Subscriptions to Prescriptions: Lessons from Louisiana's Effort to Eliminate Hepatitis C

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Abstract

Hepatitis C is a major public health concern due to its high rates of infection and mortality. Recent breakthroughs in pharmaceuticals not only have the potential to cure hepatitis C but could also cause large positive health externalities through reduced transmission. The high cost of these drugs under traditional reimbursement schemes create large obstacles to care, but a recent first-of-its-kind two-part tariff system in Louisiana aims to circumvent these obstacles using a modified subscription model with an exclusive pharmaceutical provider. Under this model, the medication is provided at no marginal cost to the state to cover the state's Medicaid and incarcerated population. This creates an incentive for Louisiana to aggressively test and treat as many patients as possible in order to maximize the benefits of this agreement. Using a number of different data sources, we implement synthetic control and event-study specifications, and find that detection and treatment of hepatitis C increased dramatically, with meaningful reductions in hepatitis C-related mortality and liver transplants after this agreement. Finally, after calculating the Marginal Value of Public Funds of this agreement, we find that the program more than pays for itself.

JEL codes: H42, I11, I18, L11

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1. Introduction

Chronic infection with the hepatitis C virus (HCV) creates an enormous public health burden on the United States. Recent estimates suggest that as many as four million Americans are infected (Hall et al., 2024), or just over 1% of the population. HCV prevalence is even higher among the incarcerated population, with Spaulding et al. (2023) estimating the prevalence in the state prison population at 8.7%, over eight times higher than in the non-incarcerated population. In addition to its high rates of infection, HCV also leads to substantial mortality. For example, Marcus et al. (2020) estimated the life expectancy at age 20 for persons with and without HCV and found that HCV caused a reduction of 12.5 years, or approximately 20%.

In 2013, a breakthrough class of "miracle" drugs, known as direct-acting antivirals (DAAs) were introduced. These drugs have cure rates greater than 95% with minimal side effects, and provide a promising potential path to eradicate HCV (Liang and Ghany, 2014). However, even with these drugs becoming available, the prevalence of HCV in the United States remained relatively flat from 2013-2020 (Hofmeister et al., 2019; Hall et al., 2024; Rosenberg et al., 2018), likely due to the staggeringly high initial list prices of treatment, which were as high as $84,000 (Barber et al., 2020). Even at these high prices, a case could be made for a government program to purchase the drug for every chronic HCV patient, as it more than pays for itself in the cost of avoided medical care. With estimated annual individual healthcare costs attributable to HCV infection ranging from $10,000 to over $46,000 for adults with end-stage liver disease, paying for DAAs would result in savings accrued to Medicare and Medicaid for most patients (Roebuck and Liberman, 2019).

In the decade since the first DAA was approved, list prices have fallen by as much as 70%, but they remain out of reach for the typical low-socioeconomic status HCV patient. While Medicaid does not often pay full list price, the vast majority of state Medicaid offices continue to ration the drug to the most advanced cases of the illness and those not using drugs or alcohol (Waters and Broder, 2018). Even though cost-benefit calculations clearly indicate it would be worthwhile to aggressively expand treatment with DAAs, it would likely require an upfront investment in the drug that liquidity-constrained Medicaid offices cannot afford. The result of this tension is a standstill where patients must wait until they become seriously

ill in order to receive care, even though it would save public dollars to treat them earlier while also preventing unnecessary suffering.

In 2019, the Louisiana Department of Health implemented a possible solution to this policy dilemma, reaching an agreement with Asugua Pharmaceuticals to gain unlimited access to their generic version of the breakthrough hepatitis C antiviral, Epclusa, for the state's Medicaid and incarcerated populations. This "modified-subscription system" was the cornerstone of their Louisiana Hepatitis C Elimination Plan (LAHCEP), which had the goal of diagnosing 90% and treating 80% of hepatitis C patients in Louisiana (Louisiana Department of Health, 2019). The agreement capped state Medicaid spending on DAAs for the next five years at a total cost equal to Louisiana Medicaid's 2018 DAAs spending, but gave Louisiana unlimited access to the drug. This agreement drove the marginal cost of treatment to zero, creating an incentive for the state to test and treat as many Louisianans as possible. In this paper, we evaluate the effects of the LAHCEP on prescriptions of DAAs, on testing and surveillance of HCV, on HCV-related mortality, and on the market for liver transplants using both the synthetic control method of Abadie and Gardeazabal (2003) and event-study designs.

Using data from the Centers for Disease Control and Prevention's (CDC) National Center for HIV, Viral Hepatitis, STD, and TB Prevention, we find that the LAHCEP increased HCV diagnoses in Louisiana by over 3,300% in 2020, over 4,000% in 2021, and over 1,900% in 2022. The slowdown in diagnoses which occurred in 2022, the most recent year for which we have data, is consistent with the state reaching diminishing marginal returns to surveillance and testing, which suggests they may have already reached a substantial portion of the HCV positive population.

Next, we use data from the Centers for Medicare and Medicaid Services State Drug Utilization Program (SDUD) to estimate the effect of the LAHCEP on prescriptions filled. We find that the LAHCEP led to an immediate increases of DAA prescriptions of 260% in 2019, 560% in 2020, 450% in 2021, and 350% in 2022. Compared with the 2018 base rate of 1.52 prescriptions per 1,000 Medicaid patients, these estimates represent increase of 211%, 270%, 165%, and 96%, respectively. We find that by the end of the fourth year of the five year program, Louisiana had treated 30,259 patients through the LAHCEP. Comparing this to the estimated statewide prevalence from Rosenberg et al. (2018) of 44,900 HCV positive patients,

this suggests that they had already treated approximately 67.4% of all patients in the state, with a full year of the five-year program left to go.

We also use restricted access data from the National Vital Statistics System to measure the effects of the LAHCEP on HCV-related mortality. We find HCV-related mortality declined 11-13% in the first four years, which implies between 300-400 fewer deaths. This translates to approximately one HCV-related death avoided for every 85 DAA prescriptions filled between 2019-2022. Because of the slow progression of HCV infection, the largest effects on mortality likely will not show up until 10-20 years after the start of the plan (Chhatwal et al., 2023). As a result, the reductions we find in the first four years likely understate the full potential of the program's ability to reduce mortality.

In addition to the reduction in harm, programs like this have the potential to generate enormous long-run cost savings by treating hepatitis C early and preventing patients from having to undergo expensive treatments to manage their disease, which could ultimately include organ transplants and dialysis. Both of these treatments are very expensive and typically covered by Medicaid, which means the costs are ultimately born by the U.S. taxpayers. As such, we also use patient-level data from the Scientific Registry of Transplant Recipients (SRTR) to estimate the effects of the LAHCEP on demand for liver transplants. We find the LAHCEP reduced the number of liver transplants in Louisianna by 27% and improved the overall liver function of candidates on the waitlist by 6.5%

This paper contributes to a growing body of work which looks at the possibility of eliminating HCV as a public health threat. This includes Sood, Ung, et al. (2019), which outlined the novel strategy for increasing access to HCV DAAs through a subscription system that was eventually used in the LAHCEP, as well as Chhatwal et al. (2023), which attempts to estimate the health benefits and cost savings of a national hepatitis C elimination initiative. The authors of this paper simulate the disease progression, healthcare costs, and eventual mortality with and without a national program designed similarly to the LAHCEP, finding that such an initiative would avert 24,000 deaths, add 220,000 life years, and would save over $18 billion in direct healthcare spending. While it is far too early to know whether the LAHCEP will eliminate HCV as a public health threat in Louisiana, we demonstrate that it was able to dramatically increase DAA utilization and has already begun to reduce mortality and the demand for organ transplants.

The LAHCEP also provides us with the opportunity to test theoretical predictions about the effect of subscription models, or two-part tariffs, in pharmaceutical markets. In a two-part tariff system, consumers pay a fixed upfront free and receive goods or services at a lower marginal cost. Recent work by Brekke et al. (2022) suggests that two-part tariffs will be most effective as a public policy tool in pharmaceutical markets when there are multiple providers of a given drug. Specifically, they find that when producers have monopoly power, they would be able to extract all the surplus in the market upfront through the initial subscription fee. However, in contexts with supply-side competition, insurers with large market shares are able to exert a credible threat to the pharmaceutical companies that they might be left out of the market entirely, which causes them to undercut one another on prices to the point where the consumer is now able to extract the full surplus from the market.

The market for DAAs in 2019 closely resembled the ideal setting for insurers and public health agencies from Brekke et al. (2022). With the introduction of Asegua Therapeutics' generic version of Epclusa, there were 10 different DAAs available which had similar cure rates and minimal side effects, making them closely substitutable. However, even with 10 DAAs there were only three pharmaceutical providers, suggesting there was still a degree of oligopoly power which is likely why the list prices for the drugs remained in the tens of thousands of dollars. This created an opportunity for the Louisiana Department of Health to negotiate with the multiple providers and avoid the aggressive surplus extraction that can take place with a monopoly provider. The deal the Louisiana Department of Health negotiated with Asegua Therapeutics capped the state's Medicaid spending on DAAs at 2018 levels while greatly increasing their access to the medications, suggesting that the state received substantial surplus in line with the predictions from Brekke et al. (2022).

A program like this also has the potential to create large positive externalities (Callison et al., 2023). Hepatitis C is a contagious virus that is spread mostly through contact with the blood of an infected person; but it can take several years for symptoms to show up, and so as many as 40% of HCV positive patients are not aware of their infection (Gnanapandithan and Ghali, 2023). This makes it extremely difficult to eradicate HCV, even with the remarkably effective DAA treatments. If most doctors know they will not be able to treat their Medicaid patients

even if they do diagnose them with HCV, this creates a disincentive to test them in the first place. By driving the marginal cost of treatment to zero, a subscription model reverses this disincentive and encourages public health agencies to greatly expand testing and monitoring in order to find and treat patients before they have the ability to spread the disease to others.

We conclude with two back-of-the-envelope calculations quantifying the benefits of the LAHCEP. We estimate that in the first four years of the program, the LAHCEP treated over 67% of the HCV positive population in Louisiana, and are on track to treat 78% by the program's end. We also show that, even under relatively conservative assumptions, that the Marginal Value of Public Funds (MVPF) of this program is likely to be positive and very large. Since the LAHCEP began, the Biden administration has released a plan for a national version of this policy solution (Chhatwal et al., 2023), so our assessment of this state-level effort is informative for what could become a national effort to eradicate HCV.

This paper proceeds as follows. Section 2 provides background on the health impacts and prevalence of hepatitis C in the United States, and the remarkable class of "direct-acting antiviral" medications which have the potential to eliminate hepatitis C as a public health concern. This section also covers the barriers to treatment which currently exist and the Louisiana Hepatitis C Elimination Plan, which attempts to overcome these barriers and treat at least 80% of infected patients by 2024. Section 3 outlines the various data sources we use and our empirical strategy for evaluating the effectiveness of this intervention. Section 4 presents our results on hepatitis C diagnoses, Medicaid prescriptions of DAAs, hepatitis C-related mortality, and liver transplant patients in Louisiana. Section 5 concludes.

2. Background

2.1. Hepatitis C and Health Outcomes

The hepatitis C virus (HCV) is a deadly virus which is typically transmitted through blood. The most common form of infection is through the sharing of contaminated needles for intravenous drug use (Williams et al., 2011), though it can also be transmitted through sexual exposure and via vertical transmission from mother to child (Tibbs, 1995). About a quarter of people infected with HCV will clear the virus spontaneously, with the rest developing chronic infection (Grebely et al.,

2012). HCV infection causes inflammation of the liver, which over time leads to an accumulation of excess protein cells, a condition known as fibrosis. As fibrosis worsens, it leads to scarring of the liver (cirrhosis), liver cancer (hepatocellular carcinoma), liver failure, and death (Bataller and Brenner, 2005). According to Westbrook and Dusheiko (2014), "Chronic infection with HCV is the leading cause of end-stage liver disease, hepatocellular carcinoma (HCC) and liver-related death in the Western world". Although cirrhosis cannot be reversed, the liver does have some ability to heal from damage if the cause of damage is treated early (Cleveland Clinic, 2025).

According to the American Liver Foundation, there are over 11,500 people on the waiting list for a liver transplant, and waits to receive a liver can last from 30 days to over five years (ALF, 2022). Priority on the liver transplant waiting list is partially determined by a candidate's MELD score, which ranges from 6 to 40 (OPTN, 2025). A higher MELD score represents a higher likelihood of death within 3 months and is calculated from measures of liver function (OPTN, 2025). In 2008, approximately 30% of registrants on the liver transplant waiting list had a primary diagnosis of HCV, making it the most common diagnosis among people who needed a liver transplant (SRTR, 2018). After the introduction of DAAs, the national prevalence of this diagnosis dropped dramatically to approximately 15% of all registrations in 2018 (SRTR, 2018). Prior work in Callison et al. (2023) finds that DAAs led to a decrease in liver transplants to HCV+ patients with an increase in transplants to HCV- patients. We build upon this work by quantifying the effects of the LAHCEP on transplant candidates in Louisiana in order to better understand how improving access to DAAs and HCV treatment in general impacts transplantation.

One of the major public health challenges in dealing with HCV is that because it can take several years for patients to develop symptoms, a large portion of HCV positive patients are unaware of their infection. Denniston et al. (2012) analyzed data from a follow-up survey to the National Health and Nutrition Examination Survey from 2001-2008 and found that just over half (50.3%) of the respondents who tested positive for HCV were unaware that they were infected prior to participating in the survey. The LAHCEP is also unique in that it not only made DAAs more widely available to patients with Medicaid coverage and prison populations, but also had a major focus on expanding testing for HCV and training physicians

to treat HCV+ patients.

2.2. Direct Acting Antivirals

Traditional treatments for HCV, which include interferon and ribavarin (RBV) regimens, were not consistently effective at clearing the virus and could produce adverse side effects, including depression, fatigue, mood disorders, anxiety, and somatic pain (Davoodi et al., 2018; Lin et al., 2020). In December 2013, the FDA approved the first direct-acting antiviral to treat hepatitis C, sofosbuvir. Sofosbuvir works by targeting the liver and preventing the HCV RNA polymerase from replicating (Gritsenko and Hughes, 2015). The combination of sofosbuvir, which is a NS5B protein inhibitor, with an NS5A protein inhibitor[1] has proven remarkably effective at treating HCV infection. Nkuize et al. (2016) described this combination as offering "a new era for the effective treatment of a variety of patients suffering from chronic hepatitis C virus infection."

A host of clinical trials have demonstrated that sofosbuvir/velpatasvir is safe and remarkably effective at achieving a sustained virologic response (SVR12), meaning that 12 weeks after treatment there is no longer any detectable HCV RNA in the patient's bloodstream. These studies have been conducted in several countries and have demonstrated that the drug achieves SVR12 in 95-99% of HCV patients.[2] Several of these studies have also shown sofosbuvir/velpatasvir to be over 85% effective at achieving SVR12 in patients who have already been diagnosed with cirrhosis or have already had a failed treatment (Miller, 2017; Asselah et al., 2019; Buggisch et al., 2019; Esteban et al., 2018; Ward and Mermin, 2015). This suggests that DAAs are not just effective at reducing harm when taken early in the progression of the disease, but can also improve outcomes for individuals who are already very sick.

Appendix Table A.1 displays summary statistics for the ten different FDA-approved DAAs which appear in the SDUD between 2014-2022. For each DAA, we include the first year it appears, the year when the largest number of Medicaid prescriptions for the drug were reimbursed, the total number of prescriptions, and

[1] These include velpatasvir, which is what is included in the LAHCEP modified subscription model, as well as other drugs like elbasvir, daclatasvir, pibrentasvir, and ledipasvir.

[2] Isakov et al. (2019) found a 99% SVR12 rate in Russia and Sweden, Izumi et al. (2018) found a 97% SVR rate in Japan, Sood, Duseja, et al. (2019) found a 93% SVR12 rate in India, Buggisch et al. (2019) found a 99% SVR12 rate in Germany, with Miller (2017), Asselah et al. (2019), and Ward and Mermin (2015) all finding a 95-100% rate in the US.

the average amount that was reimbursed per prescription. Some suggestive general trends emerge. First, state Medicaid offices are able to negotiate substantial discounts off of the list prices (initially as high as $84,000) of all these drugs. Second, as new DAAs enter the market they appear to be competing on price, as newer DAAs are being reimbursed at lower average rates, causing reimbursement rates to fall over time. Third, state Medicaid offices appear to be price sensitive, as lower-priced drugs quickly win considerable market share. DAAs that accept lower reimbursement rates than the incumbent drugs (Epclusa, Zepatier, Mavyret, Generic Epclusa) all receive tens of thousands of prescriptions while DAAs that maintain similar or even higher reimbursement rates than the incumbents (Viekira, Technivie, Vosevi, Generic Harvoni) all struggle to gain traction.

2.3. Barriers to Treatment

Despite the remarkable efficacy of DAAs in curing hepatitis C, the high cost of treatment has prevented most patients from receiving these lifesaving drugs. Trusheim et al. (2018) found that five years after the introduction of these drugs, only 15% of the estimated population with HCV in the United States had been treated. A quick back-of-the-envelope calculation illustrates that paying sticker price (orignally around $80,000) for each round of treatment is not a politically feasible approach to address hepatitis C given Medicaid's budget constraints, even if it would be cost effective in the long run. With an estimated 3.5 million HCV positive Americans in 2014 (CDC, 2016), it would cost $280 billion to treat every HCV positive person. This sum represents about 56% of the total Medicaid budget for 2014 (Burwell, 2014). Clearly, some method of rationing was necessary with such high costs. In many cases, including most state Medicaid programs, treatment with DAAs was limited to people with the most advanced conditions (Daniels and Studdert, 2020) and to those not actively using drugs or alcohol (Liao and Fischer, 2017; Waters and Broder, 2018). Through extensive lobbying and litigation, most Medicaid programs have relaxed these restrictions leading to increases in utilization (Davey et al., 2024), but there remains a degree of ambiguity over who will ultimately receive treatment since it would be fiscally impossible to treat everyone who would benefit.

2.4. *The Louisiana Hepatitis C Elimination Plan*

Motivated by the fact that in 2018, less than 3% of the HCV patients on Medicaid or in correctional facilities were able to access DAAs despite spending over $30 million on the drugs, the Louisiana Department of Health launched the 2019-2024 Louisiana Hepatitis C Elimination Plan (LAHCEP). The plan included seven broad strategies designed to address the high marginal cost of DAA treatment and the added challenge that a large portion of the HCV positive population of Louisiana was unaware of their infection (Louisiana Department of Health, 2019).

The cornerstone of the LAHCEP was the Modified Subscription Model that Louisiana entered into with Asegua Therapeutics. The general idea of this model is that it could create a mutually beneficial arrangement where instead of Louisiana spending $30 million across the six pharmaceutical companies who sold DAAs at the time, Louisiana could contract with one company to become the exclusive supplier of DAAs to the state. Asegua would receive the entire $30 million, which is more than they likely expected to receive from the state in the absence of the subscription model. In exchange, Asegua would provide unrestricted access to their DAA, which is the authorized generic version of Epclusa (sofosbuvir/velpatasvir). This agreement effectively drove the marginal cost of DAA use to zero and created an incentive for the state to treat as many infected patients as possible, regardless of disease severity or substance use. It also created an incentive for the state to seek out pre-symptomatic patients who were HCV positive but were not yet experiencing any health problems due to the virus.

The program had a stated goal of curing at least 10,000 Medicaid-enrolled and incarcerated individuals by 2020, and to screen and identify 90% of HCV patients and cure 80% of those identified by 2024. In order to achieve these goals, Louisiana also implemented strategies to educate the public on the availability of the cure, expand HCV screening and link it to treatment, strengthen surveillance activities, and expand provider capacity to treat HCV.

There are a number of reasons why we might expect a program like this to reduce mortality from HCV-related illnesses both in the short and long run, with larger effects likely to show up in the long run. This is due to the fact that HCV progresses relatively slowly. Chronic HCV infection moves through four stages of fibrosis of the liver before the most damaging outcomes (cirrhosis, decompen-

sation, liver failure) occur. This means that for many of the patients who receive DAA prescriptions under the LAHCEP, their counterfactual death would not have occurred right away, but would have been several years down the road. The other reason we expect the largest effects to show up in the long run is due to the potential effect of the program on prevalence within the state; patients cured of HCV do not transmit new infections via sexual contact or intravenous drug use.

If enough HCV cases can be cured to lower the prevalence of the virus, then this will create a positive risk externality on the populations who are at risk for becoming infected with HCV in the future, by reducing the likelihood of transmission from any given episode of needle-sharing. Both of these mechanisms are consistent with the findings of Chhatwal et al. (2023), who perform simulations to quantify the plausible health effects of a national hepatitis C elimination plan. The authors assume that 90% of all HCV patients in the U.S. will be cured of their infection within five years, and they calculate yearly mortality rates due to HCV-related illnesses. They find that the projected reduction in liver-related deaths in years 10-20 of the program are almost twice as large as the reductions in years 1-10.

Although the largest benefits are likely to accrue over the next decade or two, there are also reasons to believe that reductions in HCV-related deaths could manifest almost immediately. First, the patients who are most likely to die in the short run without getting access to DAAs are also the easiest to identify. These will generally be patients whose condition has been deteriorating over a number of years and have progressed through the stages of fibrosis into cirrhosis. Recent evidence has shown that not only can DAAs clear the virus and halt progression of fibrosis/cirrhosis, it can also reverse the damage to the liver which has already been done (Rockey, 2019; Yoo et al., 2022). Overall, this suggests that we may expect to find improvements in the first few years of the program, but that even so, these effects will likely to continue to grow in the medium and long run.

3. Data and Methods

3.1. Data Sources

We use data from a variety of sources. First, we use data on state-level testing and prevalence of hepatitis C from the Centers for Disease Control and Prevention's

(CDC) National Center for HIV, Viral Hepatitis, STD, and TB Prevention (NCHHSTP). These data includes annual counts of the number of hepatitis C diagnoses that are made in each state, as well the number of cases per 100,000 residents. The data are incomplete for some state-year combinations, as certain states do not consistently report these counts to the CDC. We focus our analysis on the group of 35 states (including Louisiana) for whom both counts and rates are reported for every year from 2012 through 2022.

Next, we track usage of DAAs in Louisiana and across other states using Medicaid's State Drug Utilization Data (SDUD). This dataset contains quarterly counts of prescriptions filled, units reimbursed, and amounts reimbursed for all outpatient drugs covered by Medicaid in each state. Counts are suppressed if there are fewer than 10 prescriptions in a given quarter. We use this data to create quarterly and annual counts of usage of the generic version of Epclusa covered by the LAHCEP, as well as all other FDA-approved DAAs. We combine prescription counts with counts of state-level Medicaid enrollment from the Centers for Medicare and Medicaid Services in order to calculate the number of DAA prescriptions per 1,000 Medicaid patients in each state.

In order to estimate the effect of the LAHCEP on hepatitis C-related deaths, we use restricted-access mortality data from the National Vital Statistics System. Our dataset contains the universe of death records in the United States from 2012-2022. Each record includes the cause of death, as well as the state and county of residence of the deceased. We code deaths as being hepatitis C-related if the main underlying cause of death is due to cirrhosis of the liver, hepatocellular carcinoma (liver cancer), nephritis, and renal hypertension. In addition to the cause of death, each record includes demographic information about the decedent including their race, ethnicity, age, gender, and marital status, which we use as controls.

Finally, to study the impact on liver transplants, we use detailed individual-level data from the Scientific Registry of Transplant Recipients.[3] This dataset contains the universe of transplant waiting list registrations and transplants from 2012 up to September 2024, the date of our extract. We use these data to create yearly

[3]This study used data from the Scientific Registry of Transplant Recipients (SRTR). The SRTR data system includes data on all donor, wait-listed candidates, and transplant recipients in the US, submitted by the members of the Organ Procurement and Transplantation Network (OPTN). The Health Resources and Services Administration (HRSA), U.S. Department of Health and Human Services provides oversight to the activities of the OPTN and SRTR contractors.

counts of liver transplant registrations and deceased donor liver transplants at the state level.

3.2. Empirical Strategy

We use several methods to determine the effect of the LAHCEP on DAA prescriptions, diagnoses, HCV-related mortality, and liver transplant waiting list registrations and transplants. First, we use the synthetic control method (SCM) of Abadie and Gardeazabal (2003) and Abadie, Diamond, et al. (2010). This method allows us to create a "Synthetic Louisiana", chosen as a weighted average of all other U.S. states, with the weights optimized in order to minimize the mean squared error between Louisiana and Synthetic Louisiana in the years leading up to the LAHCEP. We calculate these weights separately for each outcome by matching on the pre-treated outcome itself. The results of this approach are graphs showing the level and trends in the outcomes for Louisiana and Synthetic Louisiana, using Synthetic Louisiana as a counterfactual. We include in our donor pool the 31 states which had expanded Medicaid by 2017, as Louisiana did in 2016, though we demonstrate that our results are robust to including all available states in our donor pool.

We also use weighted least squares to estimate difference-in-differences (DiD) and event study models. By using SCM weights, we create a counterfactual that is most similar to Louisiana in terms of pre-period levels and trends, while also performing hypothesis tests on the causal effect of the LAHCEP. Most of our analysis is at the state level, and we use the following estimating equations:

$$y_{st} = \beta_0 + \beta_1 Post_t \times Louisiana_s + \delta_s + \gamma_t + \varepsilon_{st} \tag{1}$$

$$y_{st} = \alpha_0 + \sum_{\tau=-n}^{m} \alpha^{\tau} \Big(\mathbf{1}[t - b = \tau] \times Louisiana_s \Big) + \delta_s + \gamma_t + \varepsilon_{st} \tag{2}$$

Equation 1 is the difference-in-differences estimating equation. The variable y_{st} is an outcome for state s at time t. The coefficient of interest is β_1, and $Post_t$ takes value one if the LAHCEP is in place and 0 otherwise; $Louisiana_s$ takes value one if the state is Louisiana, and 0 otherwise. We include state (δ_s) and time (γ_t) fixed effects. The error term is ε_{st}. This is a standard difference-in-differences approach, as we have a traditional setting with all (one) treated units experiencing

the treatment at the same time.[4]

Equation 2 is the event study estimating equation. Here $\beta_1 Post_t \times Louisiana_s$ is replaced with a series of α^τ and a vector $\mathbf{1}[t - b = \tau]$. The variable τ indicates time relative to implementation of the LAHCEP. Negative τ's trace out the difference in trends in outcomes between Louisiana and control states prior to the intervention, while positive τ's trace out dynamic effects of the LAHCEP.

Results from equation 2 help support the identifying assumptions of equation 1. One of the main assumptions of the difference-in-differences approach is the parallel trends assumption; in the absence of the LAHCEP, outcomes in Louisiana and the control states would be on parallel paths. However, the counterfactual world where Louisiana did not implement the LAHCEP is not observable, and so the pre-period results from equation 2 are used to show that the pre-trends are similar. This is likely to be the case as we are using weights from the synthetic control method.

Finally, because we have few clusters and only one treated cluster, inference is complicated in our context. We address this in two ways. First, we use Wild Cluster Bootstrap (WCB). Cameron et al. (2008) note that even cluster-robust standard errors over-reject with few clusters, but they propose a cluster bootstrap-t approach. We implement this method to calculate WCB-based p-values. Second, we calculate placebo-base randomization inference p-values.[5] In order to calculate these p-values, we estimate placebo treatment effects for each of the other states in our donor pool. We do this in two steps. In the first step, we estimate a synthetic control for each state, assuming that the placebo state was treated in the second quarter of 2019 instead of Louisiana. In the second step, we save the weights for each state's synthetic control and estimate a simple difference-in-difference model with the standard "$TreatXPost$" coefficient. We do this using weighted least squares, with the synthetic control weights used to essentially convert the results of the SCM to a single coefficient estimate. We then look at the distribution of the coefficient estimates to calculate the p-value for Louisiana. We expect the estimated effect of Louisiana to be in the tail of this distribution.

[4]Since we are not leveraging variation in treatment timing, the literature regarding potential bias from two-way fixed effect in that context does not apply (Callaway and Sant'Anna, 2021; Goodman-Bacon, 2021; Sun and Abraham, 2021)

[5]See Cunningham and Shah (2018) for another example of this approach

4. Results

4.1. The Effect of the LAHCEP on Diagnoses of HCV

Figure 1 displays data on HCV diagnoses in Louisiana from 2012 through 2022 using data from the CDC's National Center for HIV, Viral Hepatitis, STD, and TB Prevention (NCHHSTP). The left side of the figure displays the raw count of the number of diagnoses reported. Between 2012 and 2018 there are very few cases reported, with the number rising from 11 in 2012 to 24 in 2015 before dropping down to below 10 per year from 2016-18. The number remains flat at eight in 2019, followed by a large spike in reported diagnoses in 2020, up from eight to 281, an increase of approximately 3,500%. There is then a further increase to 308 in 2021 followed by a decline in 2022 to 165, which is still over 20 times larger than the annual number of diagnoses from 2016-2018. The decline in 2022 is also consistent with diminishing marginal returns from the screening and testing program, which may have been able to reach the populations which were most susceptible to HCV infection first, before having to exert more effort to find new cases as the program went on. The right hand side of Figure 1 displays the rate per 100,000 residents of Louisiana, and demonstrates that the large uptick in cases had nothing to do with population change within the state.

Next, Figure 2 displays estimates of an event-study specification comparing the log of the number of annual diagnoses in Louisiana to each of the 23 other states which expanded Medicaid prior to 2017 and for which data was available in every year from 2016 through 2022. The results are consistent with the interpretation of the time series, suggesting that there was not a similar uptick in other states. There is little evidence of divergent trends prior to 2018, with almost no change in 2019 followed by a large increase in 2020. The coefficient estimate is an increase of 355 log points, consistent with an increase of approximately 3,380%.[6] The coefficient increases to 372 log points (4,023%) in 2021 before reverting to 302 log points (1,949%) in 2022.

Although our analysis shows an increase in the number of reported HCV cases, These data are almost certainly underestimating the burden of HCV in Louisiana. If we use Rosenberg et al. (2018)'s estimates of the prevalence of HCV in Louisiana,

[6] Percentage changes are calculated using the following transformation: [exp^(0.01x)-1] *100, where x is the log point difference.

this translates to roughly 45,000 cases in the state. Even if the majority of these patients are unaware of their infection, this still suggests a large share of confirmed HCV patients are not making it into this national dataset. The main takeaway for our purposes is the large increase in diagnoses that we see in 2020, which suggests that the LAHCEP was effective at increasing diagnoses, though it is possible that the agency simply devoted more resources to *reporting* the cases that were already being diagnosed because of the increased attention being paid to HCV.

Appendix Figure A.1 investigates this possibility by displaying the rates of diagnoses for Louisiana and the rest of the U.S., compared with the 2018 rates, for hepatitis C and a series of other infections tracked by the NCHHSTP, including hepatitis C, HIV, syphilis, chlamydia, and gonorrhea. If the state devoted more resources to overall reporting, we might expect to see increases for other infections as well, but the figure clearly shows that reported diagnoses are only rising specifically for hepatitis C.

It is notable that the increase in diagnoses does not materialize until 2020 when the subscription model went into effect in 2019. This suggests that any increase in prescriptions that we find in 2019 are likely going to previously diagnosed HCV patients. This would be consistent with the state focusing first on treating the sickest patients before expanding surveillance and testing to patients earlier in the course of the disease. If the patients treated first are also the ones most likely to succumb to the disease in the absence of treatment, we could expect to see reductions in mortality showing up very quickly after the implementation of the policy, even though the typical untreated course of HCV takes years or even decades to result in mortality.

4.2. The Effect of the LAHCEP on Medicaid DAA Prescriptions

Next we show how the LAHCEP shifted prescribing behavior for Louisiana Medicaid patients receiving a DAA prescription. Figure 3 displays annual numbers of prescriptions filled of the four most popular DAAs in Louisiana over the period of our study. These include Mavyret, Epclusa, Zepatier, and the generic for Epclusa which was included in the modified subscription plan with Asegua Therapeutics. In the period two to three years prior to the LAHCEP, Epclusa and Zepatier were the most popular DAAs in the state, with list prices of $75,000 and $60,000 for a 12-week course, respectively (Early and Maxted, 2017; Sokol, 2017). Then, in the

third quarter of 2017, Mavyret came onto the market, initially priced at $26,000 for an eight week course and $56,000 for a 16 week course (Grover and Erlich, 2018). Mavyret quickly increased its market share, presumably due to the lower cost and comparable effectiveness to the other two drugs.

In January of 2019, Asegua Therapeutics released its generic version of Epclusa, with a list price of $24,000. Louisiana's modified subscription agreement for this drug then goes into place in July of 2019. The generic Epclusa immediately takes almost complete market share and drastically increases the number of overall prescriptions being filled in the state. At the same time, prescriptions of all other DAAs in the state drop below 100 prescriptions by 2020. Clearly, the LAHCEP altered the mix of DAAs being used in Louisiana and looks to have increased prescriptions overall.

Figure 4 displays the annual number of Medicaid prescriptions filled per 1,000 Medicaid patients for any DAA in Louisiana compared with the national average from 2014 to 2022. Louisiana has fewer prescriptions per 1,000 Medicaid patients in each year from 2014 to 2018, though both lines are trending weakly upward in this period. In 2019 there is a spike in prescriptions in Louisiana up from 1.5 to 4.8 per 1,000, which increases to 5.5 in 2020 before returning to 3.7 in 2021 and 2.7 in 2022. At the same time, the national average remains relatively flat, climbing slightly from 1.9 to 2.0 in 2019 before remaining between 1.4 and 1.7 from 2020-2022.

The results of the synthetic control method are displayed in Figure 5, this time using the log of annual Medicaid prescriptions per 1,000 patients, and the weights from the synthetic control are used to convert this specification into an event-study in Figure 6. There is a close match in the pretreatment DAA presciptions paid for by Medicaid, but the synthetic version of Louisiana shows no sign of the increase that takes place in the state immediately after the LAHCEP goes into effect. The control group, on the other hand, shows a downward trend over the post-treatment period. Compared with the synthetic control, the LAHCEP appears to have caused increases in 130 log points (267%) in 2019, 190 log points (569%) in 2020, 170 log points (447%) in 2021, and 150 log points (348%) in 2022. Our results are roughly consistent with Auty et al. (2021), which estimated the effect of the LAHCEP on prescriptions for the first four quarters of the program, finding an average increase of over 1.7 prescriptions per 1,000 Medicaid patients per quarter. We

extend their analysis and demonstrate that prescriptions in Louisiana remained elevated relative to its synthetic control for at least three additional years. Appendix Figure A.2 displays a histogram of the placebo coefficient estimates from our randomization inference procedure. The actual DiD coefficient in Louisiana of 1.59 is the largest in magnitude, consistent with a p-value of $\frac{1}{31} = .032$

4.3. The Effect of LAHCEP on Mortality from Hepatitis C-Related Conditions

Figure 7 displays a synthetic control estimate of the effect of the LAHCEP on mortality due to hepatitis C-related conditions. The left-hand side variable is the percent of all deaths in each state which are hepatitis C-related. There is a reasonably close pre-treatment match, with both Louisiana and Synthetic Louisiana remaining relatively stable at just under six percent from 2012 through 2018. There is a divergence in 2019, with Synthetic Louisiana rising slightly while Louisiana declines. This trend continues into 2020, with a gap of about 1 percentage point opening up between the two. Both groups rise slightly in 2021 and 2022, with the gap between the two remaining relatively steady.

Figure 8 displays event-study estimates of the effect of the LAHCEP on HCV-related mortality in Louisiana. In both cases, the event-study uses the weights from the synthetic control specification to construct the control group, and standard errors are clustered at the state level. The left graph displays estimates using individual-level data on the effect of the LAHCEP on the probability that any given death is due to HCV-related illnesses. There no distinguishable trend in the pre-period, with all of the coefficients close to zero and statistically insignificant. There is then a decrease in HCV-related mortality in 2019 of about .5 percentage points, followed by larger decreases in each of the next three years averaging just over one percentage point.

One concern with using the percentage of deaths due to HCV-related illnesses is that this period includes the COVID-19 pandemic, which caused a large shock to the denominator of this ratio. If HCV patients in Louisiana were less likely to die from COVID-19 than patients in other states, reductions occurring in 2020-2022 could be spurious. To address this concern, the right graph instead estimates the effect of the LAHCEP on the log of the number of HCV-related deaths. There is again support for the equal counterfactual trends assumption, as there is little movement in the pretreatment leads. There are then negative estimates in each of

the post-treatment years of between 11-14%.

Appendix Figure A.4 further addresses concerns that our main estimates could be impacted by the COVID-19 recession by recreating the specifications from Figure 8 on a quarterly basis, stopping at the first quarter of 2020. As the intervention began in the third quarter of 2019, this leaves us with three treated quarters to evaluate. In each case, the parallel trends assumption appears reasonable, and is followed with large, statistically significant reductions which take place before COVID-19 impacted the United States. It is also worth noting that the reductions in mortality do not begin until the third quarter of 2019, which is the same quarter that the program went into effect, even though our reference period is the final quarter of 2019. This means that there are two periods following the matching of the synthetic control where Louisiana and synthetic Louisiana continue to trend similarly before diverging in precisely the same quarter that the intervention begins.

Table 1 displays the corresponding difference-in-differences estimates to the graphs in Figure 8, once again using the weights from the synthetic control model. This allows us to iteratively add controls to our specification, and to estimate p-values using the Wild Cluster Bootstrap (WCB) method proposed by Cameron et al. (2008), which corrects for possible over-rejection in cases where we have few clusters. The top panel includes individual-level regressions which look at whether the share of deaths in Louisiana that is attributable to HCV-related illness declines after the rollout of the LAHCEP. The first column includes the standard TWFE version of this model, with no controls aside from the state and year fixed effects. The point estimate of -0.0099 indicates that the share of deaths due to HCV-related illnesses in Louisiana declines by almost a full percentage point after 2018. The second column adds controls for the race and ethnicity of the individuals who passed away. The point estimate and statistical significance are mostly unchanged, though the standard errors increase slightly. Finally, the third column also adds controls for the gender, age, and marital status of each individual. The sample size shrinks slightly due to some observations missing these characteristics. The point estimate is unchanged, though the standard error is once again slightly larger. For all three specifications, the regression is significant at the 5% level and the WCB p-value is .000.

Panel B replaces the share of deaths due to HCV on the left hand side with

the log of deaths due to HCV-related illness. The estimates indicate a reduction of deaths from HCV-related illness of between 9 and 13 percent with coefficients that are significant at 5% in all three of the TWFE versions, and two of the three WCB iterations. Appendix Figure A.3 displays the corresponding distributions of placebo DiD estimates of the effect of the LAHCEP on hepatitis C-related mortality for each of the other 49 US states. For the individual probability, Louisiana displays the largest reduction in HCV-related mortality in the US, while it displays the second-largest reduction for the log of annual HCV-related deaths. In each case, there is one positive estimate which is larger in magnitude than Louisiana, meaning the p-values for the two models are .04 and .06, respectively.

Table 2 explores heterogeneous treatment effects by race,[7] by re-estimating the bottom panel from Table 1 on the specific subpopulations of White, Black, Hispanic, and all other racial groups. The estimates on White, Black, and Hispanic subpopulations are all negative and significant at the 1% level, though the point estimate is the largest for the Hispanic population. Wild-cluster p-values are slightly less precise, with .078 for White, .140 for Black, and .112 for the Hispanic group.

4.4. The Effect of LAHCEP on Liver Transplants

For our final set of outcomes, we estimate the effects of the LAHCEP on liver transplant patients. Figure 9 displays the synthetic control estimates of the effect of the LAHCEP on liver transplant registrations. The top-left of the figure shows the impact of the LAHCEP on the log of the count of new liver transplant candidate registrations on the liver transplant waiting list. We can see that there was a reduction in liver registrants around 2020. The top-right panel of the figure provides additional evidence that LAHCEP lead to meaningful improvements in liver health: The average MELD score of candidates, which measures liver function, declines after the LAHCEP was implemented, representing an improvement in liver function. The bottom panel of the figure shows that there is also a decline in transplants after the program is implemented. All three panels show a reasonable match between Louisiana and synthetic Louisiana in the pre-program era. Figure 10 displays the analogous event-study specification that uses the weights from the synthetic control specification. In all three panels of this figure, there

[7] Our first two data sources do not include race and ethnicity, so we are not able to explore heterogeneous treatment effects in either diagnoses or prescriptions

is little evidence of pre-trends, but noticeable improvements in all outcomes after LAHCEP is implemented.

Finally, Table 3 displays the estimates from the difference-in-differences specification using the weights from the synthetic control model. Each column of this table adds additional controls to the model. Panel A looks at the change in registrations on the liver transplant waiting list using the log of annual liver waiting list registration counts as the dependent variable. The first estimate in the first column indicates that there was a (statistically insignificant) 12% reduction in registrations after the program. However, as more controls are added to the model, this effect diminishes. This may be partially explained by Louisiana's expansion of Medicaid in July 2016. Lemont (2024) found that Medicaid expansion increases the number of new Medicaid-insured liver transplant candidates, which may counteract any reduction in candidates that might result from LAHCEP. Column one of Panel B shows that there is a 5% improvement in liver function, measured by the MELD score, after the LAHCEP is introduced. This improvement increases to 6.5% in the final two columns after controls are added to the model. Finally, column one of Panel C shows that there is an approximately 31% decline in transplants with the LAHCEP. This magnitude declines slightly with the addition of controls to the model, but remains large and statistically significant.

4.5. Additional Robustness Checks

One threat to our identification strategy is that, since we have only one treated state, it is possible that some outside event caused health outcomes to improve in Louisiana relative to other states across the board, and we are simply picking up the effects on our one outcome of interest that is correlated with our treatment of interest. To ensure that this is not happening, Table 4 estimates our main difference-in-differences specification on the log of deaths in Louisiana due to a series of other common illnesses.

Panel A estimates the effect of the LAHCEP on deaths from all causes, Alzheimer's disease, diabetes, heart disease, and all forms of cancer. In all five cases, the estimates are small and statistically insignificant, both in the regression specification and using the WCB method. Also, four of the coefficients are positive and only one is negative, which is the opposite of what we would expect if our earlier results were driven by overall health improvements in Louisiana. Panel B repeats

this exercise for several of the most common types of cancer which are not associated with HCV infection. These include cancers of the breast, colon, lung, and pancreas. Once again, the coefficient estimates are all small and statistically insignificant, suggesting that the mortality reductions we found above in Louisiana are specific to the types of mortality associated with HCV.

Additionally, we address concerns regarding potential confounding effects of the COVID-19 pandemic. However, we can not construct synthetic control weights for COVID-19 mortality, because this illness did not exist before the LAHCEP program. For this analysis, we use the weights from hepatitis C mortality, but use COVID-19 mortality as an outcome. These results are in Table 5. Neither estimate is statistically significant, and the point estimates are the opposite direction of our primary results for hepatitis C mortality. These findings suggest COVID-19 is not driving our estimates for the effect of the LAHCEP on hepatitis C mortality.

Table 6 tests the robustness of our results to a number of modifications and variations in functional form. The first column eases our restriction on including only states which expanded Medicaid before 2017 in our donor pool. This was meant to err on the side of caution, and to prevent us from spuriously picking up the effects of the Medicaid expansion in Louisiana and attributing them to the LAHCEP. The estimate in column 1 is very similar in magnitude and statistical precision to its counterpart in the first column of Panel B in Table 1. The second column instead estimates a Poisson specification, and the results are similar. In column three, we add a control for the number of deaths that are associated with alcohol abuse, to control for factors that might impact liver disease without necessarily being related to HCV. Again, the estimate is very similar to our main estimates in Table 1. Finally, in column four we re-estimate our main specification, but first change the validation period on our synthetic control. Now, instead of matching all the way through 2018, we only match through 2016, but still estimate the effect of the LAHCEP on years 2019 and later. Once again, our estimate is consistent with previous results.

Next, since we include four different types of mortality as being "HCV-related", we re-run our individual probability specification, iteratively dropping each of the four causes, with these results displayed in Table 7. In all four cases, we still get negative and significant coefficients on the effect of the LAHCEP on mortality, suggesting that no single cause of death from HCV-related illness is driving our

results.

Finally, we leverage our access to sub-state geographic information. For this analysis, we take each parish (county) in Louisiana, and we create a synthetic version of that county. We then run our main analysis using just that county in Louisiana as the treated county. We take the mean and several percentiles for the distribution of county-level estimates. These can be found in the top row of Table 8. We also construct a distribution of county-level effects as a percent by taking the county-level estimates and dividing by the county-level means, accounting for larger effects in counties with already high levels. These results are in the second row. Overall, the mean of the county-level estimates is fairly similar to the primary effect, and 75-95% of counties have estimates in the same direction (a decrease in HCV-related deaths due to LAHCEP).

4.6. Back of the Envelope Calculations

Is Louisiana on track to meet the stated goal of the program?

One of the stated goals of the LAHCEP was to treat 80% of the HCV population in the state. Our DAA utilization data run through the first four years of the five year program, which allows us to assess their progress. Rosenberg et al. (2018) estimated the state-level prevalence of HCV in Louisiana to be 44,900, with a 95 percent confidence interval stretching from 40,000-50,400. We calculate that through the first four years of the program, Louisiana has treated 30,259 patients, representing 67.4% of the estimated total HCV population. If they continue treating patients at the same rates in year five that they achieved in year four, they will treat approximately 4,961 more patients, for a total of 35,220. This would mean that they treated 78.4% of the total estimated population, in line with the stated goal of 80%.

Estimating the Marginal Value of Public Funds

Since the LAHCEP capped Medicaid spending at 2018 levels, the subscription is actually most likely less expensive than the status quo, as spending on DAAs was increasing in Louisiana in the years leading up to the agreement. This means that the only new expenditure from the program was the additional surveillance that was required to seek out and test potential HCV patients. To our knowledge, the

state has not released any public records on how much was spent on surveillance, but with some relatively conservative assumptions, we can show that the MVPF of this program is likely to be quite high.

Multiple studies have investigated the fraction of HCV positive Americans who are unaware of their HCV status, generally finding that it is between 40-50% (Gnanapandithan and Ghali, 2023; CDC, 2022; Denniston et al., 2012). Continuing to use the estimate by Rosenberg et al. (2018) of 44,900 HCV patients in Louisiana, if half of them are already aware of their infection, this would mean that 22,450 were unaware as of 2018. In order to meet their goal of diagnosing 90% of HCV patients, the LDH would need to find 40,410 total HCV patients. Subtracting the 22,450 patients who are already aware of their infection would leave just under 18,000 patients left to find. We can use this number to estimate the number of HCV tests that would need to be run in order to find 18,000 HCV positive patients.

Rosenberg et al. (2018) estimated that 1.3% of all Louisianans have HCV, which means even if the state tested residents randomly, it would need about 77 tests for each positive result, or just under 1.4 million tests in total. HCV lab tests are available online for as little as $60 per test. There are almost certainly economies of scale associated with conducting a mass testing operation, but again we stick with the more conservative approach and assume that each additional test costs the state $60. This suggests the entire testing operation for the LAHCEP would cost approximately $83 million. By comparison, our analysis of DAA utilization suggests that the LAHCEP led to an additional 20,200 prescriptions compared to synthetic Louisiana. This would mean that in order to break even, each additional prescription would need to reduce lifetime medical expenditures by $\frac{83{,}000{,}000}{20{,}200}$ = $4,150. Roebuck and Liberman (2019) assessed the annual savings for Medicaid from curing a patient with HCV using a DAA and found that it lead to an *annual* savings of $15,907 per patient. This means that even under these conservative assumptions, this program will easily pay for itself by reducing the cost of care for HCV patients. The benefits would further outweigh the costs if we included calculations of the Value of a Statistical Life (VSL) for the deaths avoided from the program which we measure above, or factored in the avoided costs of care for patients who never get infected in the first place because of the reduced prevalance.

5. Conclusion

This paper studies the impact of a first-of-its-kind subscription model for hepatitis C antiviral drugs that was the cornerstone of a larger program designed to eliminate hepatitis C as a public health threat in the state of Louisiana. In addition to the subscription, the intervention also included surveillance efforts to seek out and diagnose potential hepatitis C patients who may have been unaware of their infection. This allowed the public health agency to both treat them in the early stages of their disease progression as well as to prevent them from unknowingly spreading the illness to others.

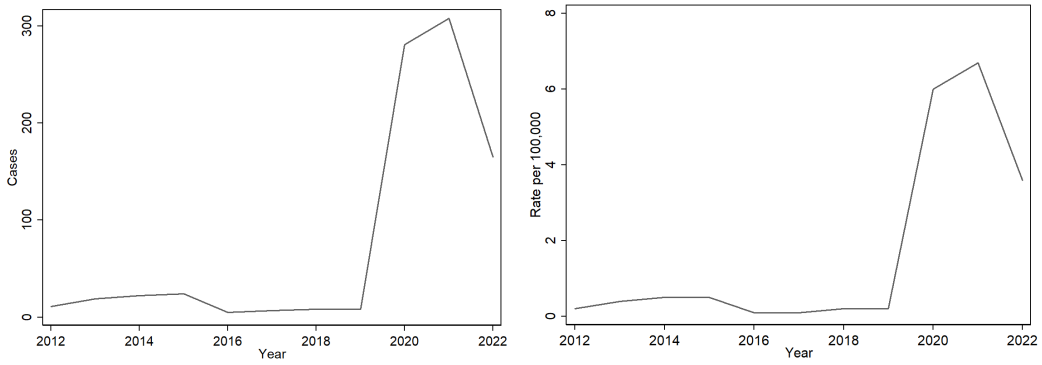
We document large increases in both diagnoses of hepatitis C and prescriptions of direct-acting antiviral medications. Our finding that prescriptions increase immediately after the subscription became active in 2019 while diagnoses do not spike until 2020 suggests that the first round of DAAs went to patients who were already diagnosed and perhaps at more advanced stages in their illness. In line with this, we also find an immediate reduction in mortality due to hepatitis C-related illness in Louisiana relative to control states, which suggests that many of the patients who were treated first must have been quite sick at the time they were treated. Additionally, we find that liver transplants performed for candidates in Louisiana decline quickly after the start of the program.

While the immediate reduction in mortality is important, it is far too early to estimate the full impact of this program. As hepatitis C typically takes many years and even decades to progress to the point of causing fatal illness, the mortality effects we find here are likely to grow over time. However, with our early results, our calculations indicate that the program has a very large Marginal Value of Public Funds (MVPF). Even under conservative assumptions, the program pays for itself.

A similar national program to the LAHCEP was endorsed by the Biden administration, which makes it vital to understand how effective this program was and what lessons might be applied to a larger scale version to cause the greatest reduction in harm. Future work should also investigate the extent to which this program succeeds in eliminating hepatitis C as a public health threat in the state. If the program was able to treat most of the patients with hepatitis C in the state, this could halt the transmission of the virus even as intravenous drug use is on the rise due to the ongoing opioid epidemic. However, Louisiana does not exist in

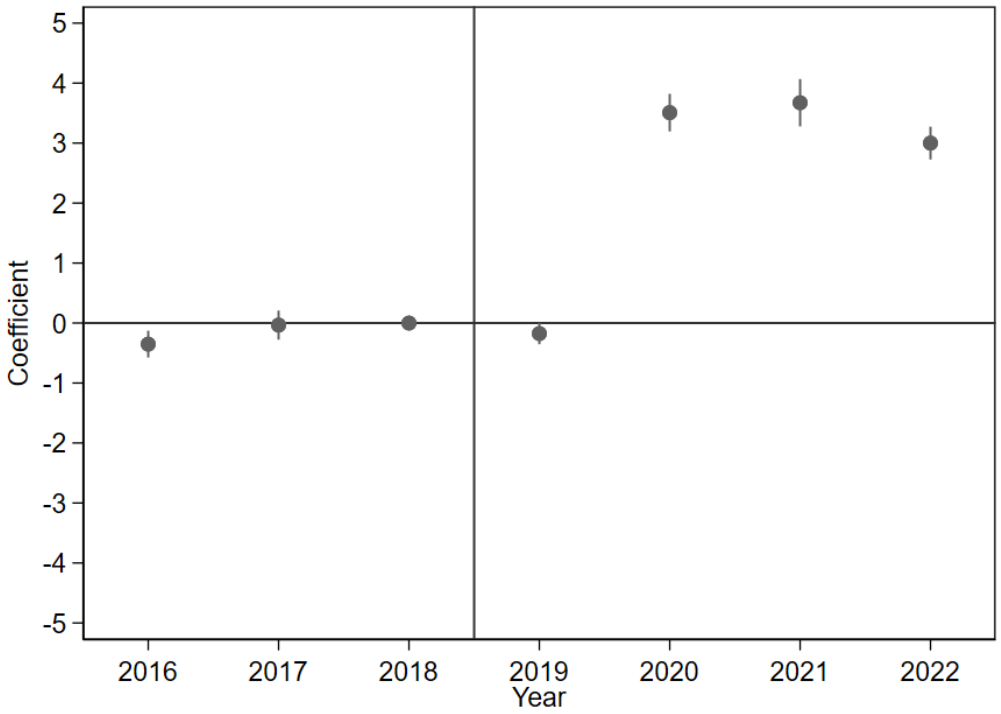
a vacuum, and hepatitis C infected individuals from outside the state could come to Louisiana and spread the disease. There is much to be learned about whether it is possible to eliminate the threat of such a disease, which an individual can carry and spread for many years without experiencing any symptoms, by monitoring what happens with hepatitis C in Louisiana in the coming years.

Figure 1 — Time Series of HCV Diagnoses in Louisiana - 2010-2022



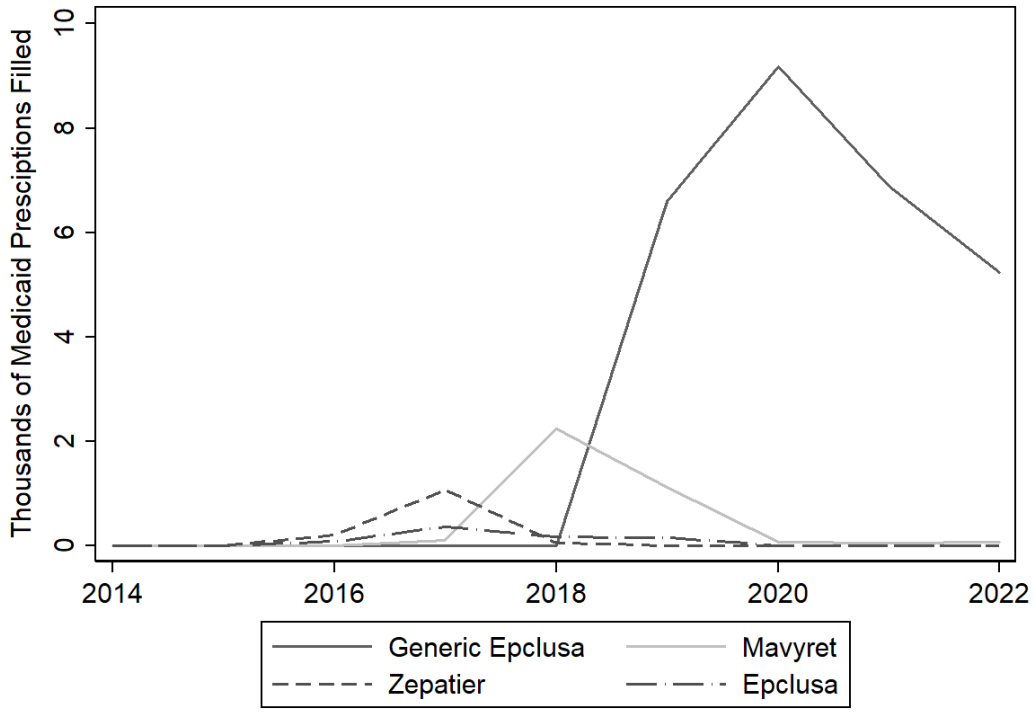
Note: This figure displays data on HCV diagnoses in Louisiana from 2012 through 2022 using data from the CDC's National Center for HIV, Viral Hepatitis, STD, and TB Prevention (NCHHSTP). The left side of the figure displays the raw count of the number of diagnoses reported, while the right side displays the number of cases per 100,000 residents of Louisiana.

Figure 2 — Event Study of the Effect of the Louisiana Hepatitis C Elimination Plan on the Log of the Number of Annual HCV Diagnoses in Louisiana - 2016-2022



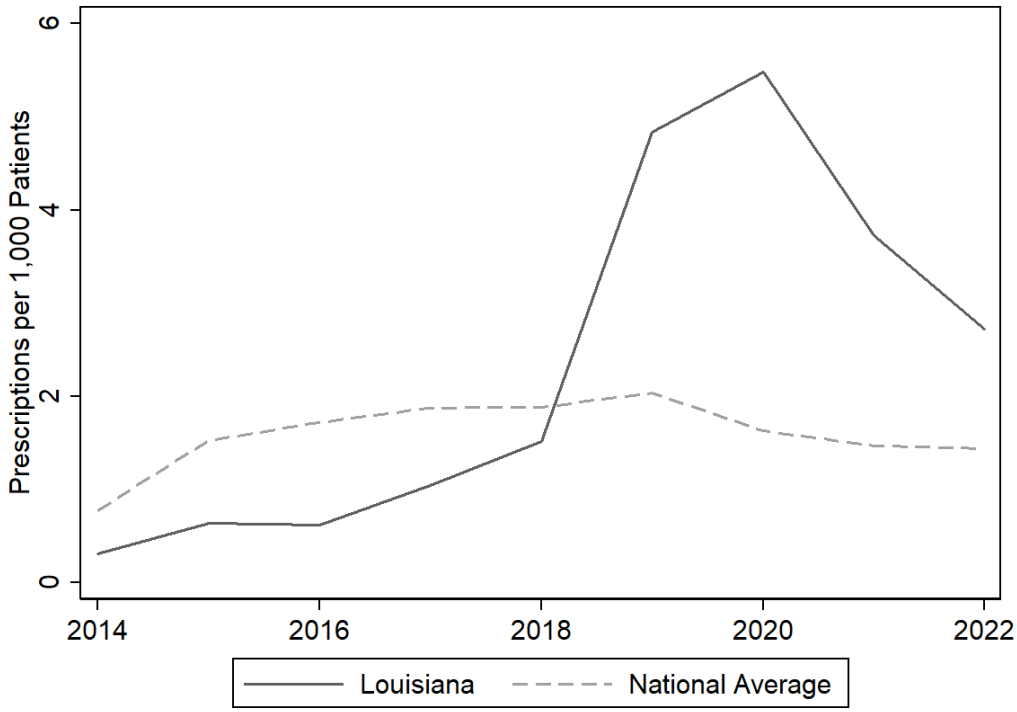
Note: This figure displays event-study estimates of the effect of the Louisiana Hepatitis C Elimination Plan on annual hepatitis C diagnoses, using data from the CDC's National Center for HIV, Viral Hepatitis, STD, and TB Prevention (NCHHSTP). All 23 of the other states which reported data on diagnoses for each year from 2016-2022 and which expanded Medicaid prior to 2017 are included as controls.

Figure 3 — Annual Prescriptions of Various Direct-Acting Antivirals Louisiana: 2014-2022



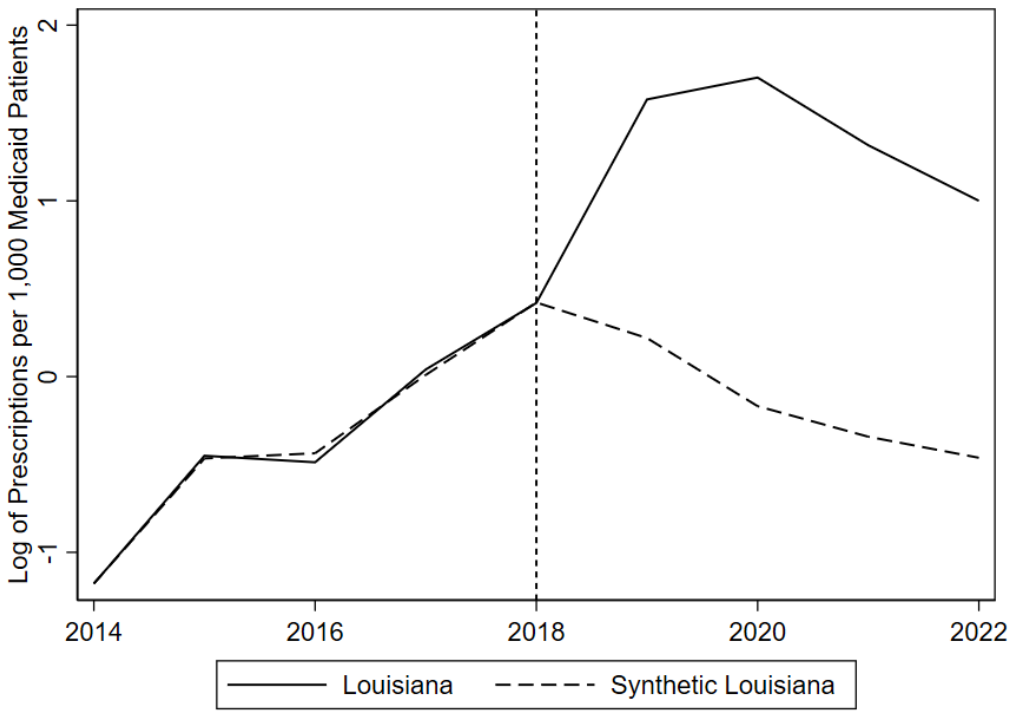
Note: This figure uses data from Medicaid's State Drug Utilization Data (SDUD) to display the annual number of Medicaid prescriptions of various direct-acting antivirals (DAAs) in Louisiana, spanning from 2014 to 2022.

Figure 4 — Annual Number of Direct-Acting Antiviral Prescriptions in Louisiana Compared with the National Average: 2014-2022



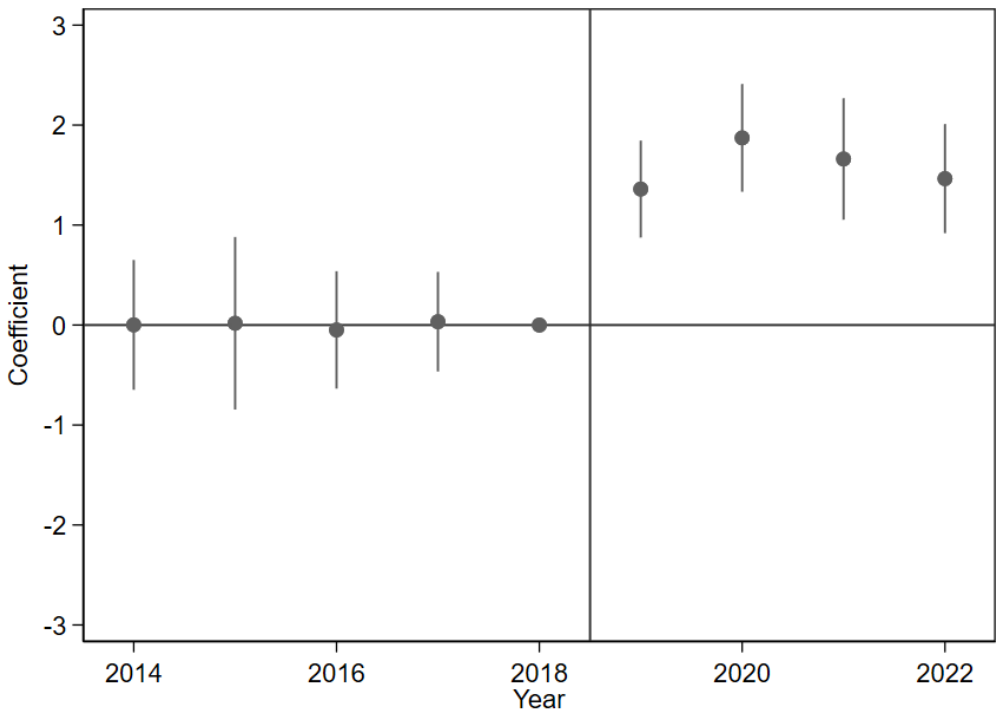
Note: This figure uses data from Medicaid's State Drug Utilization Data (SDUD) to display the annual number of Medicaid prescriptions of direct-acting antivirals (DAAs) per 1,000 Medicaid patients in Louisiana compared with the national average for the five years leading up to the Louisiana Hepatitis C Elimination Plan and the four years following it, spanning from the 2014 to 2022.

Figure 5 — Synthetic Control Estimate of the Effect of the Louisiana Hepatitis C Elimination Plan on Log DAA Prescriptions per 1,000 Medicaid Patients



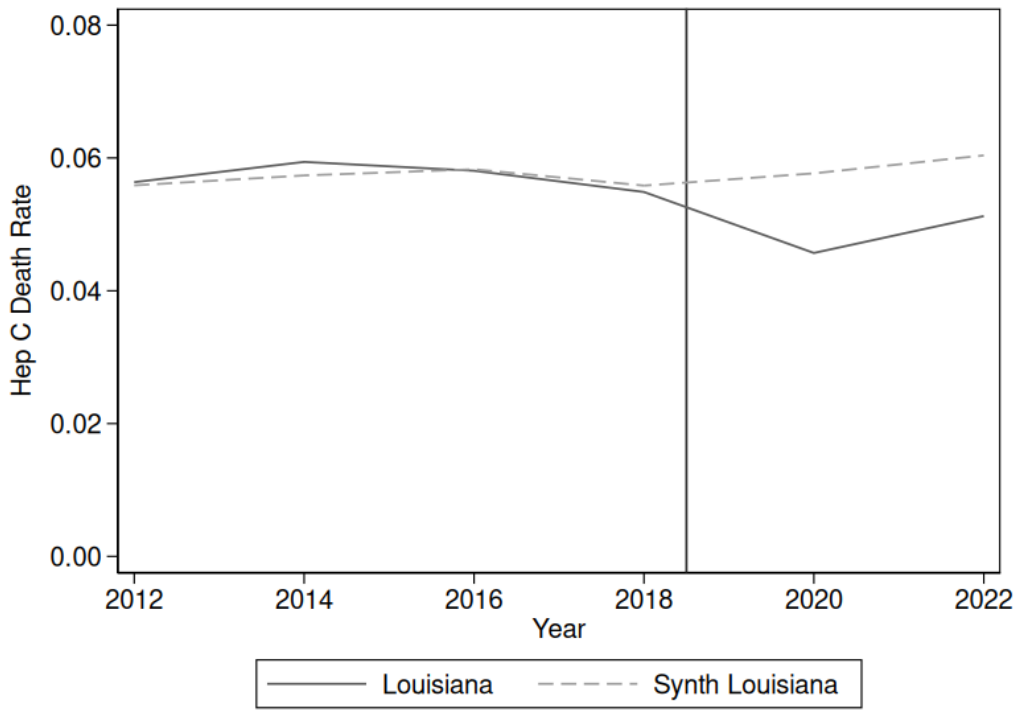
Note: This figure uses data from Medicaid's State Drug Utilization Data (SDUD) to display the annual number of the log of annual Medicaid prescriptions of direct-acting antivirals (DAAs) per 1,000 Medicaid patients in Louisiana compared with a synthetic version of Louisiana, where synthetic Louisiana is made up of a weighted average of the other 31 U.S. states which expanded Medicaid prior to 2017, where the weights are chosen to minimize the difference in quarterly prescription rates for the five years leading up to the Louisiana Hepatitis C Elimination Plan.

Figure 6 — Event-Study Estimate of the Effect of the Louisiana Hepatitis C Elimination Plan on Log DAA Prescriptions Per 1,000 Medicaid Patients, 2014-2022



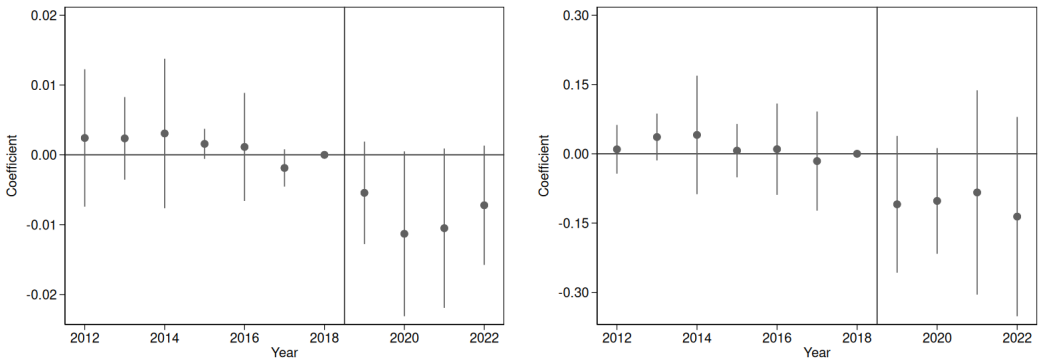
Note: This figure displays event-study coefficient estimates of the effect of the Louisiana Hepatitis C Elimination Plan on the log of annual Medicaid prescriptions per 1,000 patients of direct acting antivirals in Louisiana using data from Medicaid's State Drug Utilization Data (SDUD). Each coefficient includes a 95% confidence interval. The event-study regression uses the weights from the synthetic control method, where the weights were chosen to minimize the squared difference between Louisiana and its synthetic control in the five years leading up to the Louisiana Hepatitis C Elimination Plan. Standard errors are clustered at the state level.

Figure 7 — Synthetic Control Estimate of the Effect of the Louisiana Hepatitis C Elimination Plan on Hepatitis C-Related Mortality



Note: This figure displays the synthetic control estimate of the effect of the Louisiana Hepatitis C Elimination Plan on annual hepatitis C-related mortality in Louisiana, using restricted-access data from the National Vital Statistics System (NVSS). The black line displays the rate for Louisiana, while the dashed line displays the weighted average of the rates of the synthetic control states, where the weights are chosen in order to minimize the sum of the squared difference in the pre-treatment rates of hepatitis C-related mortality.

Figure 8 — Event-Study Estimates of the Effect of the Louisiana Hepatitis C Elimination Plan on Hepatitis C-Related Mortality

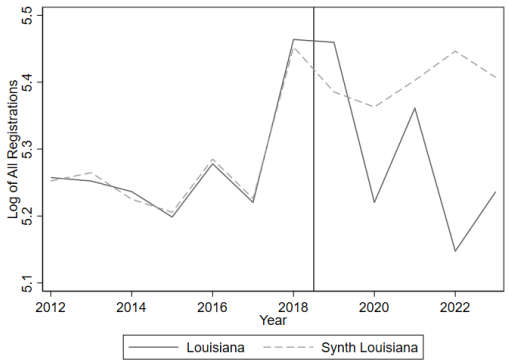


(a) Individual Probability

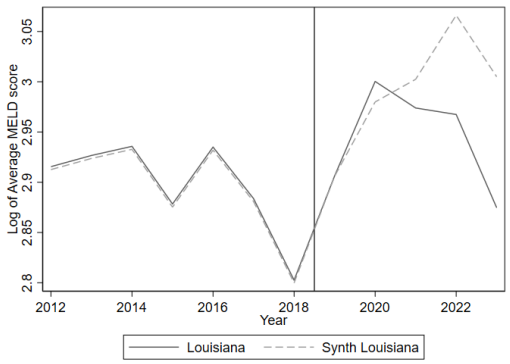
(b) Log HCV Deaths

Note: This figure displays the event-study estimates of the effect of the Louisiana Hepatitis C Elimination Plan on annual hepatitis C-related mortality in Louisiana, using restricted-access data from the National Vital Statistics System (NVSS). The left graph displays the estimate of the share of overall mortality attributable to hepatitis C-related causes, using records at the individual level. The right graph uses the log of the total number of hepatitis C-related deaths as the dependent variable.

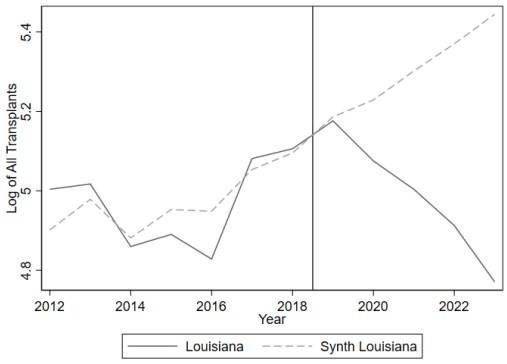
Figure 9 — Synthetic Control Estimates of the Effect of the Louisiana Hepatitis C Elimination Plan on Liver Transplant Candidates



(a) Log Candidates



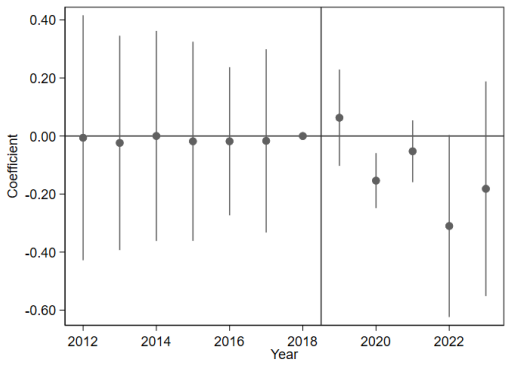
(b) Log MELD Score



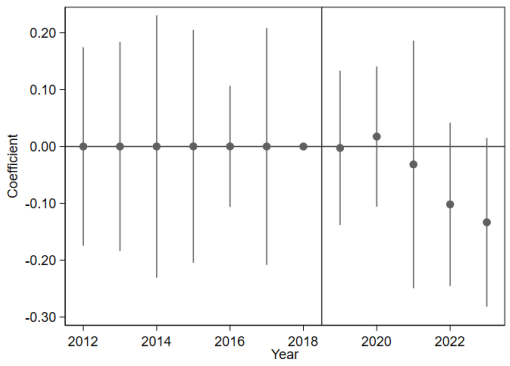
(c) Log Transplants

Note: This figure displays the synthetic control estimate of the effect of the Louisiana Hepatitis C Elimination Plan on liver transplant candidates in Louisiana, using restricted-access data from the Scientific Registry of Transplant Recipients (SRTR). The black line displays the log of the outcome for Louisiana, while the dashed line displays the weighted average of the log of the outcome in the synthetic control states, where the weights are chosen in order to minimize the sum of the squared difference in the pre-treatment log of the outcome.

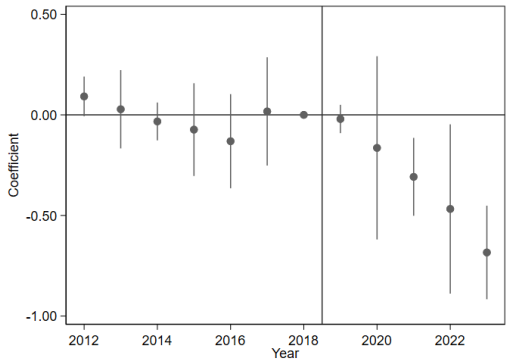
Figure 10 — Event-Study Estimates of the Effect of the Louisiana Hepatitis C Elimination Plan on Liver Transplant Candidates



(a) Log Candidates



(b) Log MELD Score



(c) Log Transplants

Note: This figure displays the event-study estimates of the effect of the Louisiana Hepatitis C Elimination Plan on liver transplant candidates in Louisiana, using restricted-access data from the Scientific Registry of Transplant Recipients (SRTR). The top-left graph displays the estimate of the log of the total number of candidates who register on the waiting list in a year, while the top-right graph uses the log of the average MELD score of candidates as the dependent variable. The bottom graph displays the estimate of the log of the total number of liver transplants in a year.

Table 1 — Difference-in-Differences Specifications of the Effect of the Louisiana Hepatitis C Elimination Plan on Hepatitis C-Related Mortality - 2012-2022

	(1)	(2)	(3)
Panel A: Individual Probability			
Louisiana x Post	-0.0099**	-0.0099*	-0.0100*
	(0.0015)	(0.0019)	(0.0020)
Wild Cluster P-Value	0.000	0.000	0.000
Dep Mean	0.056	0.056	0.056
Observations	1,129,648	1,129,648	1,120,410
Panel B: Log of Total HCV-Related Deaths			
Louisiana x Post	-0.1203*	-0.0951*	-0.1157*
	(0.0313)	(0.0243)	(0.0296)
Wild Cluster P-Value	0.000	0.118	0.000
Dep Mean	7.876	7.876	7.876
Observations	44	44	44
TWFE	Y	Y	Y
Race/Ethnicity	N	Y	Y
Sex/Age/Marriage	N	N	Y

Note: This table displays the difference-in-differences (DID) estimates of the effect of the Louisiana Hepatitis C Elimination Plan on annual hepatitis C-related mortality in Louisiana, using restricted-access data from the National Vital Statistics System (NVSS). Each panel includes the DID estimate with no controls in the first column, with controls for race and ethnicity in the second column, and with additional controls for gender, age, and marital status in the third column. Below each estimate is the Wild-cluster p-value for that estimate, along with the total number of observations included in the regression. Panel A displays the estimate of the share of overall deaths which are attributable to hepatitis C-related causes, using records at the individual level. Panel B uses the log of the total number hepatitis-C related deaths as the dependent variable. * $p < .05$, ** $p < .01$, *** $p < .001$.

Table 2 — Difference-in-Differences Specifications of the Effect of the Louisiana Hepatitis C Elimination Plan on Hepatitis C-Related Mortality - Broken Out By Race

	(1) White	(2) Black	(3) Hispanic	(4) Other
Louisiana x Post	-0.0997**	-0.1259**	-0.2004***	-0.0477
	(0.0186)	(0.0296)	(0.0362)	(0.0507)
Wild Cluster P-Value	0.078	0.140	0.112	0.402
Dep Mean	7.387	6.886	3.926	3.529
Observations	55	66	341	66

Note: This table displays the difference-in-differences (DID) estimates of the effect of the Louisiana Hepatitis C Elimination Plan on annual hepatitis C-related mortality in Louisiana broken out by race and ethnicity, using restricted-access data from the National Vital Statistics System (NVSS). * $p < .05$, ** $p < .01$, *** $p < .001$.

Table 3 — Difference-in-Differences Specifications of the Effect of the Louisiana Hepatitis C Elimination Plan on Liver Transplants - 2012-2023

	(1)	(2)	(3)
Panel A: Log Registrations			
Louisiana x Post	-0.1153	0.0077	0.0064
	(0.0633)	(0.0586)	(0.0706)
Wild Cluster P-Value	0.282	0.904	0.872
Dep Mean	5.310	5.310	5.310
Observations	84	84	84
Panel B: Log of Average MELD score			
Louisiana x Post	-0.0504**	-0.0647***	-0.0650***
	(0.0156)	(0.0117)	(0.0131)
Wild Cluster P-Value	0.150	0.012	0.064
Dep Mean	2.931	2.931	2.931
Observations	384	384	384
Panel C: Log of Transplants			
Louisiana x Post	-0.3146**	-0.2893**	-0.2712**
	(0.0447)	(0.0476)	(0.0405)
Wild Cluster P-Value	0.048	0.048	0.048
Dep Mean	5.064	5.064	5.064
Observations	60	60	60
TWFE	Y	Y	Y
Race/Ethnicity	N	Y	Y
Sex/Age	N	N	Y

Note: This table displays the difference-in-differences (DID) estimates of the effect of the Louisiana Hepatitis C Elimination Plan on annual liver transplant candidates in Louisiana, using restricted-access data from the Scientific Registry of Transplant Recipients (SRTR). Each panel includes the DID estimate with no controls in the first column, with controls for race and ethnicity in the second column, and with additional controls for gender, and age in the third column. Below each estimate is the Wild-cluster p-value for that estimate, along with the total number of observations included in the regression. Panel A displays the estimate of the log of total annual liver transplant candidates, panel B uses the log of the average MELD score of candidates as the dependent variable, and panel C uses the log of the annual liver transplants. * $p < .05$, ** $p < .01$, *** $p < .001$.

Table 4 — Placebo Difference-in-Differences Specifications of the Effect of the Louisiana Hepatitis C Elimination Plan on the Log of Mortality from Various Conditions

Panel A: Large Categories					
	(1)	(2)	(3)	(4)	(5)
	All	Alzheimer's	Diabetes	Heart	Cancer
Louisiana x Post	0.0261	-0.0317	0.0800	0.0041	0.0071
	(0.0191)	(0.0741)	(0.0399)	(0.0161)	(0.0102)
Wild Cluster P-Value	0.180	0.642	0.160	0.804	0.674
Dep Mean	10.756	7.593	7.250	9.324	9.140
Observations	66	88	77	88	44

Panel B: Cancers				
	(1)	(2)	(3)	(4)
	Breast	Colon	Lung	Pancreas
Louisiana x Post	0.0203	-0.0360	-0.0197	0.0155
	(0.0173)	(0.0363)	(0.0160)	(0.0270)
Wild Cluster P-Value	0.294	0.442	0.354	0.534
Dep Mean	6.494	6.781	7.829	6.518
Observations	66	88	77	44

Note: This table displays the difference-in-differences (DID) placebo estimates of the effect of the Louisiana Hepatitis C Elimination Plan (LAHCEP) on the log of annual mortality in Louisiana from various illnesses that should not be impacted by the LAHCEP, using restricted-access data from the National Vital Statistics System (NVSS). Below each estimate is the Wild-cluster p-value for that estimate, along with the total number of observations included in the regression. Panel A displays the estimate of the log of total mortality attributable to all causes, Alzheimer's disease, diabetes, heart disease, and all cancers. Panel B looks specifically at four of the most common types of cancer, including cancers of the breast, colon, lungs, and pancreas. * $p < .05$, ** $p < .01$, *** $p < .001$.

Table 5 — Placebo Analysis of the Effect of the Louisiana Hepatitis C Elimination Plan on the Log of Mortality from COVID-19

	(1) Individ Prob	(2) Log Sum
Louisiana x Post	0.0164	0.0946
	(0.0189)	(1.0223)
Wild Cluster P-Value	0.564	0.478
Dep Mean	0.030	2.318
N	1129648	44

Note: This table displays the difference-in-differences (DID) placebo estimates of the effect of the Louisiana Hepatitis C Elimination Plan (LAHCEP) on the log of annual mortality in Louisiana from the COVID-19 virus, which should not be impacted by the LAHCEP, using restricted-access data from the National Vital Statistics System (NVSS). Since there is no pre-LAHCEP COVID-19 deaths, synthetic control weights for hepatitis C-related mortality are used. Below each estimate is the Wild-cluster p-value for that estimate, along with the total number of observations included in the regression. * $p < .05$, ** $p < .01$, *** $p < .001$.

Table 6 — Difference-in-Differences Specifications of the Effect of the Louisiana Hepatitis C Elimination Plan on Hepatitis C-Related Mortality - Log Sum, Sensitivity Analysis

	Incl Non-Expansion	Poisson	Control Alcohol	Validation Period
Louisiana x Post	-0.1208*	-0.154***	-0.1209*	-0.1157***
	(0.0289)	(0.0099)	(0.0279)	(0.0094)
Wild Cluster P-Value	0.000		0.128	0.000
Dep Mean	7.877	2,630.590	7.876	7.888
Observations	55	44	44	55

Note: This table displays the difference-in-differences (DID) estimates of the effect of the Louisiana Hepatitis C Elimination Plan on annual hepatitis C-related mortality in Louisiana, under a number of different specifications and functional forms. The first column eases our restriction on only including states which expanded Medicaid prior to 2017 in the donor pool. The second column estimates a Poisson version of our main specification. Column three introduces a control for the share of deaths that were attributable to alcohol abuse. Finally, column four changes our the validation period of our synthetic control specification to end at 2016 rather than 2018, while still estimating the effects of the LAHCEP starting in 2019. * $p < .05$, ** $p < .01$, *** $p < .001$.

Table 7 — Difference-in-Differences Specifications of the Effect of the Louisiana Hepatitis C Elimination Plan on the Log of Hepatitis C-Related Mortality - Excluding Components of Outcome

	Excl Cirrhosis	Excl Liver Cancer	Excl Nephritis	Excl Renal Hypertension
Louisiana x Post	-0.1332	-0.1514*	-0.0873**	-0.0993*
	(0.0471)	(0.0441)	(0.0126)	(0.0203)
Wild Cluster P-Value	0.000	0.000	0.000	0.000
Dep Mean	7.631	7.660	7.343	7.681
N	44	44	44	44

Note: This table displays the difference-in-differences (DID) estimates of the effect of the Louisiana Hepatitis C Elimination Plan on the log of the annual hepatitis C-related mortality in Louisiana, using restricted-access data from the National Vital Statistics System (NVSS). Each specification excludes one of the four causes of death we have deemed to be related to hepatitis C infection. Column one drops deaths due to cirrhosis, column two drops deaths from hepatocellular carcinoma, column three drops deaths from nephritis, while column four drops deaths from renal hypertension. * $p < .05$, ** $p < .01$, *** $p < .001$.

Table 8 — Moments of Difference-in-Differences Specifications using County-Level Synthetic Control, Log of Total Hepatitis C-Related Deaths

		Percentiles				
	Mean	5	25	50	75	95
Coefficient	-0.195	-0.582	-0.404	-0.180	-0.038	0.167
Percent Effect	-0.078	-0.272	-0.137	-0.056	-0.012	0.087

Note: This table displays moments of the distribution of county-level difference-in-differences (DID) estimates of the effect of the Louisiana Hepatitis C Elimination Plan on annual hepatitis C-related mortality in Louisiana, using restricted-access data from the National Vital Statistics System (NVSS). A synthetic control county is created for each parish (county) in Louisiana, and our main analysis is run for that parish. From that set of estimates, we derive the mean and several percentiles; both for the estimates and for percent effect of the mean (county-level estimate divided by county-level mean).

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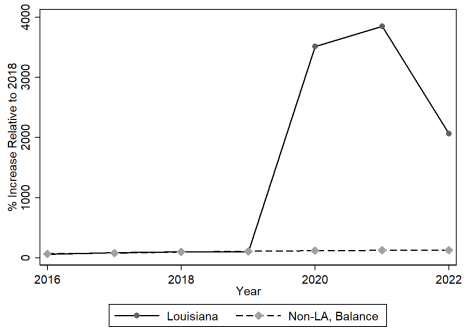
A. Online Appendix (Not for Publication)

Table A.1 — Summary Statistics of Various Direct-Acting Antivirals from the State Drug Utilization Data: 2014-2022

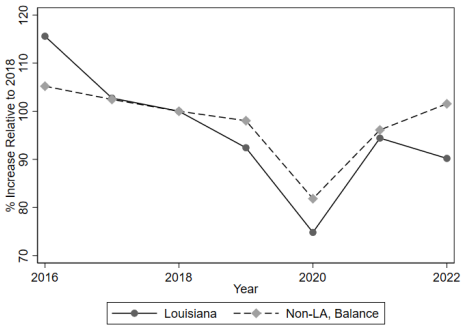
Name	First Year	Peak Year	Total Prescriptions	Avg. Reimbursement ($)
Sovaldi	2014	2014	101,933	25,250
Harvoni	2014	2016	222,855	27,592
Viekira	2015	2016	23,381	23,925
Technivia	2015	2015	102	23,997
Zepatier	2016	2017	64,058	15,511
Epclusa	2016	2017	139,482	21,951
Mavyret	2017	2018	337,018	12,266
Vosevi	2017	2018	10,910	22,027
Generic Epclusa	2019	2022	174,892	7,717
Generic Harvoni	2019	2019	2,891	11,593

Note: This table compares ten different FDA-approved direct-acting antiviral (DAA) medications used to treat hepatitis C using data from the Centers for Medicare and Medicaid Services State Drug Utilization Data (SDUD). The first column includes the brand name of each drug. The second column displays the first year the drug shows up in the SDUD data. The third column displays the year in which the drug received the most Medicaid prescriptions. The fourth column displays the total number of prescriptions for the drug in the SDUD data from 2014-2022. The fifth column displays the average amount reimbursed for the drug.

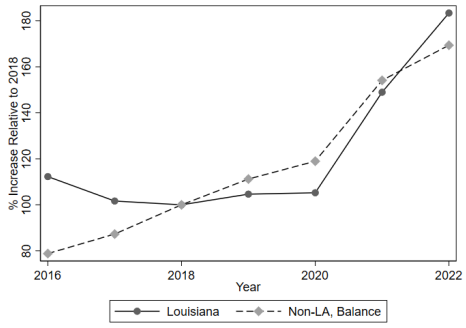
Figure A.1 — Rates of Diagnoses of Various Infections in Louisiana and the Rest of the United States, Compared with a 2018 Baseline.



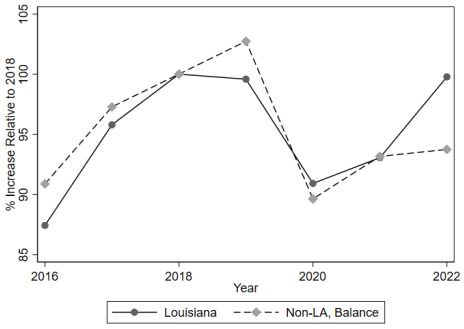
(a) Hepatitis C



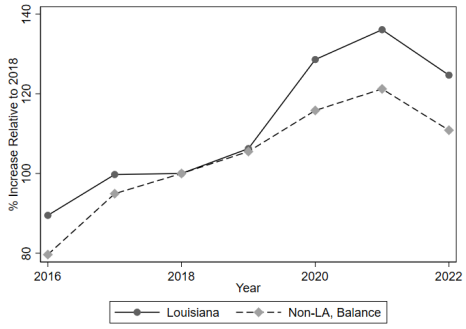
(b) HIV



(c) Syphilis



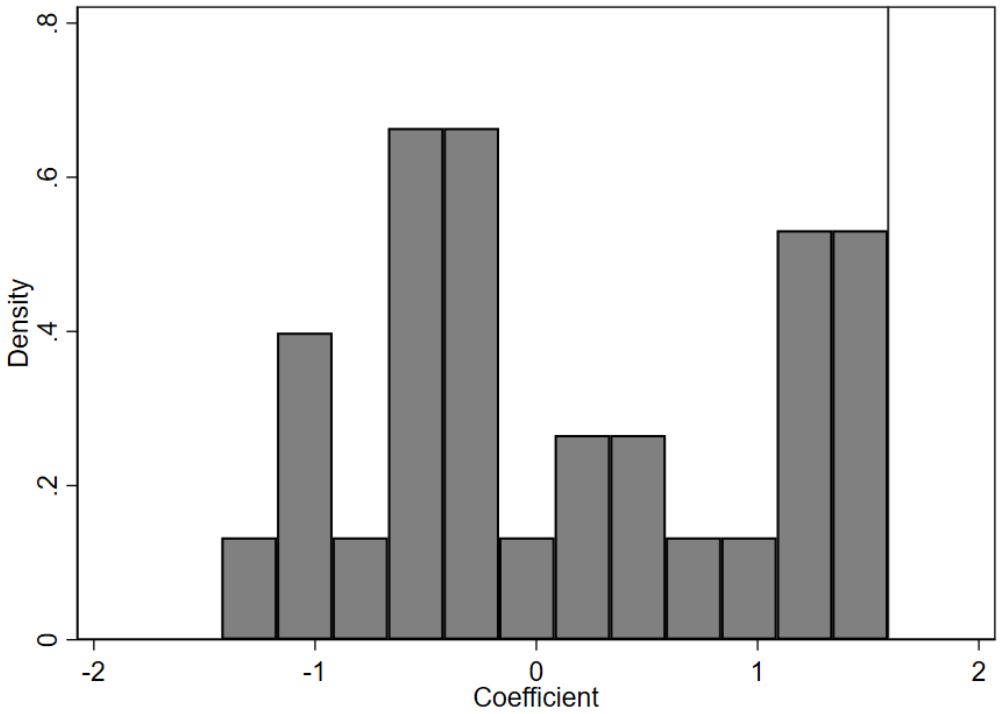
(d) Chlamydia



(e) Gonorrhea

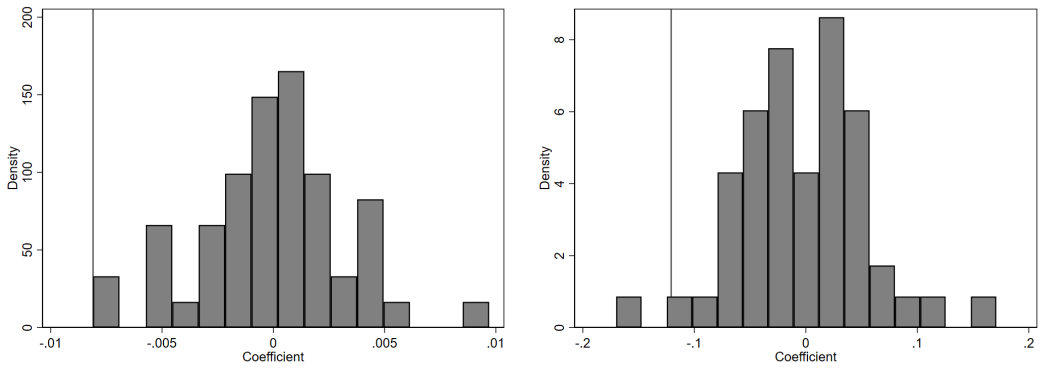
Note: This figure displays relative rates of diagnoses for Louisiana and the rest of the U.S. compared to their 2018 baseline for Hepatitis C, HIV, Syphilis, Chlamydia, and Gonorrhea, using data from the CDC's National Center for HIV, Viral Hepatitis, STD, and TB Prevention (NCHHSTP).

Figure A.2 — Distribution of Placebo DiD Estimates for the Effect of the Louisiana Hepatitis C Elimination Plan on Log DAA Prescriptions.



Note: This figure displays the distribution of placebo synthetic control estimates for the effect of the Louisiana Hepatitis C Elimination Plan on the log of annual number of direct acting antiviral prescriptions to Medicaid patients using data from the State Drug Utilization Data (SDUD). The vertical line displays the true Louisiana treatment effect.

Figure A.3 — Distribution of Placebo DiD Estimates for the Effect of the Louisiana Hepatitis C Elimination Plan on Hepatitis C-Related Mortality.

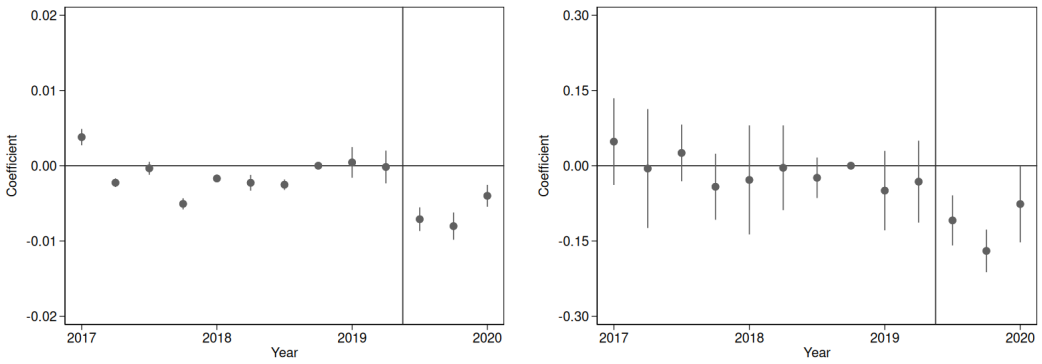


(a) Individual

(b) Log HCV Deaths

Note: This figure displays distributions of placebo synthetic control estimates for the effect of the Louisiana Hepatitis C Elimination Plan on hepatitis C-related mortality, using restricted-access mortality data from the National Vital Statistics System (NVSS). The vertical line displays the true Louisiana treatment effect. The top left graph displays the distribution of estimates of the share of overall mortality attributable to hepatitis C-related causes, using records at the individual level. The top right graph displays estimates after first collapsing records to the state-year level. The bottom left graph uses the log of the total number of hepatitis C-related deaths as the dependent variable, while the bottom right graph uses the count of hepatitis C-related deaths as the dependent variable.

Figure A.4 — Pre-COVID-19 Event-Study Estimates of the Effect of the Louisiana Hepatitis C Elimination Plan on Hepatitis C-Related Mortality



(a) Individual

(b) Log HCV Deaths

Note: This figure displays the event-study estimates of the effect of the Louisiana Hepatitis C Elimination Plan on pre-COVID-19 quarterly hepatitis C-related mortality in Louisiana, using restricted-access data from the National Vital Statistics System (NVSS). The left graph displays the estimate of the share of overall mortality attributable to hepatitis C-related causes, using records at the individual level, while the right graph uses the log of the total number of hepatitis C-related deaths as the dependent variable.