% of the county's population.

Interestingly, the increase in dispensation begins in 2016, before CARA's NP prescribing provision took effect in 2017. While this may seem counterintuitive, it aligns with anticipatory behavior. Providers likely began expanding prescribing in response to the anticipated entry of

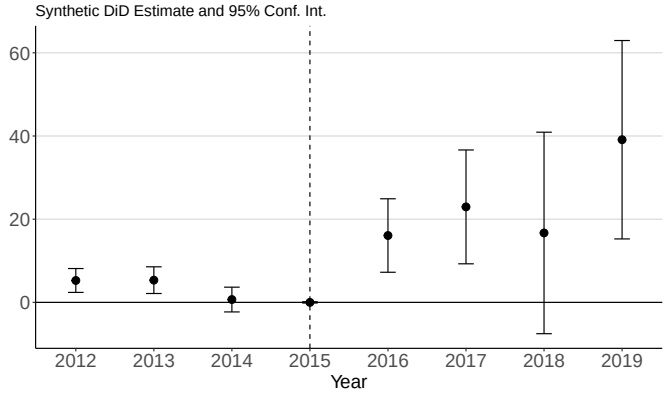
[14] MME are not always the best measure for buprenorphine, since the drug is prescribed primarily to treat opioid use disorder rather than for pain relief. Still, MME provides a convenient way to quantify the amount of buprenorphine dispensed. The most common dosage strength is 8 mg, and because buprenorphine's MME conversion factor is 1, in this case MME corresponds directly to milligrams. For example, 16 MME of buprenorphine could be supplied as two 8 mg tablets or as a single 16 mg tablet. Although MME is widely used in the literature because it allows opioid volumes to be compared across different drugs, the intention here is not cross-drug comparison but rather a straightforward accounting of buprenorphine volume.



(a) Mean Trends



(b) Dynamic DiD Results



(c) Dynamic Synthetic DiD Results

Figure 7. Effect on the Buprenorphine Dispensed Per Capita

Note: This figure examines amount of buprenorphine being dispensed across counties. Panel (a) shows raw trends in county-level averages from 2013 to 2019, comparing full-practice and restricted-practice states. Panel (b) presents event-study estimates from Equation 1, with 95% confidence intervals and standard errors clustered at the county level. Panel (c) displays estimates from the synthetic DiD specification in Equation 4, with confidence intervals computed via bootstrap resampling.

NPs. By mid-2016, CARA's passage and its implications for NP prescribing were widely known. In response, providers may have accelerated prescribing to build patient relationships before NPs entered the market. I return to this mechanism in Section V.

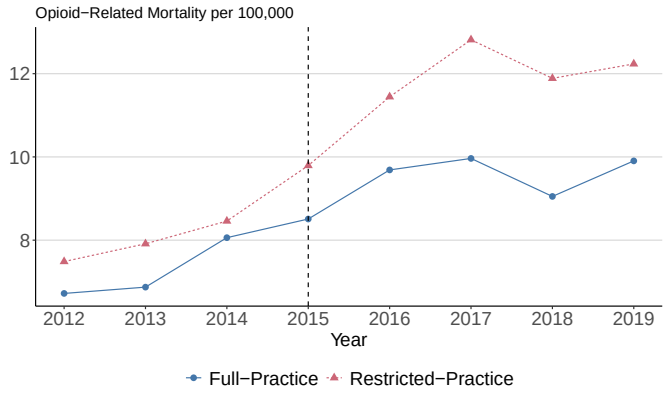
C. *Reduction in Opioid-Related Mortality*

A central question is whether increased buprenorphine dispensation translates into meaningful improvements in health outcomes. I examine opioid-related mortality as the primary outcome. Figure 8a plots average opioid overdose death rates (per 100,000 population) in full-practice and restricted-practice counties. Prior to 2016, restricted-practice counties experienced slightly higher mortality, but the trends were largely parallel. Following CARA, mortality declined in both groups, with a markedly larger reduction in full-practice counties. This divergence suggests that expanded NP prescribing authority improved access to treatment and, in turn, health outcomes.

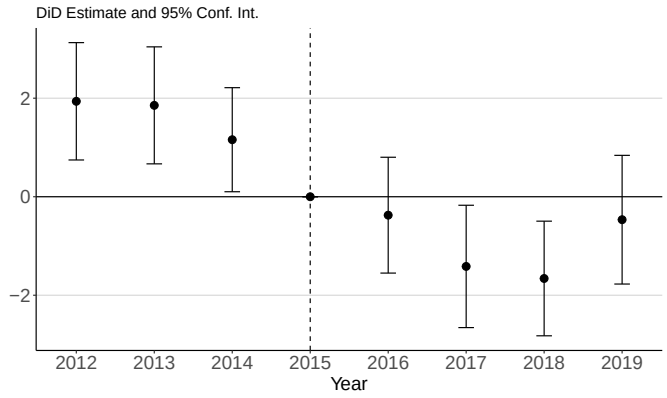
Figure 8b reports estimates based on Equation 1, while Figure 8c presents corresponding results using the synthetic DiD estimator (Equation 4). Both approaches indicate a substantial decline in opioid-related mortality. According to the synthetic DiD estimates, opioid-related mortality in full-practice counties declined by 1.86 deaths per capita relative to the 2015 average of 8.51, a reduction of 22% over the four-year period. The largest decline occurred in 2018, with 2.63 fewer deaths per capita (31%), followed by a modest tapering in 2019.

These reductions are large compared with other well-studied interventions. For example, Doleac and Mukherjee (2022) find that expanding naloxone access does not significantly reduce opioid-related deaths. While naloxone remains essential for reversing overdoses, it does not treat the underlying addiction and therefore cannot by itself reduce opioid use disorder prevalence. Similarly, Medicaid expansion, despite covering medications for OUD, has not reduced mortality (Averett, Smith and Wang 2019; Abouk et al. 2021). A likely reason is that coverage alone cannot overcome provider shortages: even if patients seek buprenorphine, in many regions there are too few prescribers to meet demand. In contrast, this policy both expanded the use of buprenorphine and addressed the existing shortage of qualified prescribers.

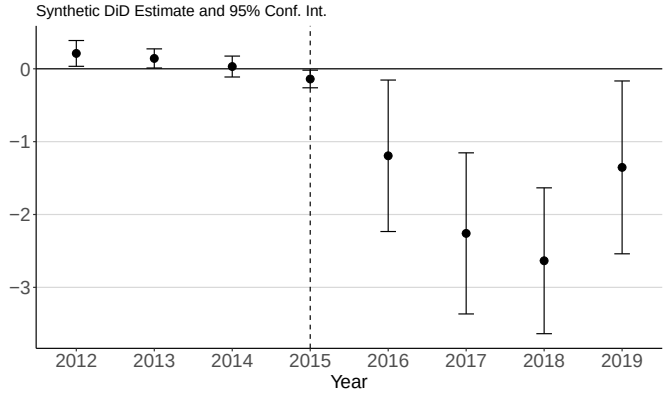
Another reason the effect is sizeable lies in county-level heterogeneity. As discussed further



(a) Mean Trends



(b) Dynamic DiD Results



(c) Dynamic Synthetic DiD Results

Figure 8. Effect on Opioid-Related Mortality Per 100,000

Note: This figure reports estimates of opioid-related mortality per 100,000 people at the county level. The construction mirrors that of Figure 6. Panel (a) presents raw trends by state practice authority. Panel (b) shows event-study estimates from Equation 1, with standard errors clustered at the county level. Panel (c) presents synthetic DiD estimates from Equation 4, with confidence intervals computed via bootstrap resampling.

in Section V, mortality reductions are concentrated in underserved areas where buprenorphine access was limited before CARA. Because 62% of counties lacked any buprenorphine access prior to the policy, the average effect is driven by those counties, which were often small and rural, while effects are negligible in larger and more urban counties with existing access. In extreme cases, the contrast is between two counties that both initially had no prescribers: after the policy, a full-practice county might gain several new prescribers, while a restricted-practice county continues to have none. Moving from no access to some access produces much larger gains in treatment initiation and overdose prevention than moving from some access to slightly more. This dynamic explains why the equal-weighted county effect is sizable, since the largest improvements naturally occur where access had previously been nonexistent.[15]

V. Mechanisms

The preceding findings highlight the importance of provider supply in expanding access to OUD treatment, as greater prescriber availability is linked to reductions in opioid-related mortality. This section explores two mechanisms behind this relationship. First, I examine how NP entry shapes the broader market, focusing on whether additional NP prescribers influence the behavior of other providers or substitute for specialized care. Second, I evaluate the policy's distributional impact by comparing treatment gains across counties with different baseline levels of buprenorphine access in 2013.

A. Prescriber Dynamics in Response to Policy Change

The timing of the increase in buprenorphine dispensation suggests that the policy's effects were not limited to NP entry. As shown earlier, dispensation began rising in 2016, before CARA's NP prescribing provision became operational in 2017, indicating that other providers adjusted prescribing behavior in anticipation of the policy change. Figure 9 presents synthetic DiD estimates from Equation 4 for (1) the total number of buprenorphine prescribers per 100,000

[15] As a complementary check, I also examine alternative aggregation methods that reduce the influence of small counties. At the state–year level, the estimated effect is smaller and statistically insignificant, with mortality declining by about 5% on average after 2016. Population-weighted estimates answer a different question: the change in mortality experienced by the average resident rather than the average county. Because CARA was designed to reduce geographic inequities in access, I emphasize equal-weighted county effects in the main analysis.

residents and (2) the number of NP prescribers per 100,000. Because NPs are included in the overall count, any divergence in timing helps isolate non-NP responses. The results are consistent with anticipatory behavior by non-NP providers: the number of all prescribers rose sharply in 2016, while NP prescribing remained flat. By 2019, the total number of prescribers had doubled relative to 2015, with roughly one-third of the increase attributable to NPs.

This anticipatory pattern likely reflects early entry by primary care physicians, particularly in full-practice states where NPs were expected to gain independent authority. Passage of CARA in mid-2016 may have prompted some physicians to begin prescribing buprenorphine in order to secure patient relationships before competition from NPs intensified. Prior to the policy, many local markets operated in a low-supply equilibrium where few if any providers offered buprenorphine, and physicians could maintain their patient base without prescribing since no competitor provided the service. CARA disrupted this status quo by creating the expectation of NP entry, which threatened to attract patients who had previously been unable to obtain buprenorphine locally. In this environment, physicians had an incentive to move early, both to preserve their existing patients and to capture new ones. Importantly, such anticipatory behavior cannot be explained by general awareness of CARA alone. If responses had occurred uniformly across states, the DiD framework would have differenced them out. The observed divergence instead suggests that physicians were reacting to anticipated changes in their competitive environment. This mechanism is consistent with broader evidence on provider competition: Currie, Li and Schnell (2023) show that U.S. state laws granting NPs prescribing authority increased competition and led primary care physicians, the specialty most directly competing with NPs, to raise prescribing of opioids and controlled anti-anxiety medications. A similar dynamic appears here, with primary care physicians entering the buprenorphine market early to secure a first-mover advantage before NP entry.

One alternative explanation is that the observed increase reflects new entry by general practitioners who incidentally prescribed buprenorphine as part of broader patient care, perhaps in response to other unobserved policies promoting general health care access in 2016. To test this, Figure D5 examines prescribing patterns for the five most common Medicare Part D medications: levothyroxine, lisinopril, simvastatin, amlodipine, and omeprazole. If new generalists had

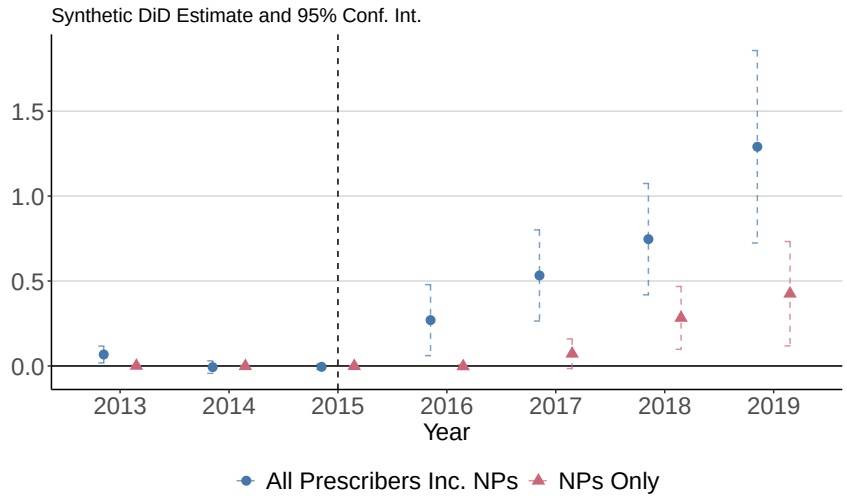


Figure 9. Anticipated Entries by Other Prescribers

Note: This figure plots synthetic DiD estimates from Equation 4, with standard deviations obtained via bootstrap resampling. The outcomes are (1) the total number of buprenorphine prescribers per 100,000 people, including NPs, and (2) the number of buprenorphine prescribing NPs per 100,000 people, both measured at the county level. Estimates for NP prescribers replicate those shown separately in Figure 6c. Confidence intervals are computed via boostrap resampling.

entered the market, similar increases would be expected in prescribing of these medications. No such effects are observed, either in the number of prescribers or in claims volume. This pattern suggests that the increase in buprenorphine prescribing reflects changes in behavior by existing providers who had not previously prescribed buprenorphine, rather than broad-based new entry. It also makes it unlikely that other policies drove entry into health care more generally, reinforcing the conclusion that the observed response was specific to buprenorphine.

While early entry of new providers and expanded prescribing are important, they raise further questions about the nature of this expansion. Specifically, was growth driven by more providers entering the market (an extensive-margin response) or by existing providers writing more prescriptions (an intensive-margin response)? Figure 10a plots synthetic DiD estimates of buprenorphine claims per prescriber, this includes incumbents and new entrants.[16] Following the policy change, claims per prescriber declined even as the total volume of buprenorphine dispensation increased. This pattern indicates that new entry, rather than greater prescribing

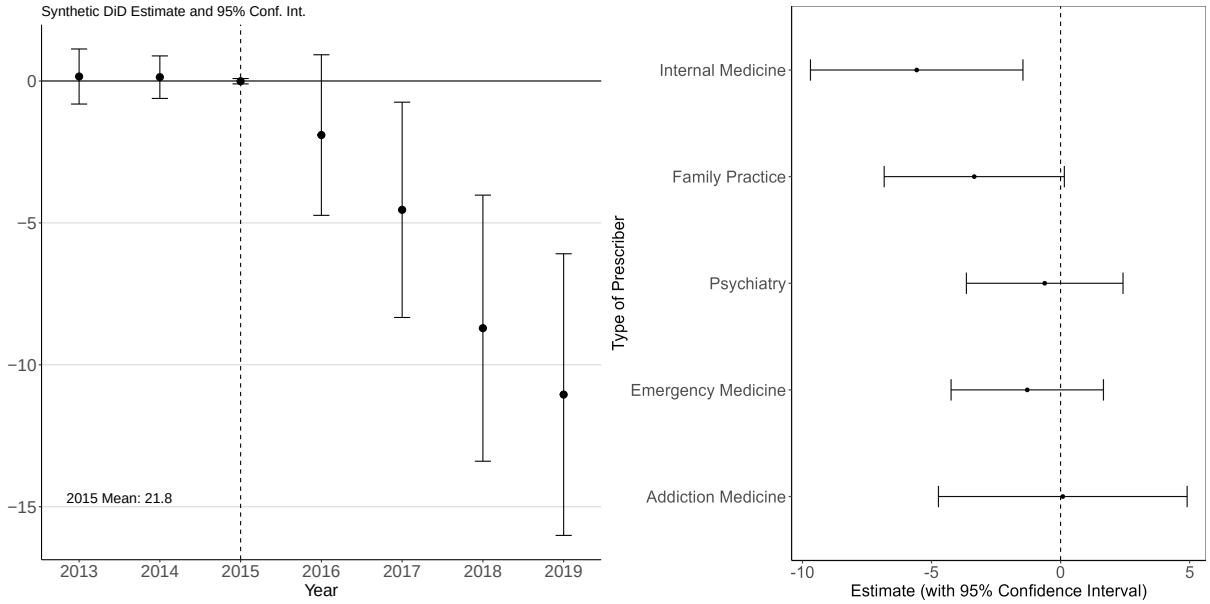
[16]Counties with no prescribers are coded as zero. The results are similar when restricting the sample to counties with at least one prescriber.

by existing providers, was the dominant driver of expansion.

This shift toward the extensive margin could have important implications for access. It also raises a concern: was this growth in primary care prescribing offset by a decline in specialized treatment? To assess whether expanded NP authority reshaped the composition of prescribers by crowding out specialists, Figure 10b presents the corresponding average treatment effect, decomposing claims per prescriber by provider type. The decline is concentrated among family and internal medicine physicians, those most substitutable for NPs in the eyes of patients. In contrast, prescribing by psychiatrists, emergency medicine physicians, and addiction specialists remains stable. This pattern suggests that the policy expanded access through primary care channels without crowding out specialized providers. Similarly, I examine whether buprenorphine prescribing displaced access to treatment at OTPs. These facilities typically serve patients with more severe addiction and are the only settings legally authorized to dispense methadone for OUD. Using methadone dispensation (in MME) per capita at OTPs as a proxy for treatment intensity in specialized care, I find that methadone use did not decline after the policy change. On the contrary, it increased, as shown in Figure D2.[17]

In summary, the policy spurred entry not only among NPs but also among other providers, particularly in primary care. This expansion reduced provider concentration, with a broader set of prescribers each serving a smaller share of patients. Although I do not directly observe the number of patients per provider, if claims per patient remained relatively stable, the decline in claims per prescriber suggests a reduction in patient load. In rural areas with limited provider access, this shift could reduce travel distances and shorten wait times for appointments. It may also ease capacity pressures: although federal regulations cap the number of patients a provider can treat at one time, most prescribers do not come close to these limits (Stein et al., 2016; Thomas et al., 2017; Andrilla, Coulthard and Patterson, 2018). Nevertheless, additional entry spreads demand more evenly across prescribers, relieving the burden on high-volume providers and making treatment more accessible at the margin.

[17]Methadone and buprenorphine are often viewed as substitutes, since patients typically receive one or the other. In practice, they can be complementary treatments for the same condition, with heterogeneous patient responses. Patients who do not respond well to buprenorphine may subsequently switch to methadone, which, as a full opioid agonist, may be more effective for severe dependence.



(a) Buprenorphine Claims Per Prescribers

(b) Buprenorphine Claims Per Prescribers by Type

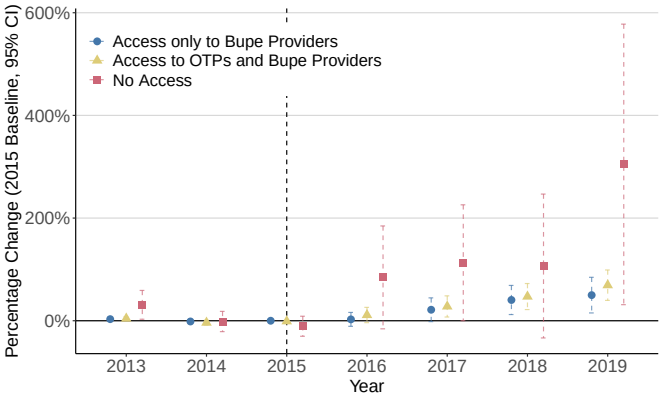
Figure 10. Effect on Other Prescribers

Note: Figures 10a and 10b report estimates from the synthetic DiD approach at the county level. The outcome in Figure 10a is the average number of buprenorphine claims per prescriber, calculated as the total number of claims divided by the number of prescribers in a given county-year. Counties with no prescribers are assigned a value of zero. Figure 10b disaggregates the estimates by provider type, ordered by total prescriber count. Both figures draw on data from the Medicare Part D database. Confidence intervals are computed via boostrap resampling.

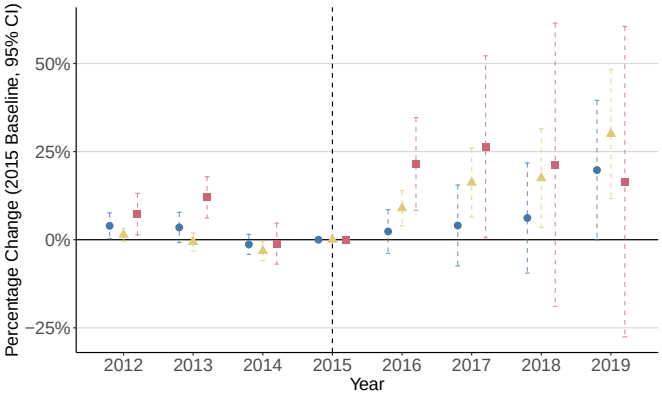
B. Reducing Treatment Inequality

Next, I examine whether the effects of NP prescribing authority vary across counties with different levels of treatment access. If the treatment gap is primarily driven by limited provider supply, the policy should have larger effects in underserved areas. Consistent with this expectation, I find that new prescriber entry disproportionately occurred in counties with limited access, leading to greater reductions in opioid-related mortality.

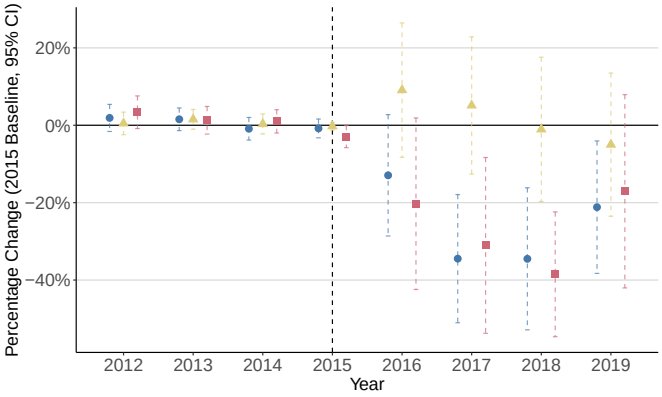
To assess this, I categorize counties based on treatment availability in 2013 using two indicators: the presence of Medicare Part D buprenorphine prescribers and whether an OTP operated in the county. Counties are grouped into three categories: (1) no access (neither buprenorphine prescribers nor OTPs), (2) buprenorphine-only access, and (3) access to both buprenorphine and OTP services. OTPs are typically located in urban areas. The majority of counties in the



(a) Number of Buprenorphine Prescribers per 100,000



(b) Buprenorphine Dispensation per Capita



(c) Opioid-Related Mortality per 100,000

Figure 11. County Heterogenous Response to NP Independent Prescribing

Note: Figures 11a, 11b, and 11c report county-level synthetic DiD estimates based on Equation 4, stratified by baseline treatment availability in 2013. Counties are grouped into three categories: (1) no access to medication for OUD, (2) access to buprenorphine providers only, and (3) access to both buprenorphine and OTPs. Outcomes are normalized to 2015 averages within each group to facilitate comparison. Confidence intervals are constructed using bootstrap resampling.

sample lacked both types of providers in 2013.[18]

Figure 11 presents results using a synthetic DiD approach, with each outcome normalized by its 2015 mean within county type.[19] Figure 11a shows that the number of buprenorphine prescribers per 100,000 increased most sharply in counties that initially lacked access. Figure 11b shows that buprenorphine dispensation rose across all county types, with early gains concentrated in underserved areas. The most pronounced heterogeneity emerges in mortality outcomes. Figure 11c shows that counties without OTP access experienced nearly a 40% decline in opioid-related mortality by 2018, while counties with both buprenorphine and OTP access saw no statistically significant change. These findings suggest that new prescribers alleviated shortages in underserved areas, where additional supply delivered the greatest marginal benefit. In contrast, expanding provider supply had little effect in counties already served by OTPs, where treatment options were already available.

On the one hand, this highlights the policy's success in reducing geographic inequities by targeting places with the greatest unmet need. On the other hand, in better-served areas, buprenorphine dispensation rose without corresponding improvements in mortality. This raises concerns that expanded supply may not have translated into effective treatment, echoing evidence from Currie, Li and Schnell (2023) that greater provider competition can increase misuse of opioids and benzodiazepines, ultimately worsening health outcomes. I return to this issue in Section VI.

A potential concern is that the observed effects might be driven by concurrent changes in OTP availability, rather than by NP prescribing authority alone. This is especially relevant given prior evidence that OTPs play a central role in treating severe OUD. If access to OTPs expanded differentially in full-practice states starting in 2016, it could confound the estimated impact of the policy. To assess this, Figure D1 compares changes in the number of OTPs across

[18] I exclude 67 counties that had OTP access but no Medicare Part D buprenorphine prescribers, as they represent a small group. These counties likely had both types of access in practice, through non-Medicare buprenorphine providers. These patterns indeed also explained why the mortality across county type is about 22% as shown before (average between these groups). Including them in the "both access" group does not materially affect the results. Ideally, access types would be defined using data from 2012 to align with the treatment definition and the start of the main analysis period. However, Medicare Part D data are only available beginning in 2013. Baseline access appears relatively stable through 2015, and using 2015 as the reference year yields similar results.

[19] Normalization ensures comparability across county types. For example, mortality levels in Los Angeles County are far higher than in a rural Iowa county, so comparing relative changes is more meaningful than comparing levels.

county types in full- and restricted-practice states. Trends are largely similar across groups, with no statistically significant differences until 2019; and even then, only in the most underserved counties. This timing is inconsistent with OTP expansion driving the earlier improvements in treatment access or reductions in mortality.

VI. Unintended Consequences

While the goal of expanding NP prescribing authority is to improve access to OUD treatment, a key concern, given the origins of the opioid epidemic, is the potential for unintended consequences. The initial wave of the crisis was fueled in part by expanded access to prescription opioids, many of which were diverted to secondary markets. Similarly, expanded buprenorphine availability could lead to informal use if some of the additional supply is diverted outside formal treatment channels. Previous results suggest this may be occurring, since mortality did not improve in areas with prior access despite higher dispensation. This section examines outcomes that point to possible diversion following the policy change, focusing on self-reported street prices and evidence from the National Survey on Drug Use and Health (NSDUH). These analyses are conducted at the state level, rather than the county level as in the main analysis, because the necessary data are not available at finer geographic detail. State-level per capita outcomes are population-weighted averages of county per capita outcomes, so these results largely reflect trends in larger, urban counties that already had access.[20]

A. Evidence from Street Prices

The most direct signal of diversion would be evidence that buprenorphine became more readily available on the street. Although direct measures of secondary-market supply are limited, self-reported transaction prices provide an indirect but informative proxy. A sharp decline in the street price of buprenorphine following the policy change is more consistent with an increase in supply than with a drop in demand, particularly since, as shown in the previous subsection, rates of illicit drug misuse did not fall. A price decline for buprenorphine, occurring alongside

[20]These findings should be interpreted with caution, because the analysis is restricted to state-level data and cannot capture county-level variation, the results are suggestive rather than definitive.

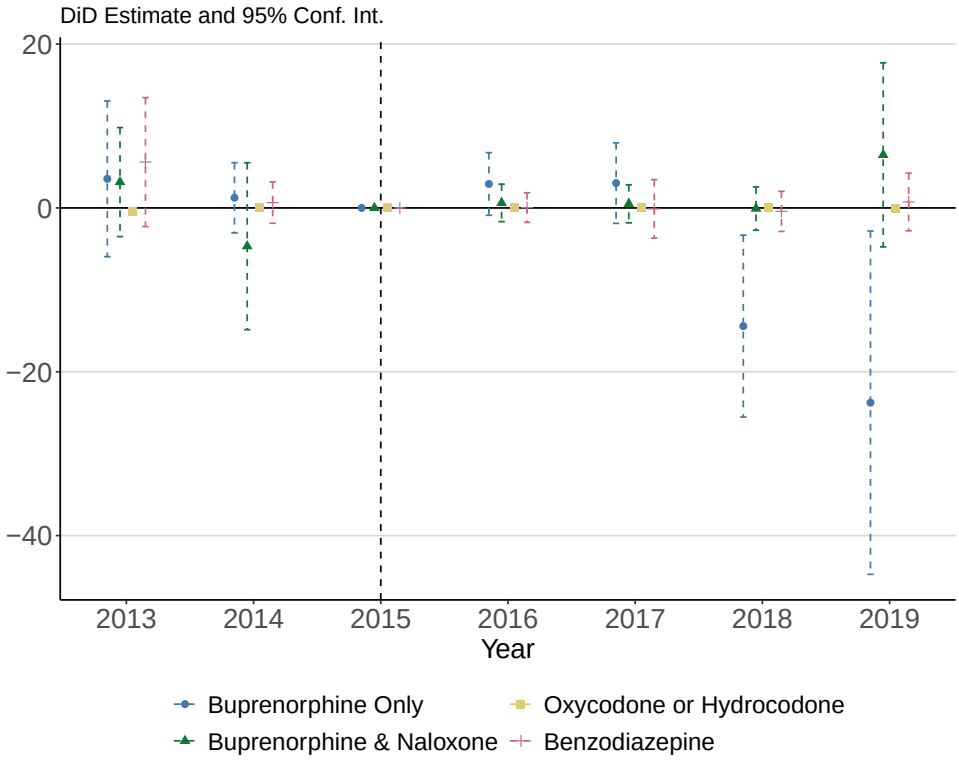


Figure 12. Secondary Market Drug Prices

Note: This figure presents state-level DiD estimates from Equation 1, using self-reported street-level drug prices from the StreetRx database. The outcome is the average price per milligram for six drugs: buprenorphine (pure formulation), buprenorphine-naloxone, hydrocodone, oxycodone, and benzodiazepines. Buprenorphine and buprenorphine-naloxone are medications for OUD; the others are commonly misused opioids or co-used substances. Observations with missing drug-state-year combinations are excluded. Standard errors are clustered at the state level.

rising dispensation, therefore points to increased supply that may reflect diversion of prescribed medication into informal markets.

To investigate potential diversion, I use data from StreetRx, a crowdsourced platform that collects self-reported information on illicit drug transactions, including price, formulation, and location.[21] I focus on two formulations of buprenorphine: (1) the pure form, which carries greater risk of misuse but remains clinically appropriate for treating OUD, and (2) the buprenorphine–naloxone combination (e.g., Suboxone), which includes an opioid antagonist to reduce

[21]For drug prices, I take the average at the state–year level. Although location is reported at the city level, many cities lack sufficient observations for reliable estimates, so the state average largely reflects prices in larger cities.

abuse potential. Both formulations can still be misused due to their opioid properties, but the presence of naloxone makes the combination less desirable for non-medical use, leaving monotherapy buprenorphine more attractive to illicit users. For comparison, I also examine prices for hydrocodone, and oxycodone, since buprenorphine may serve as a substitute for these opioids, as well as benzodiazepines, which are frequently co-used with opioids.[22] Figure 12 presents estimates from a standard DiD specification (Equation 1) at the state level.[23]

Following the policy change, the street price of pure buprenorphine declined significantly in full-practice states, while prices for the buprenorphine–naloxone combination remained stable. Prices for other opioids and benzodiazepines showed no significant changes. This divergence supports a supply-side interpretation: expanded prescriber authority likely increased the availability of buprenorphine, and some of the additional supply, particularly the more abusable pure formulation, appears to have entered secondary markets. The stability in the price of the abuse-deterrent formulation reflects its lower appeal in informal markets, since the presence of naloxone reduces misuse potential. These patterns highlight the role of prescribing decisions in limiting diversion. Encouraging use of buprenorphine–naloxone as the first-line option may help mitigate diversion risks while preserving access to effective treatment.

B. Evidence from Self-Reported Drug Use

Whether reduction in mortality is also accompanied with reduce underline addiction. I turn to NSDUH. If individuals are entering formal treatment and achieving recovery, we would expect to see declines in self-reported misuse. If, instead, they are substituting toward buprenorphine obtained through informal channels, opioid misuse rates may remain flat or rise.

Figure 13 plots synthetic DiD estimates of (1) past-year illicit drug use and (2) non-medical use of pain relievers, the NSDUH measure most closely aligned with prescription opioid misuse. In full-practice states, illicit drug use rose by approximately 20% between 2016 and 2019.[24] While

[22] Ideally, I would also include heroin and fentanyl prices. However, the database contains too few reports to support reliable estimates. In the case of fentanyl, the estimates are highly noisy, statistically insignificant, and essentially unchanged; I exclude them because the large standard errors would distort the figure relative to other estimates. For heroin, the sample size is insufficient to conduct the analysis.

[23] Due to missing data in several state–year pairs, the synthetic DiD approach is not applied. State–year observations with missing price data for a given drug are excluded from the analysis.

[24] Ideally, I would also examine fentanyl and heroin misuse. However, fentanyl has never been included in the survey, and heroin use was reported for only a few years before being removed, so neither measure can be incorporated here.

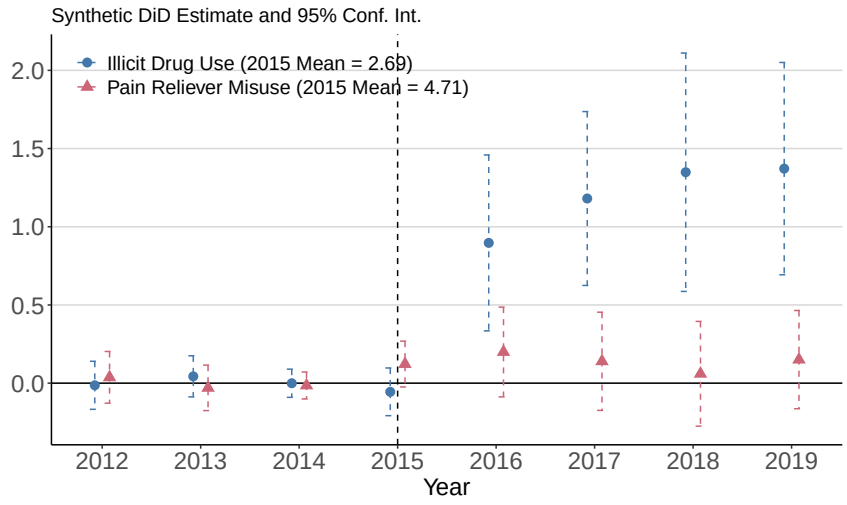


Figure 13. Survey-Reported Drug Misuse

Note: This figure reports synthetic DiD estimates from Equation 4, using data from NSDUH. The outcomes—(1) past-year illicit drug use and (2) past-year non-medical use of pain relievers—are small area prevalence estimates provided by NSDUH at the state level. Confidence intervals are constructed using bootstrap resampling. The 2015 mean in treated states is displayed in the upper-left corner.

this trend may partly reflect methodological changes introduced in 2015, such as revisions to how misuse is defined, the continued increase after 2016 suggests that it cannot be explained solely by survey redesign. Pain reliever misuse, which was subject to the same definitional change, does not show a comparable increase. The absence of a similar trend in this measure supports the interpretation that the rise in illicit drug use reflects real behavioral changes. Moreover, the flat trajectory of pain reliever misuse is inconsistent with large reductions in OUD prevalence and instead suggests that the at-risk population remained stable.

How do these results reconcile with the earlier mortality reductions? The estimates here are state-level, which means they are population weighted. In practice, a state's per capita outcome is the population-weighted average of its counties' per capita outcomes, so larger counties contribute more to the estimates than smaller ones. By contrast, the mortality analysis is conducted at the county level, where each county is given equal weight regardless of population size. StreetRx observations are concentrated in large metropolitan areas, and NSDUH is designed for state and national representativeness, which again emphasizes populous counties. Ideally, it would be preferable to run the diversion analysis at the county level, but such data are not

available. Any interpretation must therefore be viewed as speculative. With that caveat, the state-level evidence of diversion is likely driven by large urban counties with higher baseline access to buprenorphine. This helps explain the apparent discrepancy: in high-access counties, expanded dispensation coincided with stable misuse and falling street prices, consistent with diversion; in underserved counties, new prescribers eased supply constraints and mortality fell. The two sets of results should therefore be seen as complementary rather than contradictory, although the diversion mechanism remains an informed hypothesis rather than a definitive conclusion.

Why, then, does mortality not increase as in prior studies showing that greater opioid availability driven by provider competition (Currie, Li and Schnell, 2023) or expanded naloxone access (Doleac and Mukherjee, 2022) can raise opioid-related deaths? One explanation is that increased buprenorphine availability promotes harm-reducing behaviors among individuals with OUD. Even if overall misuse rates remain stable, greater access to buprenorphine may allow individuals to substitute away from more dangerous opioids such as fentanyl, or to use buprenorphine in combination with other substances in ways that reduce overdose risk. This interpretation is consistent with prior research showing that buprenorphine treatment lowers mortality even among individuals who continue to use other drugs (Sordo et al., 2017).

VII. Robustness

This section presents several robustness checks to validate the main results.

First, I test whether the treatment effect estimates are driven by idiosyncratic policy spillovers or outlier states. To examine this, I re-estimate Equation 4 using a leave-one-out approach, excluding one state at a time from the sample. Figure D4 shows that the results are stable and not sensitive to any single state. I then assess whether the observed effects reflect a broader expansion of healthcare access rather than changes specific to buprenorphine. Using Medicare Part D data, I compare trends in prescriptions of other commonly used medications. As shown in Figure D5, there is no evidence of comparable increases in prescribing for non-OUD medications.

Second, I assess the sensitivity of the results to alternative definitions of full-practice authority. The main specification excludes states that transitioned to full-practice between 2013 and 2016,

such as Utah, Nebraska, Minnesota, New York, West Virginia, Delaware, and Connecticut. I reclassify these states as treated and re-estimate the effects. I also adopt a broader definition of full-practice status, which includes states where NPs may operate independently under collaborative agreements without on-site physician supervision.[25] Under this classification, states such as Alabama, California, Florida, Kansas, North Carolina, and Tennessee are also treated. Figure D6 shows that the results remain robust under both reclassification schemes. To further rule out cross-border spillovers, I exclude counties in restricted-practice states that border full-practice states. If patients in restricted-practice states are traveling to nearby full-practice counties to access treatment, this could bias estimates downward. Removing these border counties does not meaningfully change the results, as also shown in Figure D6.

Finally, I test for violations of the parallel trends assumption by extending the pre-treatment period back to 2010 for outcomes with available data. To ensure a stable policy environment, I exclude any states that changed scope-of-practice laws between 2010 and 2019. Using the synthetic DiD event study specification (Equation 4), Figure D7 shows that pre-treatment trends remain flat, providing additional support for the identification strategy.

VIII. Discussion

CARA largely succeeded in its central aim of expanding access to treatment for OUD. The legislation references "access" and "availability" more than 50 times, and the evidence indicates that it was effective in advancing this goal. By authorizing NPs to prescribe buprenorphine and increasing federal support for treatment infrastructure, CARA meaningfully expanded treatment access. As Figure D3 shows, 477 counties gained access to OUD care between 2013 and 2019.

Yet the benefits of the policy were not evenly distributed. The largest reductions in opioid-related mortality occurred in counties that previously lacked access to buprenorphine. In contrast, counties with existing access, typically more urban and home to a larger share of individuals with OUD, saw no statistically detectable effect on mortality. As a result, although relative gains were substantial in underserved areas, the absolute reduction in mortality at the population level was more modest.

[25] This follows state-level coding based on whether "physical presence is not required" and "no on-site supervision is necessary," as documented in the Annual APRN Legislative Update.

At the same time, the evidence on diversion presents a more mixed picture. In well-served areas, increased buprenorphine dispensation did not translate into improved health outcomes. One possible explanation is that part of the additional supply entered informal markets, as suggested by declining street prices for pure buprenorphine and stable rates of self-reported drug misuse. In such cases, individuals may not have used buprenorphine as intended, limiting the potential health benefits.

These findings point to an important policy lesson: simply expanding access may not be sufficient to fully address the opioid crisis. While increasing the number of prescribers is a critical first step, it must be complemented by measures that ensure effective treatment delivery and limit diversion risks. Strategies could include encouraging use of abuse-deterrent formulations, strengthening provider training in OUD management, and addressing systemic barriers such as pharmacy availability and prior authorization requirements. Policymakers should not be complacent with the success of CARA in expanding access; more comprehensive approaches are needed to translate access into sustained improvements in health outcomes.

IX. Conclusion

This paper evaluates the impact of allowing NPs to prescribe buprenorphine independently. The findings show that the policy substantially increased access to OUD treatment, particularly in underserved areas. The expansion was driven by new prescriber entry, including early responses from non-NP providers, and was not offset by crowding out methadone-based treatment or specialist care. Importantly, reductions in opioid-related mortality were concentrated in counties that previously lacked access to treatment.

At the same time, the analysis shows that expanding access alone does not fully explain downstream outcomes. Buprenorphine dispensation also rose in well-served areas where mortality did not decline, and street prices for pure buprenorphine fell following the policy. These patterns highlight the double-edged nature of buprenorphine: while it is a highly effective treatment for OUD, expanded availability may also increase diversion and misuse if not carefully managed.

Overall, the results underscore that expanding the number of prescribers is a critical step, but not sufficient on its own. Comprehensive strategies are needed to ensure treatment is

both effective and safe. Policies that encourage use of abuse-deterrent formulations, strengthen provider training in OUD management, and reduce barriers such as pharmacy stocking and prior authorization requirements can help ensure that greater access translates into sustained improvements in health outcomes.

Institutional Details

A1. Medication for OUD and Its Regulations

Buprenorphine, methadone, and naltrexone are the only medications sanctioned by the Food and Drug Administration for OUD management today. Buprenorphine, a partial opioid agonist, mitigates cravings and withdrawal symptoms and also has less overdose potential than methadone, rendering it a safer option in OUD treatment. Due to its pharmacological attributes, buprenorphine's prescription regulations are more lenient compared to methadone. It can be prescribed outside of federally approved OTPs, which permits office-based treatments. Nonetheless, eligible physicians are required to complete a training course and submit a notification of intent to the Substance Abuse and Mental Health Services Administration.[26]

Methadone, a full opioid agonist with a long half-life,[27] effectively mitigates opioid cravings and withdrawal symptoms, making it suitable for withdrawal treatment. Its distribution is tightly controlled, as there is a risk of overdose with methadone, given that it is a full opioid agonist. Methadone is solely distributed through OTPs, requiring patients to visit clinics for their doses regularly or stay inpatient. This limits access, but methadone remains critical in treating more severe OUD patients, as it is more long-lasting than buprenorphine.

Naltrexone, a non-opioid, is non-addictive and does not induce withdrawal upon cessation. Given its non-opioid nature, it is less effective than methadone and buprenorphine in curbing cravings that accompany opioid withdrawal. Naltrexone can be administered in many ways, including a monthly injection that can be provided by any practitioner within their scope of practice, making it less regulated than buprenorphine or methadone. Primarily, it is utilized for alcohol use disorder and, to a lesser extent, OUD treatment (Volkow, Blanco et al. 2020).

The Drug Addiction Treatment Act of 2000 is the primary law that governs buprenorphine and methadone prescriptions when used for treating OUD, which separates them from other con-

[26] Under Drug Addiction Treatment Act, physicians may apply for a waiver to prescribe buprenorphine for the treatment of opioid addiction or dependence outside of an OTP. The act was intended to bring the treatment of addiction back to the primary care provider. Thus, most waivers are obtained after taking an 8-hour course from one of the five medical organizations designated in the Act.

[27] Methadone has a relatively long half-life (24–36 hours or longer). Steady-state serum levels generally do not reach until about five half-lives. This implies that patients may not experience the full effect of the initial dose for 4 or more days, even with consistent daily dosing.

trolled substances with additional restrictions. The primary distinction between buprenorphine and methadone and other controlled substances is that, first, the buprenorphine and methadone prescriber needs to meet eligibility criteria under the law. Before 2016, this excluded NPs. Second, methadone must only be used in OTPs. CARA includes NPs and PAs as eligible under the Drug Addiction Treatment Act.[28] However, methadone regulation remained unchanged.

Medicare Part D Buprenorphine Prescribers

A limitation of relying on Medicare Part D data is the extent to which these prescribers represent all active buprenorphine prescribers. To address this, I obtained the DEA's 2019 dataset on doctors authorized to prescribe buprenorphine through a public request. Although this dataset is a cross-sectional snapshot rather than panel data (with only a "last updated" attribute), it can help assess whether Medicare Part D data serves as a reasonable proxy for the broader prescriber population in 2019. Specifically, I aim to evaluate whether the number of Medicare Part D buprenorphine prescribers predicts the total number of active prescribers, and how many active buprenorphine prescribers are also Medicare Part D providers. It is noteworthy that approximately 50% of eligible prescribers do not actively prescribe buprenorphine, as reported by Duncan et al. (2020). Given my county-level analysis, I aggregate the number of prescribers from both the Medicare Part D and DEA datasets at the county level for 2019. I then conduct a regression analysis, regressing the number of DEA-listed prescribers at the county level (divided by two to account for active prescribers) on the adjusted Medicare Part D prescriber count, while controlling for county demographics and including state fixed effects.

In Table B1, the number of Medicare Part D prescribers strongly predicts the number of active buprenorphine prescribers at the county level, with a high R^2 and regardless of additional covariates. This is consistent with expectations, as Medicare Part D prescribers often also serve patients who are not covered by Medicare Part D. However, the population of prescribers who do not treat Medicare patients is missing from this data.

To estimate the proportion of buprenorphine prescribers who are Medicare Part D providers, I

[28]Despite CARA's inclusivity toward physician assistants, the impact of physician assistants would be much smaller. These professionals typically require closer collaboration with physicians, constraining their ability to prescribe independently.

Table B1— Medicare Part D Buprenorphine Prescribers Predict All Buprenorphine Prescribers

	Number of DEA Prescribers / 2		
	(1)	(2)	(3)
Medicare Part D Prescribers	1.519***	1.492***	1.553***
	(0.1085)	(0.1144)	(0.1179)
County Demographics		✓	✓
State Fixed Effects			✓
Constant	-0.2627	21.85***	
	(0.3529)	(5.671)	
Fit statistics			
Observations	3,143	3,143	3,143
R^2	0.82627	0.83208	0.85194
Within R^2			0.82444

Note: Standard errors are clustered at the county level. The observation is at county level. The table presents regression results examining the relationship between the number of Medicare Part D buprenorphine prescribers and the estimated number of active buprenorphine prescribers, as derived from the DEA data and adjusted to reflect only active prescribing practitioners (divided by two). $^{***}p < 0.01$

conducted a simple exercise assuming that Medicare Part D prescribers are representative of the broader prescriber population. Achieving a one-to-one correspondence, where each additional Medicare Part D prescriber aligns with an additional general prescriber, requires multiplying the Medicare Part D prescriber count by approximately 1.5. This implies that Medicare Part D prescribers account for about two-thirds of the total buprenorphine prescriber population.

B1. Comprehensive Addiction and Recovery Act of 2016

CARA is extensive legislation addressing various components of the opioid epidemic, including prevention, treatment, recovery, law enforcement, criminal justice reform, and overdose reversal. It authorizes more than $181 million annually in new federal funding to combat the opioid crisis.[29] The funding under CARA is distributed through various departments, such as the Department of Health and Human Services and the Substance Abuse and Mental Health Services Administration. These grants are primarily allocated to state health departments, which then design and implement their policies to use these funds, often expanding treatment access. According to Murrin (2020), a significant portion of the grants across states was used similarly to expand treatment access.

[29] https://www.ncbi.nlm.nih.gov/books/NBK575704/, accessed: 07/30/2024

A pivotal aspect of CARA is the inclusion of NPs and PAs under the Drug Addiction Treatment Act, thereby increasing the number of practitioners eligible to treat OUD. The focus on NP authority in this paper is due to their relative independence in practice compared to PAs, who face stricter supervision requirements under state laws.

dditionally, CARA includes several provisions aimed at broadening the national response to the opioid crisis, such as expanding research and education on addiction, improving access to naloxone for overdose reversal, and increasing support for law enforcement and criminal justice efforts. While these measures contribute to the broader strategy, their direct effect on treatment access is more limited, and they are unlikely to vary substantially across states.

B2. Drug Dictionary

In addition to the primary medications for OUD, such as methadone, buprenorphine, and naltrexone discussed in Section A.A1, several other opioids and opioid inhibitors play a significant role. This section outlines and elaborates on all the drugs mentioned in the study.

Oxycodone is a semi-synthetic opioid analgesic developed for the treatment of moderate to severe pain. It gained prominence through its extended-release version, OxyContin, produced by Purdue Pharma. Introduced in the late 1990s, its aggressive marketing significantly impacted the escalation of opioid use for pain management, subsequently increasing the risks of opioid misuse and addiction. In medical practice, oxycodone is considered when alternative pain relief methods are ineffective or unsuitable. Despite its therapeutic benefits for chronic pain, surgical recovery, and cancer-related pain, its potential for misuse and addiction, driven by the euphoric effects it can induce, remains a significant concern. Misuse ranges from non-prescribed usage to consuming higher doses than prescribed, or altering the drug form for enhanced effect.

Hydrocodone, known under brand names like Vicodin and produced by entities such as Mallinckrodt Pharmaceuticals, is a semi-synthetic opioid for moderate to severe pain relief. Functionally similar to oxycodone, it binds to the brain and spinal cord's opioid receptors, altering pain perception and emotional response. It is prescribed for acute pain, such as post-surgical pain or injuries, and certain chronic pain conditions. Like oxycodone, hydrocodone's risk of addiction and abuse poses a serious concern, often misused for its euphoric effects and

contributing to the opioid crisis.

Fentanyl, a highly potent synthetic opioid analgesic, is up to 100 times more potent than morphine. Both prescription and illicitly manufactured forms of fentanyl exist, with the latter significantly influencing the opioid crisis by being added to counterfeit pills or mixed with other drugs, enhancing the risk of fatal overdoses. Its synthetic nature allows for cost-effective production, exacerbating the spread of fentanyl-laced illicit drugs.

Naloxone is a life-saving medication designed to counteract opioid overdoses, including those from drugs like morphine and heroin. It works by displacing opioids from their receptors in the brain, rapidly reversing overdose effects, particularly respiratory depression. Available for administration via injection or nasal spray, naloxone's accessibility enables emergency use by both medical and non-medical individuals, significantly contributing to efforts to combat the opioid epidemic. Its harmlessness in individuals without opioids in their system further underscores its utility in emergency overdose interventions.

Suboxone combines buprenorphine with naloxone, an opioid antagonist, in a single medication used primarily for opioid addiction treatment. This combination helps reduce opioid cravings and withdrawal symptoms without producing the euphoric effects of other opioids. Naloxone's inclusion aims to prevent misuse by inducing withdrawal symptoms if the medication is injected, promoting its use as intended. Administered as a sublingual film or tablet, Suboxone is a cornerstone of medication-assisted treatment programs, which integrate medication with counseling and behavioral therapies for a comprehensive approach to addiction recovery.

Synthetic DiD Weight Construction

C1. Unit Weights

For the unit weights $\hat{\omega}^{sdid}$, I solve the following optimization problem. For clarity, Y denotes the residualized outcome (I omit the tilde notation for convenience):

$$(\hat{\omega}_0, \hat{\omega}^{sdid}) = \arg \min_{\omega_0 \in \mathbb{R},\, \omega \in \Omega} \ell_{unit}(\omega_0, \omega), \tag{C1}$$

where

$$\ell_{unit}(\omega_0, \omega) = \sum_{t=1}^{T_{pre}} \left(\omega_0 + \sum_{i=1}^{N_{co}} \omega_i Y_{it} - \frac{1}{N_{tr}} \sum_{i=N_{co}+1}^{N} Y_{it} \right)^2 + \zeta^2 T_{pre} \|\omega\|_2^2,$$

$$\Omega = \left\{ \omega \in \mathbb{R}_+^{N_{co}} : \sum_{i=1}^{N_{co}} \omega_i = 1,\ \omega_i = N_{tr}^{-1} \text{ for all } i = N_{co}+1, \ldots, N \right\},$$

where $\mathbb{R}_+$ denotes the positive real line. We set the regularization parameter ζ as

$$\zeta = (N_{tr} T_{post})^{1/4} \hat{\sigma} \quad \text{with} \quad \hat{\sigma}^2 = \frac{1}{N_{co}(T_{pre}-1)} \sum_{i=1}^{N_{co}} \sum_{t=1}^{T_{pre}-1} \left(\Delta_{it} - \bar{\Delta} \right)^2, \tag{C2}$$

where

$$\Delta_{it} = Y_{i(t+1)} - Y_{it}, \quad \text{and} \quad \bar{\Delta} = \frac{1}{N_{co}(T_{pre}-1)} \sum_{i=1}^{N_{co}} \sum_{t=1}^{T_{pre}-1} \Delta_{it}.$$

Thus, ζ is calibrated to match the typical one-period change in outcomes Δ_{it} for untreated units in the pre-treatment period, scaled by the theoretically motivated factor $(N_{tr} T_{post})^{1/4}$.

C2. Time Weights

The time weights $\hat{\lambda}^{sdid}$ are obtained by solving

$$(\hat{\lambda}_0, \hat{\lambda}^{sdid}) = \arg \min_{\lambda_0 \in \mathbb{R},\, \lambda \in \Lambda} \ell_{time}(\lambda_0, \lambda), \tag{C3}$$

where

$$\ell_{time}(\lambda_0, \lambda) = \sum_{i=1}^{N_{co}} \left(\lambda_0 + \sum_{t=1}^{T_{pre}} \lambda_t Y_{it} - \frac{1}{T_{post}} \sum_{t=T_{pre}+1}^{T} Y_{it} \right)^2,$$

$$\Lambda = \left\{ \lambda \in \mathbb{R}_+^T : \sum_{t=1}^{T_{pre}} \lambda_t = 1,\ \lambda_t = T_{post}^{-1} \text{ for all } t = T_{pre}+1, \ldots, T \right\}.$$

The main difference between Equations C1 and C3 is that the former includes regularization, while the latter does not. This distinction follows from the formal results in Arkhangelsky et al. (2021). Specifically, the regularization in unit weights accounts for the possibility of correlation across time for the same unit, while no analogous adjustment is required across units within a given period once systematic components of outcomes are captured by a latent factor structure.

Additional Figures and Tables

Table D1— 2015 State Level Health Providers Landscape

State	NP Full Practice States # NP per 100,000 (1)	# GP per 100,000 (2)	Ratio (NP:DOC) (3)	Bupe Prsrbr. per 100,000 (4)	State	NP Restricted Practice States # NP per 100,000 (5)	# GP per 100,000 (6)	Ratio (NP:DOC) (7)	Bupe Prsrbr. per 100,000 (8)
AK	12.6	84.0	0.15	2.17	AL	14.3	34.1	0.42	3.29
AZ	7.9	39.4	0.20	0.97	AR	11.7	49.5	0.24	1.01
CO	12.5	55.0	0.23	1.74	CA	9.4	37.3	0.25	1.26
CT	19.4	22.3	0.87	4.26	FL	16.9	41.9	0.40	2.49
DC	25.1	50.3	0.50	3.12	GA	12.6	32.9	0.38	1.68
DE	28.9	49.8	0.58	3.07	IL	12.0	41.4	0.29	1.28
HI	6.1	47.4	0.13	1.33	IN	18.4	49.8	0.37	2.10
IA	18.2	67.2	0.27	0.22	KS	22.9	59.5	0.38	0.86
ID	14.1	55.3	0.25	1.39	KY	26.9	42.6	0.63	4.95
MD	11.0	27.8	0.39	4.06	LA	11.0	33.0	0.33	3.47
ME	19.7	74.4	0.26	11.73	MA	28.6	28.9	0.99	8.76
MN	22.7	60.1	0.38	1.20	MI	17.4	53.5	0.32	3.28
MT	13.0	58.9	0.22	1.26	MO	12.8	43.0	0.30	1.50
ND	36.7	67.4	0.55	0.66	MS	15.7	37.0	0.42	2.44
NE	19.8	59.4	0.33	0.58	NC	15.1	39.7	0.38	2.20
NH	17.2	51.2	0.34	5.26	NJ	7.5	27.7	0.27	3.19
NM	10.0	56.5	0.18	3.84	OH	14.4	41.7	0.34	4.06
NV	9.1	33.1	0.28	1.38	OK	8.0	53.6	0.15	1.59
NY	9.2	28.2	0.33	3.30	PA	14.4	53.3	0.27	4.29
OR	8.1	53.0	0.15	2.56	SC	10.6	45.1	0.24	1.88
RI	21.7	35.7	0.61	8.33	SD	20.0	57.9	0.35	0.70
VT	15.0	62.1	0.24	12.62	TN	21.1	35.1	0.60	4.91
WA	16.3	60.9	0.27	2.08	TX	7.3	35.4	0.21	1.07
WY	8.7	55.5	0.16	2.04	UT	11.3	33.0	0.34	2.60
					VA	11.0	43.6	0.25	1.60
					WI	31.2	54.1	0.58	1.90
					WV	12.6	60.1	0.21	6.34
Average	13.7	40.8	0.33	2.74		13.3	44.5	0.30	2.44

Note: The table presents the number of primary healthcare providers per 100,000 in each state, categorized by NP practice authority as defined in McMichael and Markowitz (2023). Column (1), (2), (3), (5), (6), and (7) are derived from the NPESS 2015 database and include providers with NPI numbers. GP is defined as those whose primary taxonomy is general practice (208D00000X) or family practice (207Q00000X). Columns (4) and (8) are derived from Medicare Part D Prescribers - by Provider for the number of buprenorphine prescribers in the Medicare Part D program. This should be considered the lower bound of all buprenorphine providers, as some eligible prescribers might not have seen any patients, and some providers might not have submitted a claim through Medicare Part D.

Table D2— State-Level Policy Balance Test

	Naloxone Access	Involuntary Commitment	Opioid Prescribing Limit
	(1)	(2)	(3)
NP Indep. Bupe.	0.074	-0.096	-0.074
	(0.100)	(0.102)	(0.087)
Year Fixed Effects	✓	✓	✓
State Fixed Effects	✓	✓	✓
Observations	408	408	408
R^2	0.656	0.684	0.601
	PDMP	Informed Consent for Opioid	Medicaid Expansion
	(4)	(5)	(6)
NP Indep. Bupe.	0.022	-0.044	0.169*
	(0.034)	(0.075)	(0.075)
Year Fixed Effects	✓	✓	✓
State Fixed Effects	✓	✓	✓
Observations	408	408	408
R^2	0.227	0.614	0.782

Note: Each column reports results from a balancing regression estimated at the state-year level. The dependent variable is a binary indicator equal to one if a specific opioid-related state policy is in effect in a given year. The key independent variable is an indicator for whether NPs are authorized to independently prescribe buprenorphine. Standard errors are clustered at the state level. This table tests whether the timing of NP prescribing authority is systematically associated with other policy changes that may confound the main results. $^{*}p < 0.05$

Table D3— Lagged Opioid Mortality and the Timing of NP Independent Prescribing Authority

	NP Independent Prescribing Authority	
	(1)	(2)
Constant	0.036	
	(0.043)	
1-Year Lag Opioid Mortality	0.001	0.000
	(0.010)	(0.013)
2-Year Lag Opioid Mortality	-0.012	-0.006
	(0.018)	(0.022)
3-Year Lag Opioid Mortality	0.016	0.013
	(0.016)	(0.014)
Year Fixed Effects		✓
Observations	216	216
R^2	0.008	0.033

Note: Each observation is a state-year. The dependent variable is a binary indicator equal to one if, in that year, NPs were authorized to independently under state law. The sample excludes always-treated states and includes only the year of adoption for newly adopting states, reflecting the one-time nature of the policy change. The key independent variables are lagged values of opioid-related mortality per 100,000 residents. Standard errors are clustered at the state level.

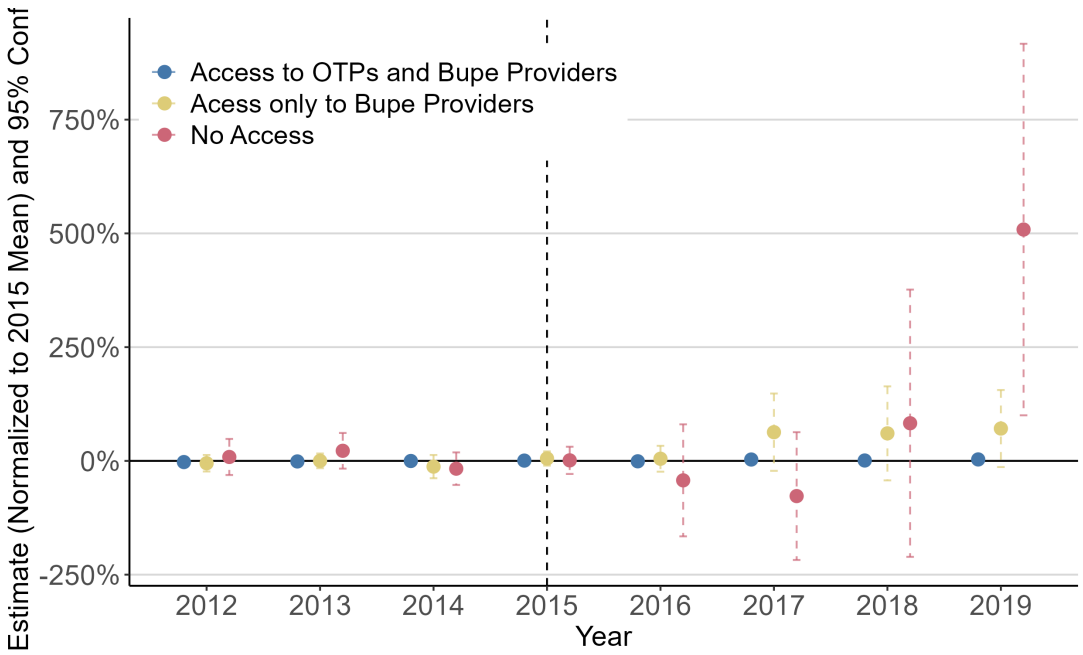


Figure D1. County Heterogenous Response on Number of OTPs

Note: This figure reports county-level synthetic DiD estimates from Equation 4, where the outcome is the number of OTPs per 100,000 residents. Counties are stratified by baseline treatment availability in 2013: (1) no access to medication for OUD, (2) access to buprenorphine providers only, and (3) access to both buprenorphine and OTPs. Estimates are normalized to 2015 averages within each group to facilitate comparison across strata. Confidence intervals are constructed via bootstrap resampling.

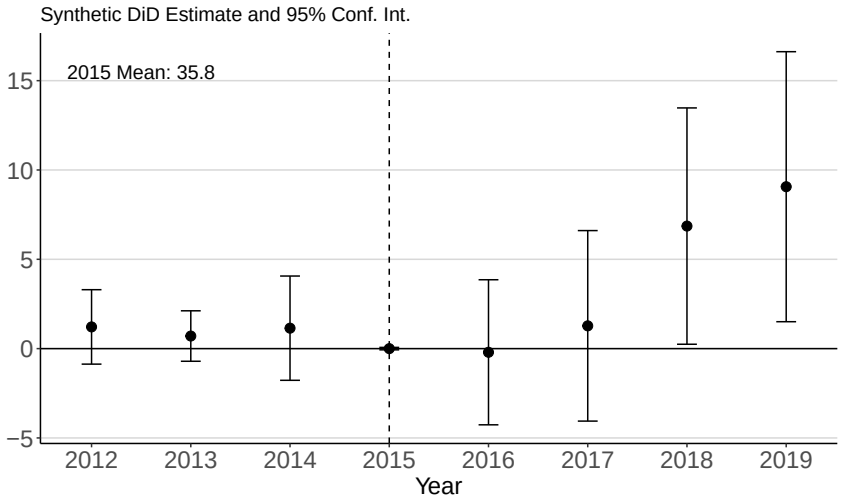


Figure D2. OTP Methadone Dispensation Per Capita

Note: This figure presents synthetic DiD estimates from Equation 4, with the outcome defined as methadone dispensation at OTP, measured in per capita terms at the county level. Confidence intervals are constructed using bootstrap resampling.

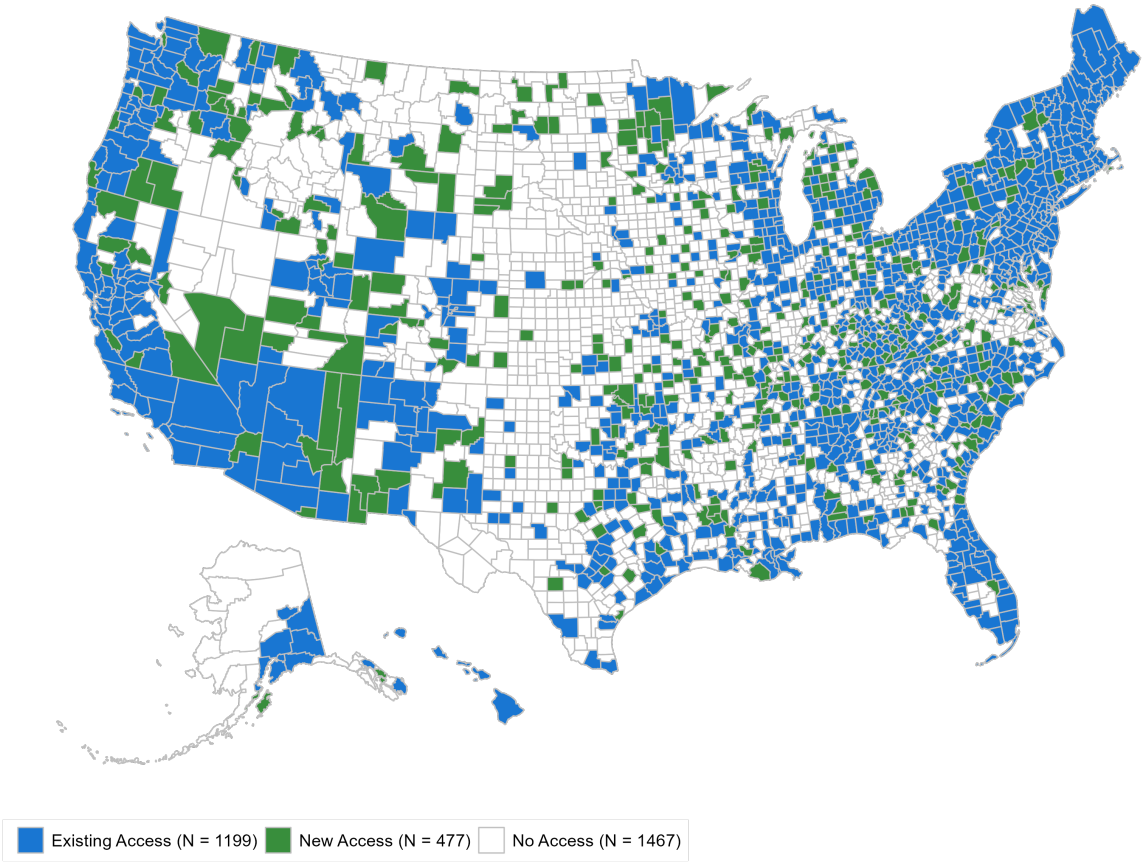
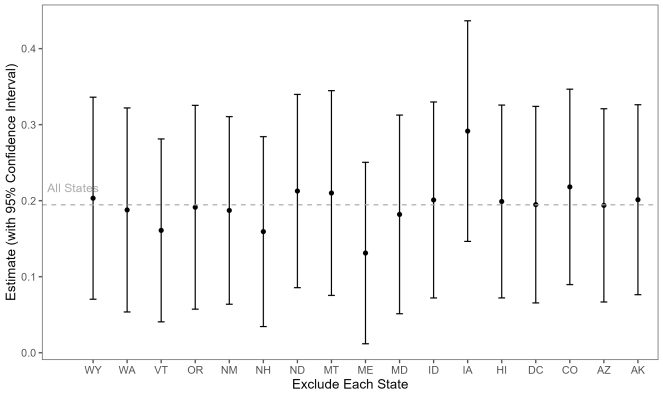
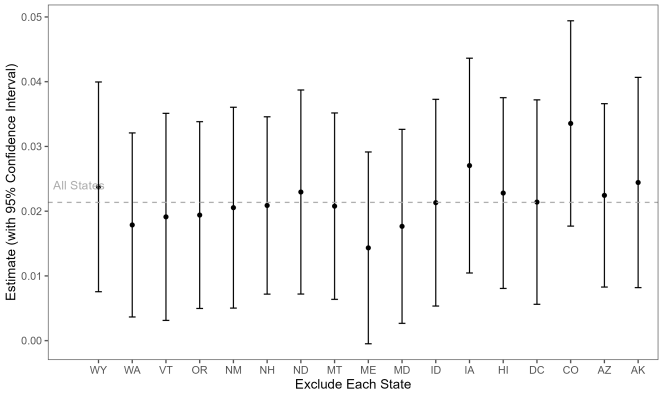


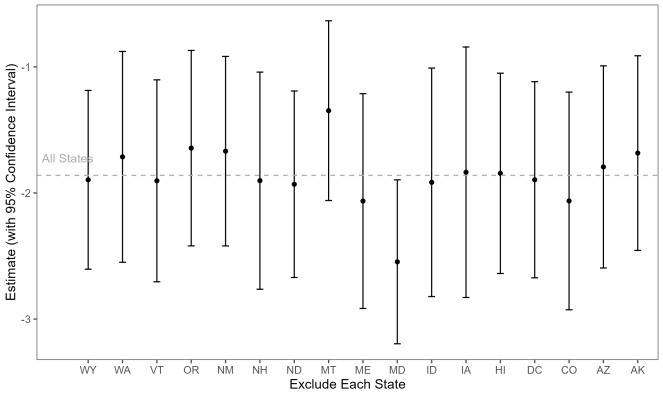
Figure D3. County Gained Access in 2019 Compare to 2013



(a) Number of buprenorphine prescribing NPs per 100,000



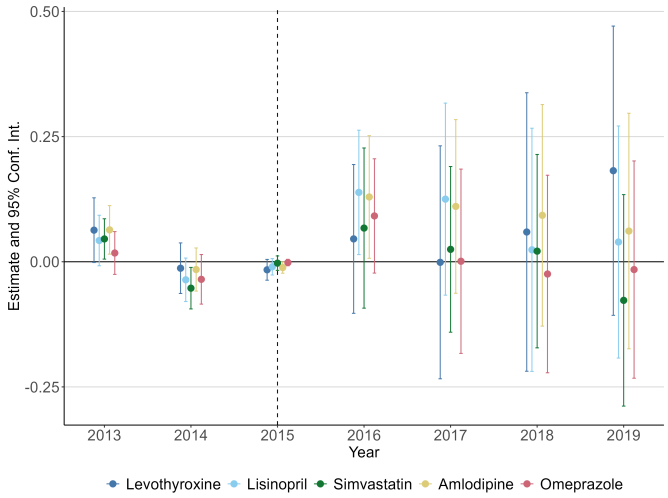
(b) Buprenorphine Dispensation per Capita



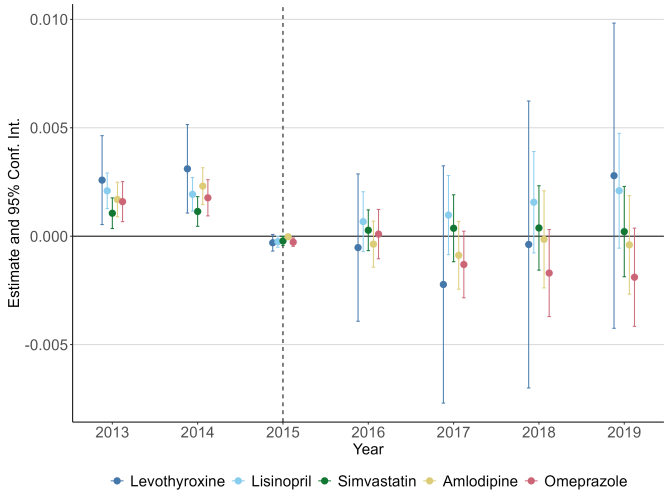
(c) Opioid-Related Mortality per 100,000

Figure D4. Robustness Check: Leave One Out

Note: This robustness check re-estimates Equation 4 for each of the three main outcomes presented in Section IV: (1) buprenorphine prescribers per 100,000 population, (2) buprenorphine dispensation per capita (in morphine gram equivalents), and (3) opioid-related mortality per 100,000 population. Estimates are obtained by sequentially excluding one state at a time. The grey dashed line marks the estimate using the full sample. Confidence intervals are constructed using bootstrap resampling.



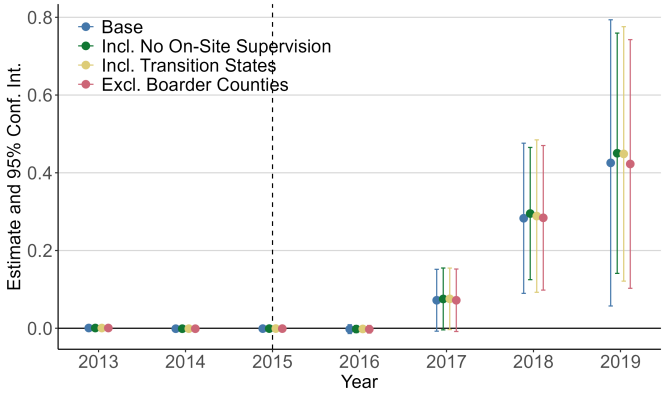
(a) Number of Prescribers per 100,000



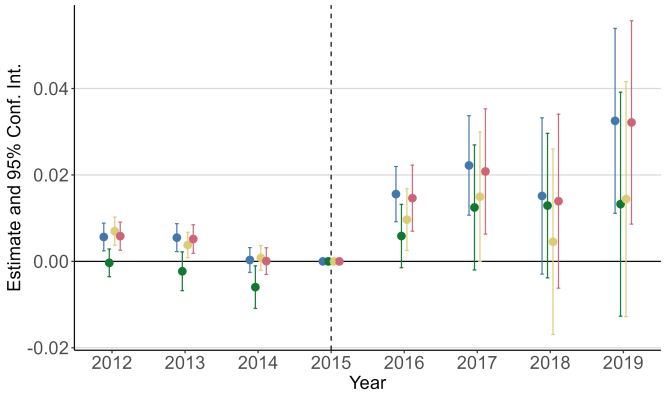
(b) Number of Claims per Capita

Figure D5. Robustness Check: Effect of Other Drugs

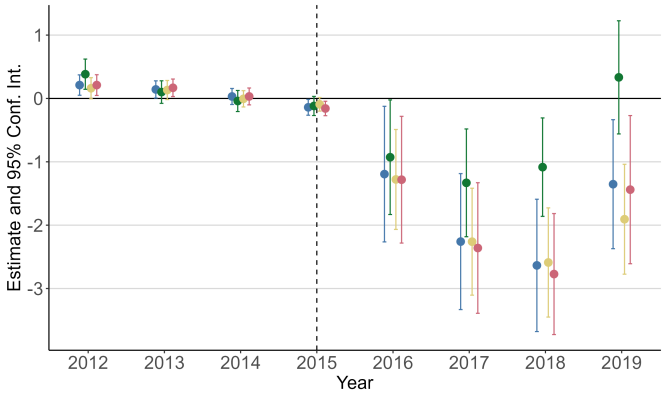
Note: These figures present estimates from Equation 4, using the number of prescribers per 100,000 and claims per capita as outcomes for commonly prescribed medications unrelated to OUD. The analysis includes five drugs with the highest claim volumes in the 2013 Medicare Part D data: levothyroxine, lisinopril, simvastatin, amlodipine, and omeprazole. Confidence intervals are constructed using bootstrap resampling.



(a) Number of Buprenorphine Prescribing NPs per 100,000



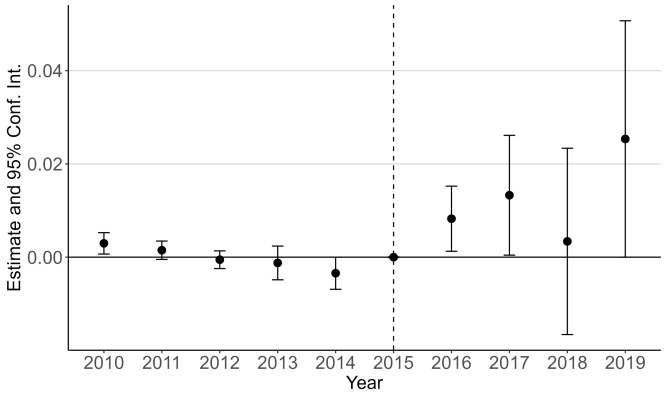
(b) Buprenorphine Dispensation per Capita



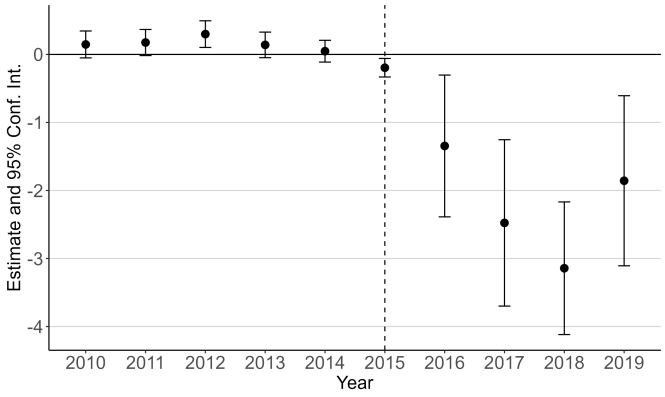
(c) Opioid-Related Mortality per 100,000

Figure D6. Robustness Check: Under Alternative Definitions of Treatment States

Note: This figure presents robustness checks estimating Equation 4 using alternative definitions of treatment status. Outcomes include: (1) the number of buprenorphine prescribers per 100,000 population; (2) buprenorphine dispensation per capita (in morphine gram equivalents); and (3) opioid-related mortality per 100,000 population. "Base" reflects the preferred classification used throughout the paper. "Incl. Transition States" reclassifies states that transitioned to full NP practice authority between 2013 and 2016 as treated. "Incl. No On-Site Supervision" additionally includes restricted-practice states that did not require on-site physician supervision. "Excl. Border Counties" removes counties in restricted-practice states that share a border with full-practice states. Confidence intervals are constructed using bootstrap resampling.



(a) Buprenorphine Dispensation per Capita



(b) Opioid-Related Mortality per 100,000

Figure D7. Robustness Check: Prolonged Pre-Treatment Periods

Note: This figure presents robustness check estimates from Equation 4 using an extended pre-treatment period. Outcomes include: (1) buprenorphine dispensation per capita (measured in morphine gram equivalents) and (2) opioid-related mortality per 100,000 population. The pre-treatment window is expanded to include 2010–2012, while the post-treatment period remains 2016–2019. Confidence intervals are constructed using bootstrap resampling.

*

References

Abouk, Rahi, Lorens Helmchen, Ali Moghtaderi, and Jesse Pines. 2021. "The ACA Medicaid expansions and opioid mortality: Is there a link?" *Medical Care Research and Review*, 78(6): 713–724.

Abouk, Rahi, Rosalie Liccardo Pacula, and David Powell. 2019. "Association between state laws facilitating pharmacy distribution of naloxone and risk of fatal overdose." *JAMA internal medicine*, 179(6): 805–811.

Alexander, Diane, and Molly Schnell. 2019. "Just what the nurse practitioner ordered: Independent prescriptive authority and population mental health." *Journal of Health Economics*, 66: 145–162.

Alpert, Abby. 2016. "The anticipatory effects of Medicare Part D on drug utilization." *Journal of health economics*, 49: 28–45.

Alpert, Abby, David Powell, and Rosalie Liccardo Pacula. 2018. "Supply-Side Drug Policy in the Presence of Substitutes: Evidence from the Introduction of Abuse-Deterrent Opioids." *American Economic Journal: Economic Policy*, 10(4): 1–35.

Alpert, Abby, William N Evans, Ethan MJ Lieber, and David Powell. 2022. "Origins of the opioid crisis and its enduring impacts." *The Quarterly Journal of Economics*, 137(2): 1139–1179.

Andrilla, C Holly A, Cynthia Coulthard, and Davis G Patterson. 2018. "Prescribing practices of rural physicians waivered to prescribe buprenorphine." *American journal of preventive medicine*, 54(6): S208–S214.

Arkhangelsky, Dmitry, Susan Athey, David A Hirshberg, Guido W Imbens, and Stefan Wager. 2021. "Synthetic difference-in-differences." *American Economic Review*, 111(12): 4088–4118.

Averett, Susan L, Julie K Smith, and Yang Wang. 2019. "Medicaid expansion and opioid deaths." *Health economics*, 28(12): 1491–1496.

Connery, Hilary Smith. 2015. "Medication-assisted treatment of opioid use disorder: review of the evidence and future directions." *Harvard review of psychiatry*, 23(2): 63–75.

Currie, Janet, and Hannes Schwandt. 2021. "The opioid epidemic was not caused by economic distress but by factors that could be more rapidly addressed." *The ANNALS of the American Academy of Political and Social Science*, 695(1): 276–291.

Currie, Janet, Anran Li, and Molly Schnell. 2023. "The Effects of Competition on Physician Prescribing." National Bureau of Economic Research.

Degenhardt, Louisa, Sarah Larney, Jo Kimber, Natasa Gisev, Michael Farrell, Timothy Dobbins, Don J Weatherburn, Amy Gibson, Richard Mattick, Tony Butler, et al. 2014. "The impact of opioid substitution therapy on mortality post-release from prison: retrospective data linkage study." *Addiction*, 109(8): 1306–1317.

Dever, Jill A, Marci F Hertz, Laura J Dunlap, John S Richardson, Sara Beth Wolicki, Bradley B Biggers, Mark J Edlund, Michele K Bohm, Didier Turcios, Xinyi Jiang, et al. 2024. "The medications for opioid use disorder study: methods and initial outcomes from an 18-month study of patients in treatment for opioid use disorder." *Public Health Reports®*, 139(4): 484–493.

Doleac, Jennifer L, and Anita Mukherjee. 2022. "The effects of naloxone access laws on opioid abuse, mortality, and crime." *The Journal of Law and Economics*, 65(2): 211–238.

Donahoe, J Travis. 2023. "Supplier enforcement and the opioid crisis." *Available at SSRN 5260245*.

Duncan, Alexandra, Jared Anderman, Travis Deseran, Ian Reynolds, and Bradley D Stein. 2020. "Monthly patient volumes of buprenorphine-waivered clinicians in the US." *JAMA network open*, 3(8): e2014045–e2014045.

Evans, William N, Ethan MJ Lieber, and Patrick Power. 2019. "How the reformulation of OxyContin ignited the heroin epidemic." *Review of Economics and Statistics*, 101(1): 1–15.

Gui, Lance. 2025. "The Last Mile to First Treatment: Search for Opioid Use Disorder Medication." Working Paper.

Gui, Lance, Chuan Qin, and Mo Xiao. 2024. "Anatomy of Opioid Diversion: Examining Supply-Side Curtailment." *Available at SSRN 5044557*.

Kranz, Sebastian. 2023. "xsynthdid:Synthetic Differences-in-Differences with Time-Varying Covariates." *https://github.com/skranz/xsynthdid*, Accessed: 2024-08-26.

Krawczyk, Noa, Bianca D Rivera, Victoria Jent, Katherine M Keyes, Christopher M Jones, and Magdalena Cerdá. 2022. "Has the treatment gap for opioid use disorder narrowed in the US?: A yearly assessment from 2010 to 2019"." *International Journal of Drug Policy*, 110: 103786.

Larochelle, Marc R, Dana Bernson, Thomas Land, Thomas J Stopka, Na Wang, Ziming Xuan, Sarah M Bagley, Jane M Liebschutz, and Alexander Y Walley. 2018. "Medication for opioid use disorder after nonfatal opioid overdose and association with mortality: a cohort study." *Annals of internal medicine*, 169(3): 137–145.

Ma, Jun, Yan-Ping Bao, Ru-Jia Wang, Meng-Fan Su, Mo-Xuan Liu, Jin-Qiao Li, Louisa Degenhardt, Michael Farrell, Frederic C Blow, Mark Ilgen, et al. 2019. "Effects of medication-assisted treatment on mortality among opioids users: a systematic review and meta-analysis." *Molecular psychiatry*, 24(12): 1868–1883.

Mallatt, Justine. 2018. "The effect of prescription drug monitoring programs on opioid prescriptions and heroin crime rates." *Available at SSRN 3050692*.

Mallatt, Justine. 2022. "Policy-induced substitution to illicit drugs and implications for law enforcement activity." *American Journal of Health Economics*, 8(1): 30–64.

McBain, Ryan K, Andrew Dick, Mark Sorbero, and Bradley D Stein. 2020. "Growth and distribution of buprenorphine-waivered providers in the United States, 2007–2017." *Annals of internal medicine*, 172(7): 504–506.

McMichael, Benjamin J, and Sara Markowitz. 2023. "Toward a uniform classification of nurse practitioner scope of practice laws." *Medical Care Research and Review*, 80(4): 444–454.

Murrin, Suzanne. 2020. "States' Use of Grant Funding for a Targeted Response to the Opioid Crisis." U.S. Department of Health and Human Services OEI-BL-18-00460. Retrieved from U.S. Department of Health and Human Services, Office of Inspector General website.

Pei, Zhuan, Jörn-Steffen Pischke, and Hannes Schwandt. 2019. "Poorly measured confounders are more useful on the left than on the right." *Journal of Business & Economic Statistics*, 37(2): 205–216.

Rees, Daniel I, Joseph J Sabia, Laura M Argys, Dhaval Dave, and Joshua Latshaw. 2019. "With a little help from my friends: the effects of Good Samaritan and naloxone access laws on opioid-related deaths." *The Journal of Law and Economics*, 62(1): 1–27.

Sedney, Cara L, Maryam Khodaverdi, Robin Pollini, Patricia Dekeseredy, Nathan Wood, and Treah Haggerty. 2021. "Assessing the impact of a restrictive opioid prescribing law in West Virginia." *Substance abuse treatment, prevention, and policy*, 16(1): 14.

Severtson, Stevan Geoffrey, Becki Bucher Bartelson, Jonathan M Davis, Alvaro Muñoz, Michael F Schneider, Howard Chilcoat, Paul M Coplan, Hilary Surratt, and Richard C Dart. 2013. "Reduced abuse, therapeutic errors, and diversion following reformulation of extended-release oxycodone in 2010." *The Journal of Pain*, 14(10): 1122–1130.

Soliman, Adam. 2025. "Disrupting drug markets: The effects of crackdowns on rogue opioid suppliers." *American Economic Journal: Economic Policy*. Forthcoming.

Sordo, Luis, Gregorio Barrio, Maria J Bravo, B Iciar Indave, Louisa Degenhardt, Lucas Wiessing, Marica Ferri, and Roberto Pastor-Barriuso. 2017. "Mortality risk

during and after opioid substitution treatment: systematic review and meta-analysis of cohort studies." *BMJ*, 357.

Stein, Bradley D, Mark Sorbero, Andrew W Dick, Rosalie Liccardo Pacula, Rachel M Burns, and Adam J Gordon. 2016. "Physician capacity to treat opioid use disorder with buprenorphine-assisted treatment." *JAMA*, 316(11): 1211–1212.

Thomas, Cindy Parks, Erin Doyle, Peter W Kreiner, Christopher M Jones, Joel Dubenitz, Alexis Horan, and Bradley D Stein. 2017. "Prescribing patterns of buprenorphine waivered physicians." *Drug and alcohol dependence*, 181: 213–218.

Timko, Christine, Nicole R Schultz, Michael A Cucciare, Lisa Vittorio, and Christina Garrison-Diehn. 2016. "Retention in medication-assisted treatment for opiate dependence: a systematic review." *Journal of addictive diseases*, 35(1): 22–35.

Traczynski, Jeffrey, and Victoria Udalova. 2018. "Nurse practitioner independence, health care utilization, and health outcomes." *Journal of health economics*, 58: 90–109.

Volkow, Nora D, Carlos Blanco, et al. 2020. "Medications for opioid use disorders: clinical and pharmacological considerations." *The Journal of clinical investigation*, 130(1): 10–13.