

The Effect of Pre-Exposure Prophylaxis for HIV (PrEP) Exposure on Syphilis

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October 28, 2026

Abstract

Pre-exposure prophylaxis (PrEP) is highly effective at preventing HIV. By lowering the expected cost of risky sex, PrEP exposure may increase the spread of other sexually transmitted infections like syphilis. However, more frequent screening of PrEP users could increase syphilis detection even if underlying incidence does not change. I estimate the effect of PrEP's 2012 introduction on syphilis using cross-state variation in the pre-treatment share of households consisting of male same-sex couples (MSS) as a proxy for access to PrEP. Using Medicaid claims data, I construct three syphilis outcomes that each measure different aspects of a change in observed infections. I estimate that PrEP exposure, measured as a one-standard-deviation higher MSS, increases the syphilis diagnosis rate by 21.1 cases per 100,000 beneficiaries, a 66% increase relative to the 2011 mean, significant at the 10% level. This implies that PrEP exposure increased diagnosed syphilis. However, a rise in the diagnosis rate cannot distinguish between a true increase in infections and an increase in detection. The estimated effect on the testing rate is small, about 5% of the 2011 mean, and not statistically significant. Increased testing is therefore too small to account for most of the rise in diagnoses. The estimated effect on the yield rate, positive tests per total tests, is large, about 53% of the 2011 mean, but imprecise and not statistically significant. This suggests that a higher share of tests came back positive which is consistent with a true increase in infections. Among men, the diagnosis rate rises by 34.5 cases per 100,000, significant at the 5% level, and the testing and yield estimates are again positive but not statistically significant. Together, these results suggest that PrEP's introduction increased the underlying incidence of syphilis, which is consistent with PrEP access inducing risk compensation.

JEL Classification: I12, I18

Keywords: PrEP, sexually transmitted infections, risk compensation, health policy

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1 Introduction

Pre-exposure prophylaxis for HIV (PrEP) medications are taken routinely to protect oneself from getting HIV. The first PrEP drug was approved by the U.S. Food and Drug Administration (FDA) in 2012 and is primarily intended for individuals at elevated risk of acquiring HIV, including men who have sex with men (MSM), people who inject drugs, and individuals whose sexual partners are living with HIV (CDC, 2021). PrEP has been cited as a major tool for ending the HIV epidemic because it is about 99% effective at preventing HIV acquisition through sex when taken as directed (HHS, 2019). Evidence since its introduction suggests PrEP has been effective at lowering HIV transmission at the population level as well, though its uptake is uneven across the United States (Beheshti et al., 2025; Sullivan et al., 2025).

While PrEP is effective at preventing HIV transmission, clinicians and researchers have been concerned that PrEP’s availability may lower the perceived cost of risky sex and lead users to reduce other risk-mitigating behaviors like using condoms or limiting sexual partners. This could increase the incidence of other diseases associated with risky sex, such as bacterial sexually transmitted infections (STIs). This concern is especially salient given that bacterial STI rates in the United States had already been rising since the early 2000s and the same groups at risk of HIV tend to have higher incidence of bacterial STIs as well (CDC, 2024).

Risk compensation is when individuals change their behavior based on how safe they perceive themselves to be. The concept was introduced by Peltzman (1975), who argued that automobile safety regulations were offset by more reckless driving, so that highway deaths did not decrease and pedestrians may have been made worse off. It has since been applied to a variety of settings, including needle exchanges, access to birth control, and previous HIV treatment innovations (Beheshti et al., 2026; Lakdawalla et al., 2006; Packham, 2022; Willage, 2020).

Several descriptive studies have examined the association between PrEP use and risk compensation and reported increased rates of bacterial STIs and decreased condom use among PrEP users (Traeger et al., 2018). Small, causal studies have found mixed results in terms of risk compensation and PrEP. Some estimate increases in syphilis but argue that much of the increase is driven by increased STI screening of PrEP patients (Parker et al., 2025; Quaife et al., 2020; von Schreeb et al., 2024). These studies provide important evidence on testing and diagnoses among individuals who initiate PrEP, but do not estimate the causal population-level effect of PrEP exposure on bacterial STI diagnoses and testing. At the United States population level, Eilam and Delhomme (2025) use CDC surveillance data and the 2000 Census share of male same-sex partnerships in a triple-difference design comparing men and women, and estimate that PrEP increased male syphilis rates by 16.2%

between 2012 and 2018. Their syphilis measure includes only primary and secondary cases, whereas I include diagnoses at all stages. Like other studies, they cannot directly separate changes in incidence from changes in detection.

Observing changes in bacterial STI testing matters because, when PrEP was introduced, the Centers for Disease Control and Prevention (CDC) issued clinical guidelines directing providers to screen PrEP users for bacterial STIs like syphilis more frequently than if they were not taking PrEP (CDC, 2025). This means that an observed increase in the observed syphilis diagnosis rate could be impacted by two different mechanisms. It could represent a genuine increase in underlying syphilis in the population, or it could reflect more frequent testing catching infections that would otherwise have gone undiagnosed, or some combination of the two. As a result, existing studies can establish that diagnoses are rising but cannot say which channel is driving the increase.

In this paper, I ask estimate the effect of PrEP access on syphilis outcomes. Identifying the causal effect of PrEP on these outcomes is complicated because PrEP was approved for all adults in the United States at the same time which leaves no clear comparison group. Because of this, I use a pre-treatment proxy to approximate state-level differences PrEP access based on the share of their population that was recommended to take PrEP. The largest group PrEP is recommended for in the United States is men who have sex with men, so I use the share of cohabiting male same-sex couple households in a state (MSS), measured in the 2010 Census revised estimates. To validate this proxy, I first estimate its relationship with the rate of PrEP patients per 100,000 Medicaid beneficiaries aged 15 and older in a given state-year. I then estimate the effect of differential PrEP exposure on the syphilis diagnosis rate, testing rate, and yield rate, defined as the number of tests classified as positive divided by the total number of tests performed. The diagnosis rate measures the level of observed syphilis cases and is useful to compare against other studies and surveillance statistics. The testing rate measures the level of syphilis screening occurring in a given states year, which allows me to directly test for changes in detection. The yield rate measures the share of observed tests that come back positive, which allows me to approximate the actual level of syphilis in the population while netting out different levels of testing. Estimating effects on all three outcomes helps parse out the extent to which changes in syphilis incidence and screening each affect any observed change in the diagnosis rate.

I first show that MSS predicts PrEP uptake. I estimate that a one-standard-deviation higher MSS is associated with approximately 7.3 additional PrEP patients per 100,000 Medicaid beneficiaries after PrEP's introduction. The relationship is much stronger among men than among women which is consistent with the goal of the male same-sex-couple share proxy.

In the main results, a one-standard-deviation higher MSS increases the syphilis diagnosis rate by 66.2% relative to its 2011 baseline mean. Implying that PrEP access increased diagnosed syphilis, but a rise in diagnoses alone cannot distinguish more infections from more detection. The estimated effect on the testing rate is small and imprecise. This suggests that increased screening is not driving the increase in observed diagnoses. The estimated effect on the yield rate is large, a 52.9% increase relative to its baseline mean, but is not statistically significant. The coefficient suggests that a higher share of tests came back positive, consistent with more infections among those tested. Interpreting all three results together suggests that there was an actual increase in syphilis in states with higher PrEP access which is consistent with PrEP inducing risk compensation. However, the imprecision of the testing and yield rates prevent me from ruling out part of the increase in the diagnosis rate being driven by testing.

The estimated effects are concentrated among men, consistent with their substantially greater use of PrEP. Among men, a one-standard-deviation higher MSS increases the diagnosis rate by 34.5 cases per 100,000, a 96.8% increase relative to the male baseline mean, an estimate that is statistically significant at the 5% level. The male testing estimate is larger in proportional terms than the pooled estimate, and male testing rises in the later years of the sample, consistent with the more frequent screening recommended for PrEP users. Its confidence interval, however, again rules out increases large enough to account for the rise in male diagnoses. The male yield estimate is positive but imprecise. Among women, the estimates are positive but smaller and not statistically significant.

The results hold up in several additional checks. Event-study estimates show no evidence of a differential change between 2010 and 2011, the two years observed before PrEP’s introduction, and the diagnosis and yield effects emerge after 2014, in step with the delayed rise in PrEP uptake. The main results are nearly unchanged when Kansas, Maine, and Idaho, which have incomplete observations in the claims data, are excluded. Finally, leave-one-out estimates show that the diagnosis, yield, and testing point estimates remain positive when any single state is excluded. However, the diagnosis and yield estimates are smaller when Delaware or Nevada is omitted.

2 Background

2.1 HIV and PrEP

Human Immunodeficiency Virus (HIV) emerged in the United States in the 1980s. Doctors and researchers were initially unaware of how the virus spread or how to treat it, making

it very deadly. Although infections were initially concentrated among men who have sex with men, by the mid-1990s HIV was the leading cause of death for men aged 25-44 and one of the leading causes of death for women aged 25-44 (CDC, 1996). This changed with the introduction of Highly Active Antiretroviral Therapy (HAART) in 1996, a combination of medications that suppressed viral replication, which decreased the mortality of the disease and made it a more manageable chronic condition. In the years that followed, practitioners began using antiretroviral medications to prevent HIV transmission to HIV-negative individuals. First, clinicians began using post-exposure prophylaxis (PEP), a 28-day course of antiretroviral medications taken after a potential exposure to HIV. In 2005, the CDC issued recommendations extending PEP to non-occupational exposures (CDC, 2005). Then, pre-exposure prophylaxis for HIV (PrEP) was introduced. Unlike PEP, which is taken after a potential exposure, PrEP is taken consistently before any known exposure by people at high risk of acquiring HIV. PrEP was approved by the FDA in July 2012 (U.S. Food and Drug Administration, 2012). When taken as directed, PrEP is approximately 99% effective at preventing HIV acquisition through sex (CDC, 2021). Access to knowledgeable prescribers, insurance coverage, and consistent daily adherence all affect PrEP’s true impact outside of a clinical trial setting (Harris, 2021). Previous work has estimated that areas with the highest PrEP uptake saw a significant decrease in HIV diagnoses, but PrEP uptake, and therefore its effectiveness, was concentrated in areas with larger White populations (Beheshti et al., 2025).

2.2 Bacterial STIs

Bacterial sexually transmitted infections (STIs) are infections transmitted through sexual contact and include chlamydia, gonorrhea, and syphilis, the three most commonly reported bacterial STIs in the United States. These infections are frequently asymptomatic or have mild symptoms that can be missed. This means that without consistent screening, many cases may be undiagnosed. However, some cases of bacterial STIs can have severe complications including infertility, heart problems, and death (CDC, 2026a).

I focus on syphilis and include diagnoses at all stages of infection. Early-stage diagnoses typically reflect recent transmission, while later-stage and latent diagnoses may reflect infections acquired substantially earlier. The diagnosis measure therefore captures both recent infections and previously acquired infections that are detected during the sample period. Syphilis is an ideal bacterial STI to focus on in this context for a few reasons. First, men who have sex with men already had disproportionate rates of syphilis before PrEP’s introduction (Beheshti et al., 2026). Additionally, syphilis and HIV are both tested for using a

blood test, while chlamydia and gonorrhea are not (CDC, 2026b). Routine HIV tests are important for PrEP users, because an individual should not start taking PrEP if they are HIV-positive, and they should stop taking PrEP and transition to HIV treatment if they contract HIV (CDC, 2026d). So increasing syphilis screening by adding a syphilis test to routine HIV testing blood work could be particularly convenient for patients and providers. Finally, syphilis is particularly relevant in the context of HIV prevention, because having an untreated syphilis infection increases the likelihood of someone contracting HIV CDC, 2012.

Screening recommendations vary substantially based on a variety of risk factors including sex, age, pregnancy, and self-reported sexual behavior and drug use. The CDC recommends annual chlamydia and gonorrhea screening for sexually active women under age 25 and for older women at increased risk (CDC, 2026c; U.S. Preventive Services Task Force, 2021). Syphilis screening is recommended during pregnancy and for other populations at elevated risk. Sexually active men who have sex with men are recommended to undergo syphilis, gonorrhea, and chlamydia screening annually, with screening every three to six months recommended for those at increased risk, including people using PrEP (CDC, 2026b).

Although bacterial STIs and HIV are both sexually transmitted, they differ in important ways. HIV is caused by a virus and can be treated but not cured. Bacterial STIs are caused by bacteria and are generally curable with antibiotics. Thus, while PrEP prevents the acquisition of HIV, it does not prevent bacterial STIs. There is currently no comparable medication routinely used as pre-exposure prophylaxis for bacterial STIs.

3 Data

The main dataset I use in this analysis is individual-level administrative claims data from the Medicaid Analytic eXtract (MAX) and Transformed Medicaid Statistical Information System Analytic Files (TAF) from 2010-2022. These data collectively cover Medicaid beneficiaries across all 50 states. All individual-level claims for Kansas and Maine are missing in 2010 because of data-reporting issues (Mathematica Policy Research, 2014). Additionally, all individual-level outpatient claims for Idaho are missing in 2011 (Mathematica Policy Research, 2017). I include these three states in the main specification and show that the results are robust to their exclusion in Section 6.2. Individual level claims data are well suited to this analysis because they capture both diagnoses and tests, allowing me to estimate effects separately on diagnosis, testing, and yield rates. I supplement the claims data with the 2010 Decennial Census, which I use to construct the male same-sex couple share, as well as demographic controls constructed from the American Community Survey (ACS) and an indicator for Medicaid expansion.

Using Medicaid data means I am analyzing a specific subset of the United States population, which is important to keep in mind when interpreting results. Medicaid enrollees are by construction lower-income and are also disproportionately younger and more racially diverse than the United States population as a whole (SOURCE). While this may mean the results are not perfectly generalizable, this is a key population for both HIV and bacterial STI risk. Young people disproportionately contract bacterial STIs. In 2023, people aged 15-24 accounted for nearly half (48.2%) of reported chlamydia, gonorrhea, and syphilis cases nationally, despite comprising only about 13% of the U.S. population (CDC, 2024). Black Americans are also disproportionately affected by both HIV and bacterial STIs. In 2023, Black/African American people accounted for approximately 38% of new HIV diagnoses and 32.4% of chlamydia, gonorrhea, and syphilis cases despite representing only about 12% of the U.S. population (CDC, 2024).

3.1 PrEP Identification

I use the prescription drug (Rx) files to identify PrEP prescriptions, which I use to estimate the quasi-first-stage relationship between MSS and PrEP use. PrEP consists of a small number of branded and generic drugs. Truvada (emtricitabine/tenofovir disoproxil fumarate) was the first drug approved for PrEP use. Descovy (emtricitabine/tenofovir alafenamide) was approved for PrEP in 2019. Generic Truvada became available in 2020, and Apretude, an injectable option, became available in 2022. A handful of other PrEP drugs entered the market after 2022 and are therefore not included in this analysis.

Truvada and Descovy are approved for both HIV treatment as part of antiretroviral therapy and HIV prevention, PEP and PrEP. This creates a measurement obstacle, because the same national drug code (NDC) can appear for either use, and no ICD code distinguished PrEP prescriptions during the sample period (CDC, 2021; HRSA, 2024). I exploit the clinical fact that when Truvada or Descovy is prescribed as part of HIV treatment, it is always co-prescribed with at least one additional antiretroviral drug, while PrEP is prescribed as a standalone regimen (NIH, 2021). I classify a Truvada or Descovy fill as a PrEP prescription if it is not accompanied by a co-prescribed antiretroviral therapy drug within 90 days of the fill. Because PEP is a single 28-day course, I additionally require a beneficiary's cumulative Truvada or Descovy fills to exceed 30 days' supply before classifying them as a PrEP user, so that standalone PEP courses are not counted as PrEP. Apretude is only prescribed for PrEP, which makes it straightforward to identify using NDC codes or HCPCS code J0739. The only caveat is that Apretude must be pulled from both prescription and outpatient files because of state-by-state variation in the billing of injectable drugs.

Figure 1 shows the growth in PrEP patients among Medicaid beneficiaries aged 15 and older over the study period by sex. PrEP use is low in the first few years after FDA approval, then starts growing around 2014. This pattern is useful for interpreting the event-study estimates later in the paper where a similar delayed effect is reflected. This delayed uptake trend is also present in the all-payer trend of PrEP uptake in the United States, which is discussed further in the appendix.

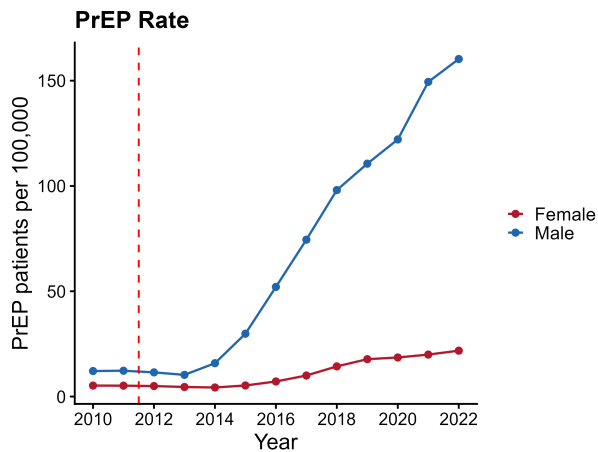


Figure 1: PrEP Rate by Sex, Medicaid Beneficiaries Aged 15 and Older

The PrEP rate is the number of patients with a PrEP prescription per 100,000 male or female Medicaid beneficiaries aged 15 and older, measured annually. Rates are computed from counts summed across the 50 states. The dashed vertical line marks PrEP's 2012 FDA approval.

The graph also shows that the majority of PrEP users are men. This motivates heterogeneity analysis by sex later in the paper.

3.2 STI Outcomes

From the individual-level claims, I construct three state-year outcomes: the syphilis diagnosis rate, testing rate, and yield rate. I use CPT codes to identify syphilis tests and ICD-9 and ICD-10 diagnosis codes to identify syphilis diagnoses at all stages. The testing rate includes all observed syphilis tests. I classify a syphilis test as positive if the same beneficiary has a claim containing a syphilis diagnosis code within 30 days following the observed test. The diagnosis and testing rates are expressed per 100,000 Medicaid beneficiaries aged 15 and older in each state-year. A beneficiary can contribute more than one positive diagnosis in a year if the positive tests are more than 90 days apart. The diagnosis rate is the number of unique positive diagnosis events per 100,000 beneficiaries. The yield rate is the number of positive testing events divided by the total number of syphilis test events, multiplied by 100. Following CMS guidelines, I suppress state-year-sex counts of each outcome that pertain to between 1 and 10 patients. I set suppressed counts to zero in my analysis.

Figure 2 compares the aggregate syphilis diagnosis rate in the Medicaid claims with the national total syphilis rate reported by the CDC, which covers all stages of syphilis, including congenital syphilis, and rose from 14.8 cases per 100,000 population in 2011 to 62.2 in 2022 (CDC, 2024). Levels are higher in the claims, reflecting the restriction to Medicaid beneficiaries aged 15 and older, a younger and lower-income population than the U.S. as a whole, and a case definition that allows a beneficiary to contribute more than one case per year. Indexed to 2011, however, the two series follow similar trajectories, remaining flat through 2012 and rising steadily thereafter, with a sharp increase in 2021–2022. The Medicaid series also declines in 2020, consistent with disruptions to routine care and testing during the COVID-19 pandemic. This similarity provides reassurance that the diagnosis measure captures the broader resurgence in syphilis documented in surveillance data.

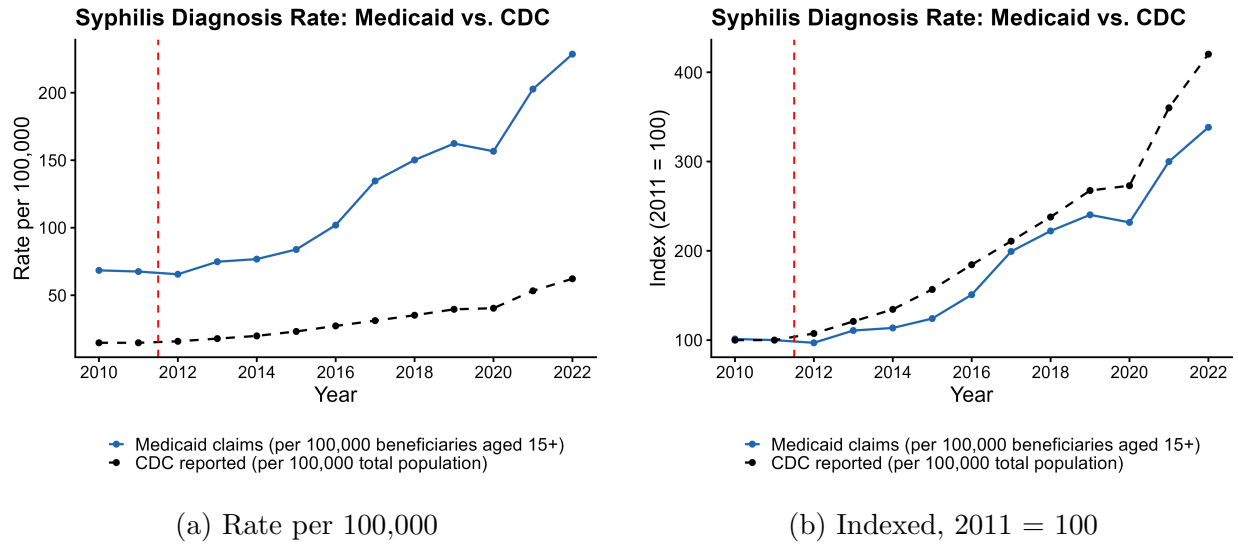


Figure 2: Syphilis Diagnosis Rate: Medicaid Claims and CDC Surveillance

The Medicaid series is the total number of syphilis cases divided by the total number of Medicaid beneficiaries aged 15 and older across the 50 states, per 100,000. The CDC series is reported total syphilis (all stages, congenital syphilis, and stage not stated) per 100,000 U.S. population, from CDC STI Surveillance, Table 1. The dashed vertical line marks PrEP’s FDA approval in 2012.

Rising diagnoses alone are difficult to interpret, however, since they could reflect greater underlying transmission, more intensive screening, or both. Figure 3 shows national trends in the syphilis testing and yield rates. The yield rate scales cases by the total number of tests performed, providing a measure that is less mechanically tied to changes in testing volume. Nationally, the testing rate rises only modestly and fluctuates from year to year, while the yield rate roughly triples between 2012 and 2022.

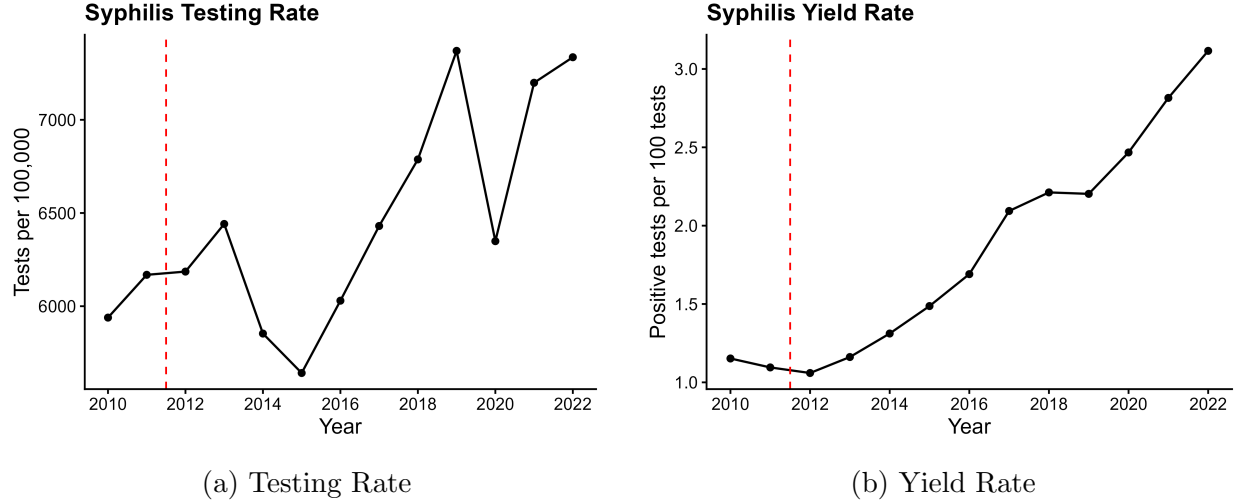


Figure 3: National Syphilis Testing and Yield Rates, Medicaid Beneficiaries

The testing rate is the number of syphilis test events per 100,000 Medicaid beneficiaries aged 15 and older in the state, measured annually. The yield rate is the number of syphilis cases divided by the total number of syphilis test events in the state, multiplied by 100, measured annually. A case is a test followed within 30 days by a syphilis diagnosis, counted at most once per beneficiary in any 90-day period. Rates are computed from counts summed across the 50 states. The dashed vertical line marks PrEP's FDA approval in 2012.

3.3 Male Same-Sex Couples Proxy for PrEP Exposure

Identifying the causal effect of PrEP's introduction is complicated by the lack of a clean control group, because all states get access at the same time. To address this, I use the U.S. Census Bureau's 2010 Decennial Census revised estimates of the share of male same-sex couple households among all households in a state as a proxy, fixed before PrEP's approval, for the size of each state's population likely to take up PrEP. The Census Bureau released revised same-sex couple household counts after identifying a coding error that inflated the original 2010 estimates. I use the corrected counts, described in O'Connell and Feliz (2011). The average state male same-sex couple share is 0.247 percent, with a standard deviation of 0.0878 percentage points. This proxy is imperfect because it does not capture single gay men, people who inject drugs, or women who use PrEP. That said, the measure is highly predictive of subsequent state-level PrEP use.

Figure 4 maps the male same-sex couple share and the 2016 state Medicaid PrEP rate. It shows that states with high MSS tend to have high Medicaid PrEP rates as well. Oregon, Washington, New York, and Massachusetts are all in the highest sextile of both MSS and PrEP use. Similarly, states like North Dakota, South Dakota, Montana, and Idaho are in the lowest quantile for both MSS and PrEP use. Of course this relationship is not a perfect. Florida, Nevada, and Texas have high male same sex couples shares, but have moderate PrEP rates. Conversely, Illinois and Minnesota have high PrEP rates relative to their MSS. To formally validate my use of MSS as a proxy for PrEP access, I estimate the effect of MSS

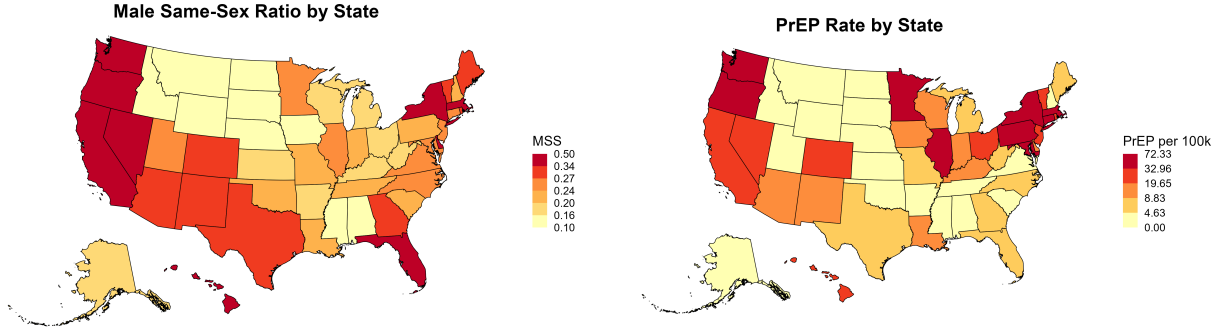


Figure 4: MSS and the State PrEP Rate

The left map shows each state's 2010 Census male same-sex couple share (MSS), in percent. The right map shows each state's 2016 PrEP rate, defined as PrEP patients per 100,000 Medicaid beneficiaries aged 15 and older. In each map, states are shaded by sextile of the 50-state distribution. DC is excluded.

on the Medicaid PrEP rate in the results section.

3.4 Controls

My preferred empirical specifications use time-varying state-level demographic controls to avoid confounding the effect of PrEP access on bacterial STI outcomes. I include controls for the share of the state population that is low-income by race, age group (15-24, 25-34, 35-44, and 45-64), and sex. My threshold for low-income is households under 130% of the federal poverty line to proxy for Medicaid eligibility. The Census Bureau did not release standard ACS 1-year estimates for 2020 because of pandemic-related data collection problems, so for 2020 I use the Bureau's experimental 1-year PUMS file and its experimental person weights. I also control for state Medicaid expansion status under the Affordable Care Act, coded from the Kaiser Family Foundation as an indicator equal to one in years when a state's expansion was in effect (KFF, 2026).

Table 1 displays summary statistics for the data in my sample split by states below and above the median MSS and for the years before and after PrEP's approval. States with above-median male same-sex couple shares expanded adult Medicaid at a higher rate than below-median MSS states. The low-income age group shares are similar across the high MSS and low MSS groups. In both groups of states PrEP use and syphilis diagnosis, testing, and yield rates rose after 2012. The increases appear larger for all outcomes in the above-median group. However, these descriptive statistics don't account for differences in Medicaid expansion and other differences between above and below median PrEP access states that may effect the outcomes, but are controlled for in the regression estimates using demographic controls and state fixed effects.

	Below-median MSS		Above-median MSS	
	2010–2011	2012–2022	2010–2011	2012–2022
<i>A. PrEP exposure</i>				
MSS (%)	0.177 (0.038)	0.177 (0.037)	0.318 (0.062)	0.318 (0.062)
<i>B. PrEP use</i>				
PrEP rate, pooled	1.4 (2.2)	13.7 (21.3)	6.5 (6.3)	37.0 (37.8)
PrEP rate, male	2.5 (4.7)	26.9 (41.0)	10.2 (9.7)	71.2 (72.2)
PrEP rate, female	0.9 (1.6)	4.4 (7.8)	4.7 (5.4)	10.4 (12.0)
<i>C. Syphilis outcomes, pooled</i>				
Diagnosis rate	25.5 (39.2)	77.0 (90.1)	36.7 (37.7)	126.3 (135.5)
Testing rate	4,128 (2,730)	4,716 (2,232)	4,354 (2,989)	5,677 (3,039)
Yield rate	0.48 (0.57)	1.40 (1.17)	0.68 (0.50)	2.05 (2.03)
<i>D. Syphilis outcomes, male</i>				
Diagnosis rate	23.5 (31.6)	82.9 (102.9)	44.5 (47.0)	166.7 (178.1)
Testing rate	1,399 (941)	2,080 (1,369)	2,141 (1,918)	3,392 (2,251)
Yield rate	1.46 (1.90)	3.23 (2.60)	1.75 (1.30)	4.39 (3.38)
<i>E. HIV testing</i>				
HIV testing rate	6,100 (3,394)	6,928 (2,566)	6,374 (3,616)	8,016 (3,429)
<i>F. Controls</i>				
Black non-Hispanic, below 130% FPL (%)	4.1 (4.3)	3.7 (3.9)	2.9 (2.5)	2.6 (2.2)
White non-Hispanic, below 130% FPL (%)	13.0 (3.1)	11.6 (3.1)	8.7 (3.3)	7.5 (2.9)
Hispanic, below 130% FPL (%)	1.9 (1.1)	1.8 (0.9)	5.5 (4.1)	4.9 (3.6)
Ages 15–24, below 130% FPL (%)	4.1 (0.7)	3.5 (0.7)	3.6 (0.8)	3.0 (0.8)
Ages 25–34, below 130% FPL (%)	2.8 (0.6)	2.5 (0.6)	2.6 (0.6)	2.3 (0.6)
Ages 35–44, below 130% FPL (%)	2.1 (0.5)	2.0 (0.5)	2.1 (0.5)	1.9 (0.5)
Ages 45–64, below 130% FPL (%)	3.9 (1.0)	3.7 (1.0)	3.6 (0.8)	3.4 (0.8)
Male share of population below 130% FPL (%)	45.1 (1.4)	45.0 (1.7)	45.4 (1.5)	45.1 (1.3)
Medicaid expansion in effect (%)	0.0 (0.0)	43.6 (49.7)	0.0 (0.0)	62.9 (48.4)
<i>G. Sample</i>				
Beneficiaries aged 15+ (thousands)	533 (456)	713 (641)	1,227 (1,787)	1,660 (2,363)
States	25	25	25	25
State-years	48	275	49	275

Table 1: Summary Statistics

Each cell reports the unweighted mean across state-years, with the standard deviation in parentheses. States are divided at the median 2010 male same-sex couple share (MSS) across the 50 states. The PrEP, diagnosis, and testing rates are per 100,000 Medicaid beneficiaries aged 15 and older (male or female beneficiaries for the sex-specific rows). The yield rate is syphilis cases per 100 syphilis tests, and the HIV testing rate is HIV tests per 100,000 beneficiaries aged 15 and older. Control shares are percentages of the state’s total population, from ACS 1-year PUMS. DC is excluded. Kansas and Maine are missing in 2010, and Idaho’s outpatient claims are missing in 2011. State and state-year counts refer to the pooled syphilis sample.

4 Empirical Strategy

I estimate the effect of differential PrEP exposure on bacterial STI outcomes by exploiting cross-state variation in exposure to PrEP’s introduction following its FDA approval in 2012. I consider three syphilis outcomes: the diagnosis rate, testing rate, and yield rate. As described in Section 3, I use the pre-period share of male same-sex couple households in a state, measured in the 2010 Census, as a proxy for differential PrEP exposure and estimate a continuous-treatment difference-in-differences specification that allows post-2012 changes in outcomes to vary with the state’s pre-period MSS share:

$$Y_{st} = \beta (\text{MSS}_s \times \text{Post}_t) + \gamma X_{st} + \mu_s + \tau_t + \epsilon_{st} \quad (1)$$

where MSS_s is the 2010 Census male same-sex couple share in state s , expressed in percentage

points, and Post_t is an indicator equal to one in 2012 and subsequent years. The coefficient β captures the differential post-2012 change in each outcome caused by a one-percentage-point higher pre-period male-same sex couple share (MSS). To make the results more easy to interpret relative to the distribution of MSS, I report effects scaled to a one-standard-deviation (0.0878-percentage-point) difference in MSS. Standard errors are clustered at the state level because treatment intensity varies at the state level.

In addition to state and year fixed effects, a subset of specifications includes the time-varying, state-level controls X_{st} described in Section 3. These controls include the shares of the state population who are Black non-Hispanic, White non-Hispanic, and Hispanic and below 130% of poverty, the shares in each of four age groups and below 130% of poverty, the male share of the population below 130% of poverty, and an indicator for Medicaid expansion.

Quasi-First Stage. To validate the proxy, I estimate the relationship between the male same-sex couple share and the PrEP rate:

$$\text{PrEP}_{st} = \beta (\text{MSS}_s \times \text{Post}_t) + \gamma X_{st} + \mu_s + \tau_t + \epsilon_{st} \quad (2)$$

where PrEP_{st} is the rate of patients prescribed PrEP per 100,000 Medicaid beneficiaries aged 15 and older in state s in year t . A positive and significant $\hat{\beta}$ indicates that states with higher male same-sex couple shares experienced differential PrEP uptake after 2012, supporting the proxy.

Event Study. The identifying assumption behind equation (1) is that, absent the introduction of PrEP, post-2012 changes in STI outcomes would not have been systematically related to the state’s pre-period MSS share. This assumption would be violated if states with more male same-sex couples were on differential STI trends prior to 2012 for reasons unrelated to PrEP. To assess this, I estimate an event-study version of equation (1), replacing the single $\text{MSS}_s \times \text{Post}_t$ interaction with a full set of year-by-treatment-intensity interactions:

$$Y_{st} = \sum_{\substack{k=2010 \\ k \neq 2011}}^{2022} \beta_k (\text{MSS}_s \times \mathbf{1}[t = k]) + \gamma X_{st} + \mu_s + \tau_t + \epsilon_{st} \quad (3)$$

where $\mathbf{1}[t = k]$ is an indicator for year k , and 2011, the year immediately preceding FDA approval, is the omitted reference category. The coefficient β_{2010} captures the differential change between 2010 and 2011 associated with the state’s pre-period MSS share. An estimate close to zero provides evidence against differential changes in STI outcomes immediately prior to PrEP’s introduction. The coefficients $\{\beta_k\}_{k \geq 2012}$ trace out the dynamic pattern of differential post-2012 changes in outcomes. I estimate equation (3) separately for each

outcome, and apply the same specification to equation (2) to assess pre-trends in the quasi-first stage.

To estimate whether the male same-sex couple share predicts PrEP uptake differentially by sex, I estimate equation (1) separately for the male and female subsamples. Because PrEP uptake is substantially greater among men, we would expect to see a larger effect for men. However, the effect among women need not be zero. Some women are at high risk of contracting HIV and thus are the target population to take PrEP. I therefore interpret the sex-specific estimates as evidence on whether the relative magnitude of the effects is consistent with differential PrEP use across sex.

I assess the sensitivity of the main results in two additional ways. First, I re-estimate the specifications excluding Kansas, Maine, and Idaho, which have incomplete data in the outpatient or prescription claims files during part of the sample period, as described in Section 3. Second, I conduct a leave-one-out analysis, re-estimating the model after excluding each state one by one to assess whether results are driven by any single state. All results are estimated over the 2010–2022 sample period.

5 Results

In this section, I first estimate the quasi-first-stage effect of the male same-sex share on the PrEP rate. This demonstrates whether my chosen proxy predicts PrEP uptake following PrEP’s introduction. Then, I move on to the main results where I estimate the effects of differential PrEP exposure on the syphilis diagnosis rate, which conveys the effect on observed syphilis diagnoses, the testing rate, which conveys the effect on syphilis screening, and on the syphilis yield rate, which approximates the true change in syphilis cases by netting different levels of testing. Section 6 reports estimates for male and female beneficiaries separately, estimates excluding states with incomplete claims, and leave-one-out estimates.

5.1 Effect of Male Same-Sex Couple Share on the PrEP Rate

This quasi-first-stage provides a direct check that the MSS measure captures meaningful cross-state variation in PrEP exposure. Figure 5 presents the event-study estimates for the PrEP rate. The 2010 coefficient is close to zero and not statistically significant relative to the omitted 2011 year, providing no evidence of differential PrEP trends immediately prior to FDA approval. The coefficients remain near zero in the first three years following PrEP’s FDA approval, then rise steadily. This pattern mirrors the raw trend of PrEP take shown in Figure 1. The event study supports the use of the pre-treatment MSS share as a proxy

for differential PrEP access across states.

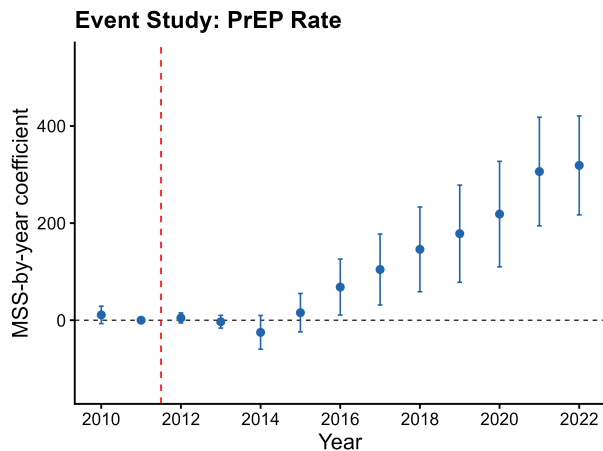


Figure 5: Event Study: PrEP Rate

The PrEP rate is the number of patients with a PrEP prescription per 100,000 Medicaid beneficiaries aged 15 and older in the state, measured annually. Coefficients and 95% confidence intervals are from the event-study specification in Equation (3) applied to the quasi-first stage in Equation (2), with 2011 as the omitted reference year. Event-study estimates shown are from the specification with demographic controls. The dashed vertical line marks PrEP’s 2012 FDA approval.

Table 2 shows a positive and statistically significant relationship between MSS and subsequent PrEP uptake. In the preferred specification with demographic controls, the coefficient on $MSS \times Post$ is 82.88 ($p < 0.01$), compared with 129.7 without controls. A one-standard-deviation higher MSS (0.0878 percentage points) is associated with approximately 7.3 additional PrEP patients per 100,000 Medicaid beneficiaries aged 15 and older following PrEP’s introduction, nearly twice the 2011 baseline mean of 4.0.

Dependent Variable: Model:	PrEP Rate	
	(1)	(2)
<i>Variables</i>		
MSS $\times$ Post	129.7*** (20.96)	82.88*** (18.94)
Demographic Controls	No	Yes
2011 Baseline Mean	4.03	4.03
<i>Fixed-effects</i>		
State	Yes	Yes
Year	Yes	Yes
<i>Fit statistics</i>		
Observations	648	648
<i>Clustered (State) standard-errors in parentheses</i>		
<i>Signif. Codes: ***: 0.01, **: 0.05, *: 0.1</i>		

Table 2: Quasi-First Stage: Effect of MSS $\times$ Post on the PrEP Rate

The PrEP rate is the number of patients with a PrEP prescription per 100,000 Medicaid beneficiaries aged 15 and older in the state, measured annually. Specifications marked “Yes” in the Demographic Controls row include controls, from ACS 1-year PUMS, for the shares of the state population who are Black non-Hispanic, White non-Hispanic, and Hispanic and below 130% of the federal poverty level. They also include the shares of the state population who are in each of four age groups (15–24, 25–34, 35–44, and 45–64) and below 130% of poverty, the male share of the population below 130% of poverty, and an indicator for Medicaid expansion. The unit of observation is the state-year, 2010–2022, excluding DC. All specifications include state and year fixed effects. Standard errors clustered at the state level are reported in parentheses.

5.2 Syphilis

Figure 6 presents the event-study estimates for the diagnosis rate. The 2010 coefficient is close to zero and not statistically significant relative to the omitted 2011 reference year, and the coefficients remain near zero through 2014, mirroring the delayed rise in PrEP uptake in Figure 5. From 2015 onward the coefficients are positive and rise through 2019. Individual post-period coefficients are imprecisely estimated, however, and most 95% confidence intervals include zero.

Figure 7 presents the corresponding estimates for the testing and yield rates. The testing-rate coefficients are noisy and do not exhibit a clear post-2012 pattern. The yield-rate coefficients follow a pattern similar to the diagnosis rate: they are close to zero in 2010 and through 2014 and positive from 2015 onward, although they are imprecisely estimated.

Table 3 reports the estimated effects on the three syphilis outcomes. Columns (1) and (2) show a positive relationship between MSS and the syphilis diagnosis rate. In the preferred specification with demographic controls, the coefficient is 240.8 and statistically significant at the 10% level. Without controls, it is 323.8 and significant at the 5% level. A one-standard-deviation higher MSS is associated with approximately 21.1 additional syphilis cases per 100,000 beneficiaries, a 66.2% increase relative to the 2011 baseline mean of 31.9 per 100,000.

The testing-rate estimates in columns (3) and (4) are positive but statistically impre-

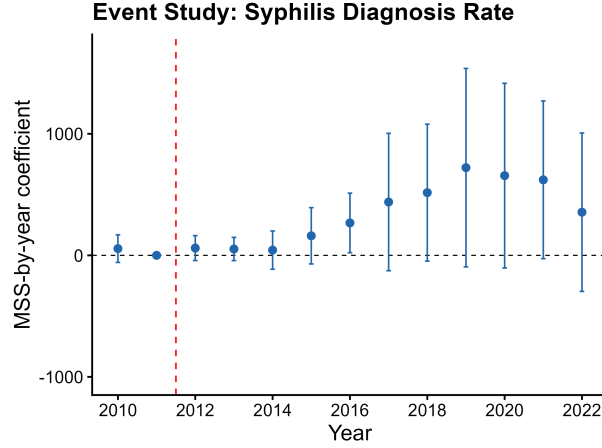


Figure 6: Event Study: Syphilis Diagnosis Rate

The diagnosis rate is the number of syphilis cases per 100,000 Medicaid beneficiaries aged 15 and older in the state, measured annually. A case is a test followed within 30 days by a syphilis diagnosis, counted at most once per beneficiary in any 90-day period. Coefficients and 95% confidence intervals are from the event-study specification in Equation (3), with 2011 as the omitted reference year. Event-study estimates shown are from the specification with demographic controls. The dashed vertical line marks PrEP's 2012 FDA approval.

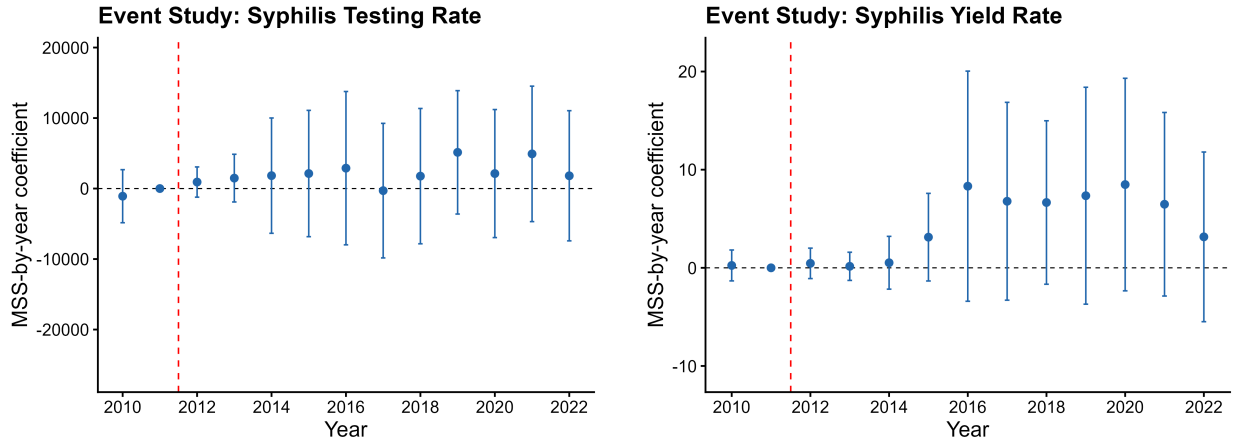


Figure 7: Event Studies: Syphilis Testing and Yield Rates

The testing rate is the number of syphilis test events per 100,000 Medicaid beneficiaries aged 15 and older in the state, measured annually. The yield rate is the number of syphilis cases divided by the total number of syphilis test events in the state, multiplied by 100, measured annually. A case is a test followed within 30 days by a syphilis diagnosis, counted at most once per beneficiary in any 90-day period. Coefficients and 95% confidence intervals are from the event-study specification in Equation (3), with 2011 as the omitted reference year. Event-study estimates shown are from the specification with demographic controls. The dashed vertical line marks PrEP's 2012 FDA approval.

cise. The preferred estimate of 2,549.3 implies roughly 224 additional tests per 100,000 beneficiaries for a one-standard-deviation higher MSS, about 5% of the 2011 baseline mean of 4,242. The yield-rate estimates in columns (5) and (6) are also positive. Without controls, the coefficient is 4.786 and significant at the 5% level. With controls, it is 3.553 and not statistically significant at conventional levels. The preferred estimate implies that a one-standard-deviation higher MSS raises the yield rate by 0.31 percentage points, a 52.9%

increase relative to the 2011 baseline mean of 0.59.

Dependent Variables: Model:	Diagnosis Rate		Testing Rate		Yield Rate	
	(1)	(2)	(3)	(4)	(5)	(6)
<i>Variables</i>						
MSS $\times$ Post	323.8** (142.4)	240.8* (138.7)	3,920.2 (3,456.4)	2,549.3 (2,929.9)	4.786** (2.369)	3.553 (2.428)
Demographic Controls	No	Yes	No	Yes	No	Yes
2011 Baseline Mean	31.92	31.92	4,241.95	4,241.95	0.59	0.59
<i>Fixed-effects</i>						
State	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
<i>Fit statistics</i>						
Observations	647	647	647	647	647	647

Clustered (State) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table 3: Effect of MSS $\times$ Post on Syphilis Outcomes

The diagnosis rate is the number of syphilis cases per 100,000 Medicaid beneficiaries aged 15 and older in the state, measured annually. A case is a test followed within 30 days by a syphilis diagnosis, counted at most once per beneficiary in any 90-day period. The testing rate is the number of syphilis test events per 100,000 Medicaid beneficiaries aged 15 and older in the state, measured annually. The yield rate is the number of syphilis cases divided by the total number of syphilis test events in the state, multiplied by 100, measured annually. Specifications marked “Yes” in the Demographic Controls row include controls, from ACS 1-year PUMS, for the shares of the state population who are Black non-Hispanic, White non-Hispanic, and Hispanic and below 130% of the federal poverty level. They also include the shares of the state population who are in each of four age groups (15–24, 25–34, 35–44, and 45–64) and below 130% of poverty, the male share of the population below 130% of poverty, and an indicator for Medicaid expansion. The unit of observation is the state-year, 2010–2022, excluding DC. All specifications include state and year fixed effects. Standard errors clustered at the state level are reported in parentheses.

The magnitudes of the testing and yield coefficients suggest that most of the 66% increase in diagnoses is attributable to a higher share of positive tests rather than being driven by increased syphilis detection. If the rise in diagnoses were driven entirely by more testing, testing would have had to rise by roughly the same 66% that the diagnosis rate rose. However, the 90% confidence interval for the testing rate only covers a -5% to $+15\%$ change from the 2011 baseline mean. Even at the upper end of this interval increased testing could only account for a fraction of the estimated increase in diagnoses. The remaining increase is consistent with a rise in underlying syphilis incidence. However, I cannot rule out some effect from increased testing given the imprecision of the testing and yield estimates.

6 Robustness and Validity Checks

6.1 Male and Female Beneficiaries

Because PrEP uptake is concentrated among men, particularly men who have sex with men, the identifying logic of the MSS proxy predicts that the effects of PrEP exposure should be larger for men than in the pooled sample. I check for this by re-estimating the main

specifications separately for male and female beneficiaries. Although men disproportionately use PrEP, I do not treat women as a placebo group, because some women use PrEP themselves and changes in risky sexual behavior among men could affect women’s syphilis outcomes through sexual networks. I therefore interpret differences between men and women as heterogeneity in exposure rather than as a placebo test.

I first examine whether the relationship between MSS and PrEP uptake differs by sex. Figure 8 shows the male and female event-study estimates side by side. For both, the 2010 coefficient is close to zero and not statistically significant relative to the omitted 2011 year. The male coefficients remain near zero through 2015 and then grow sharply. The female coefficients rise as well, but the effect is much smaller.

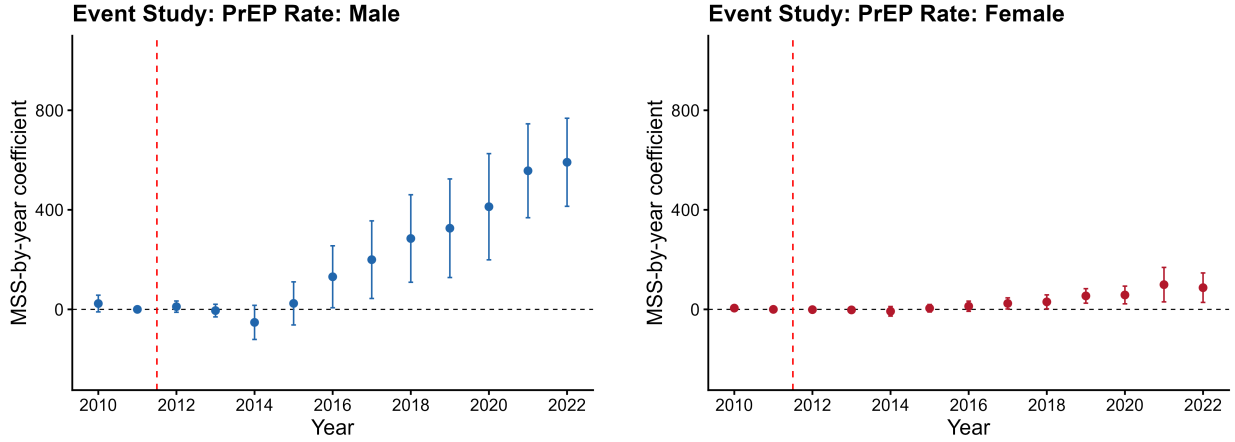


Figure 8: Event Study: PrEP Rate, Male and Female

The PrEP rate is the number of patients with a PrEP prescription per 100,000 Medicaid beneficiaries aged 15 and older in the state, measured annually. Male and female coefficients are estimated separately. The left panel shows male beneficiaries and the right panel shows female beneficiaries, on a common vertical axis. Coefficients and 95% confidence intervals are from the event-study specification in Equation (3) applied to the quasi-first stage in Equation (2), with 2011 as the omitted reference year. Event-study estimates shown are from the specification with demographic controls.

Table 4 confirms a much stronger relationship for men. The coefficient on $MSS \times Post$ is 152.8 in the male sample and 20.67 in the female sample. The female coefficient is positive and statistically significant but roughly one-seventh the size of the male coefficient. Together, the event-study estimates and tables show that the MSS proxy captures greater PrEP uptake among men which coincides with the known proportion of PrEP use by sex.

Figure 9 shows the male and female diagnosis-rate event-study estimates side by side. For men, the 2010 coefficient is close to zero and not statistically significant, providing no evidence of a differential change immediately prior to PrEP’s introduction. After 2014, the male coefficients become positive, rising through roughly 2019 and remaining elevated thereafter. The female coefficients are smaller and less precisely estimated. For women, the 2010 coefficient is also close to zero, and the coefficients turn positive after 2014 and peak

Dependent Variable: Model:	Male		Female	
	(1)	PrEP Rate (2)	(3)	(4)
<i>Variables</i>				
MSS $\times$ Post	245.3*** (44.01)	152.8*** (39.62)	28.86*** (8.060)	20.67** (8.164)
Demographic Controls	No	Yes	No	Yes
2011 Baseline Mean	6.51	6.51	2.66	2.66
<i>Fixed-effects</i>				
State	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
<i>Fit statistics</i>				
Observations	647	647	647	647

Clustered (State) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table 4: Quasi-First Stage: Effect of MSS $\times$ Post on the PrEP Rate, Male and Female

The PrEP rate is the number of patients with a PrEP prescription per 100,000 Medicaid beneficiaries aged 15 and older in the state, measured annually. Columns (1) and (2) restrict the sample to male beneficiaries and columns (3) and (4) to female beneficiaries. The male and female specifications are estimated separately. Mississippi in 2021 is excluded from the sex-specific samples because prescription claims could not be linked to beneficiary sex that year. Specifications marked “Yes” in the Demographic Controls row include controls, from ACS 1-year PUMS, for the shares of the state population who are Black non-Hispanic, White non-Hispanic, and Hispanic and below 130% of the federal poverty level. They also include the shares of the state population who are in each of four age groups (15–24, 25–34, 35–44, and 45–64) and below 130% of poverty, the male share of the population below 130% of poverty, and an indicator for Medicaid expansion. The unit of observation is the state-year, 2010–2022, excluding DC. All specifications include state and year fixed effects. Standard errors clustered at the state level are reported in parentheses.

around 2019, but all post-period 95% confidence intervals include zero.

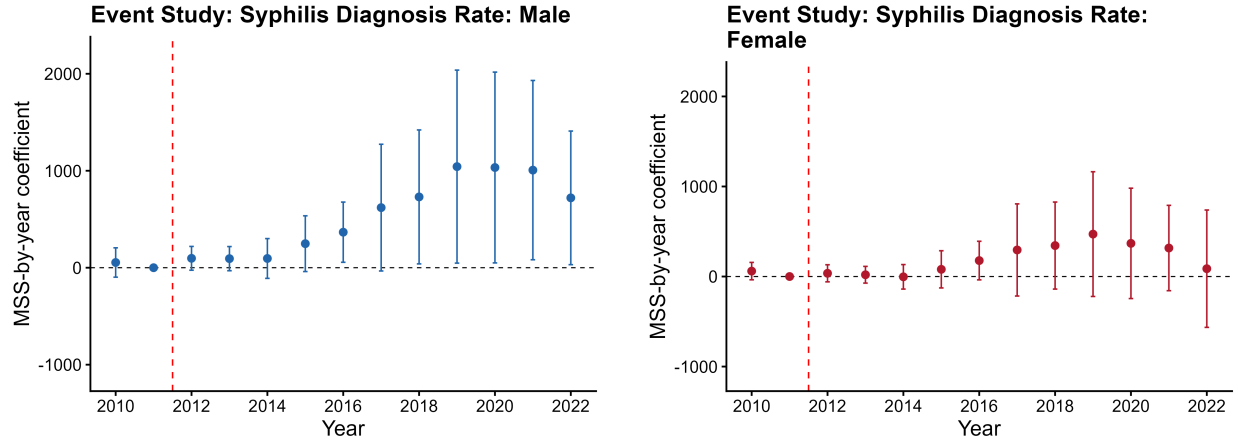


Figure 9: Event Study: Syphilis Diagnosis Rate, Male and Female

The diagnosis rate is the number of syphilis cases per 100,000 Medicaid beneficiaries aged 15 and older in the state, measured annually. A case is a test followed within 30 days by a syphilis diagnosis, counted at most once per beneficiary in any 90-day period. Male and female coefficients are estimated separately. The left panel shows male beneficiaries and the right panel shows female beneficiaries. Coefficients and 95% confidence intervals are from the event-study specification in Equation (3), with 2011 as the omitted reference year. Event-study estimates shown are from the specification with demographic controls.

Figure 10 shows the corresponding estimates for the testing and yield rates. The male estimates are in the left column and the female estimates in the right column. The male

testing-rate coefficients rise from 2018 onward. The 2019 coefficient is statistically significant at the 5% level, and the 2020–2022 coefficients are similar in size, although their 95% confidence intervals include zero. This pattern is consistent with an increase in screening for PrEP users. However, these increases are much smaller than the corresponding rise in diagnoses. The female testing-rate estimates are imprecise and do not display a clear post-2012 pattern. For men, the yield coefficients are close to zero in 2010 and become positive after 2014. For women, the yield coefficients are close to zero through 2014 and positive afterward, though none are statistically significant.

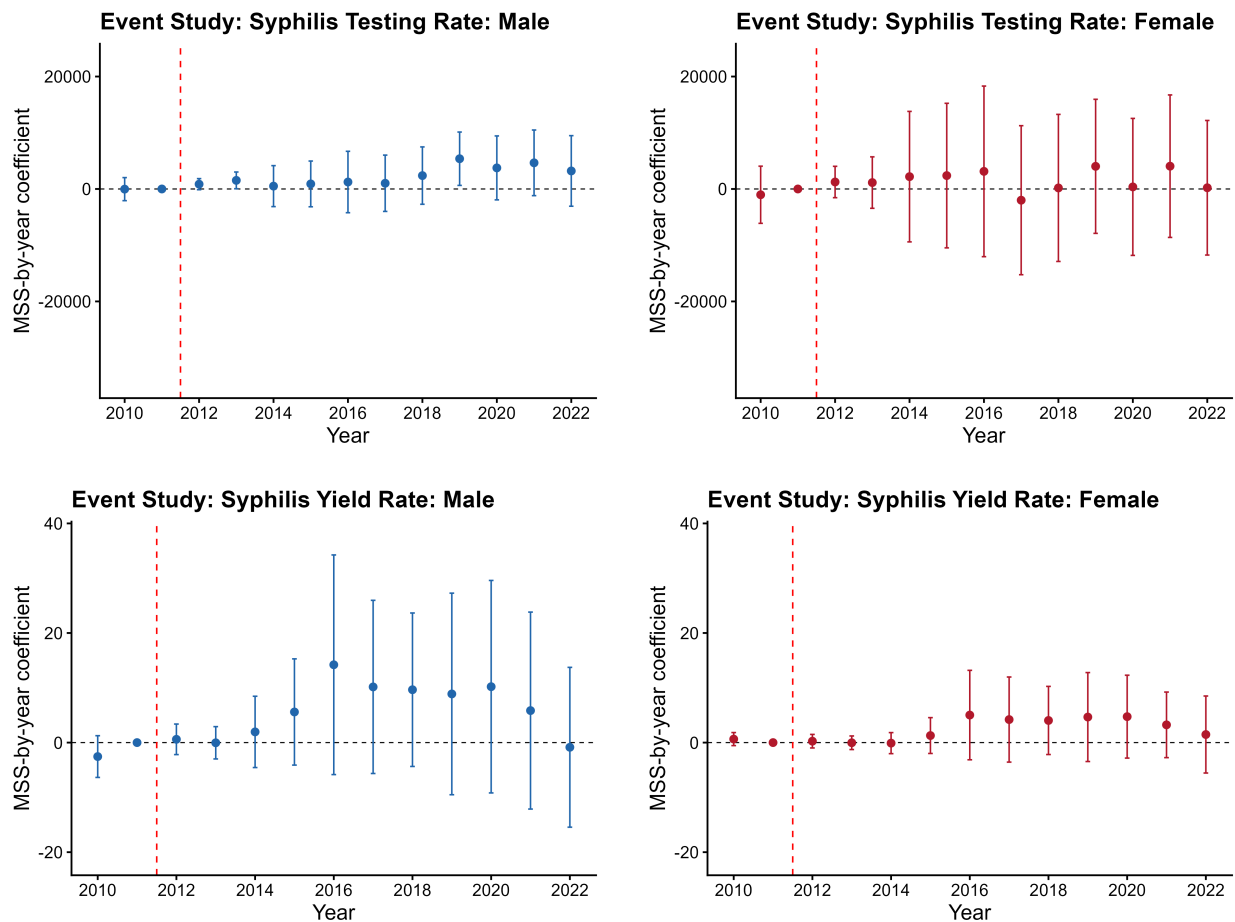


Figure 10: Event Studies: Syphilis Testing and Yield Rates, Male and Female

The testing rate is the number of syphilis test events per 100,000 Medicaid beneficiaries aged 15 and older in the state, measured annually. The yield rate is the number of syphilis cases divided by the total number of syphilis test events in the state, multiplied by 100, measured annually. A case is a test followed within 30 days by a syphilis diagnosis, counted at most once per beneficiary in any 90-day period. Male and female coefficients are estimated separately. The left column shows male beneficiaries and the right column shows female beneficiaries. Coefficients and 95% confidence intervals are from the event-study specification in Equation (3), with 2011 as the omitted reference year. Event-study estimates shown are from the specification with demographic controls.

Table 5 reports the syphilis estimates by sex. Because baseline rates differ substantially by sex, I compare effects relative to each sample’s 2011 baseline mean. For the diagnosis

rate, the male coefficient is positive and significant. The preferred estimate implies that a one-standard-deviation higher MSS raises the male diagnosis rate by 34.5 per 100,000, a 96.8% increase relative to the male 2011 baseline mean of 35.6. This is larger than the 66.2% increase in the pooled sample. The male testing-rate estimates are positive but not statistically significant. The coefficient corresponds to a 9.3% increase relative to the male baseline mean of 1,793 which is slightly larger in proportional terms than the pooled estimate. Its 90% confidence interval, from about -2% to $+21\%$ of the male baseline mean, likewise rules out increases in testing large enough to account for the 96.8% rise in male diagnoses. The male yield-rate coefficient is 7.896 without controls, significant at the 10% level, and 6.229 with controls, which is not statistically significant. The preferred estimate corresponds to a 34.8% increase relative to the male baseline mean of 1.57, smaller in proportional terms than the pooled estimate. For women, the syphilis estimates are positive but not statistically significant for any outcome. With controls, the female diagnosis-rate coefficient of 118.5 implies a 34.5% increase relative to the female baseline mean of 30.2, about one-third of the proportional male effect, while the female yield-rate estimate corresponds to a 36.2% increase, similar in proportional terms to the male estimate.

Dependent Variables: Model:	Male						Female					
	Diagnosis Rate		Testing Rate		Yield Rate		Diagnosis Rate		Testing Rate		Yield Rate	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
<i>Variables</i>												
MSS $\times$ Post	500.5*** (178.3)	392.8** (168.0)	2,835.6 (1,869.1)	1,894.3 (1,423.5)	7.896* (4.205)	6.229 (4.188)	174.7 (121.7)	118.5 (120.4)	3,776.1 (4,718.5)	2,054.4 (4,098.2)	2.321 (1.717)	1.691 (1.768)
Demographic Controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
2011 Baseline Mean	35.61	35.61	1,792.95	1,792.95	1.57	1.57	30.17	30.17	5,686.71	5,686.71	0.41	0.41
<i>Fixed-effects</i>												
State	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>Fit statistics</i>												
Observations	647	647	647	647	647	647	647	647	647	647	647	647

Clustered (State) standard-errors in parentheses

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table 5: Effect of MSS $\times$ Post on Syphilis Outcomes, Male and Female

The diagnosis rate is the number of syphilis cases per 100,000 Medicaid beneficiaries aged 15 and older in the state, measured annually. A case is a test followed within 30 days by a syphilis diagnosis, counted at most once per beneficiary in any 90-day period. The testing rate is the number of syphilis test events per 100,000 Medicaid beneficiaries aged 15 and older in the state, measured annually. The yield rate is the number of syphilis cases divided by the total number of syphilis test events in the state, multiplied by 100, measured annually. Columns (1)–(6) restrict the sample to male beneficiaries and columns (7)–(12) to female beneficiaries. The male and female specifications are estimated separately. Specifications marked “Yes” in the Demographic Controls row include controls, from ACS 1-year PUMS, for the shares of the state population who are Black non-Hispanic, White non-Hispanic, and Hispanic and below 130% of the federal poverty level. They also include the shares of the state population who are in each of four age groups (15–24, 25–34, 35–44, and 45–64) and below 130% of poverty, the male share of the population below 130% of poverty, and an indicator for Medicaid expansion. The unit of observation is the state-year, 2010–2022, excluding DC. All specifications include state and year fixed effects. Standard errors clustered at the state level are reported in parentheses.

The results by sex are consistent with the identifying logic of the MSS proxy. The

relationship between MSS and PrEP uptake is substantially stronger among men, and the diagnosis effect is both larger and more precisely estimated for men than in the pooled sample. The male yield estimates are similarly imprecise, and the female estimates are positive but not statistically significant.

6.2 Excluding States with Incomplete Claims

Kansas and Maine are absent from the MAX files in 2010 because of data-reporting issues, while Idaho appears in the prescription files in 2011 but not in the outpatient files. These states are included in the main analysis, but I re-estimate the specifications after excluding all three to verify that the results are not driven by these data limitations.

Figure 11 shows that the event-study estimates for the PrEP rate in this restricted sample follow the same pattern as in the full sample.

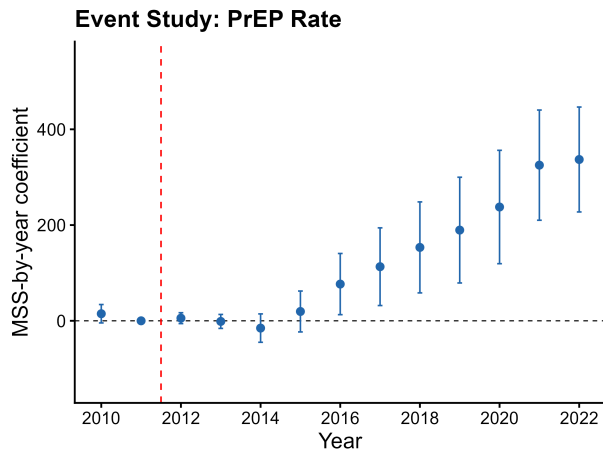


Figure 11: Event Study: PrEP Rate, Excluding Kansas, Maine, and Idaho

The PrEP rate is the number of patients with a PrEP prescription per 100,000 Medicaid beneficiaries aged 15 and older in the state, measured annually. Sample excludes Kansas, Maine, and Idaho. Coefficients and 95% confidence intervals are from the event-study specification in Equation (3) applied to the quasi-first stage in Equation (2), with 2011 as the omitted reference year. Event-study estimates shown are from the specification with demographic controls.

Table 6 shows a similarly positive and statistically significant relationship between MSS and PrEP uptake. With demographic controls, the coefficient on $MSS \times Post$ is 86.25 ($p < 0.01$), compared with 82.88 in the full sample.

Figure 12 presents the event-study estimates for the diagnosis rate in the restricted sample. As in the full sample, the 2010 coefficient is close to zero and not statistically significant relative to the omitted 2011 year, and the coefficients become positive after 2014.

Figure 13 presents the corresponding estimates for the testing and yield rates. The testing coefficients remain imprecisely estimated and do not display a clear post-2012 pattern, while the yield coefficients follow the same pattern as in the full sample.

Dependent Variable:	PrEP Rate	
Model:	(1)	(2)
<i>Variables</i>		
MSS $\times$ Post	130.8*** (21.63)	86.25*** (19.61)
Demographic Controls	No	Yes
2011 Baseline Mean	4.06	4.06
<i>Fixed-effects</i>		
State	Yes	Yes
Year	Yes	Yes
<i>Fit statistics</i>		
Observations	611	611

Clustered (State) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table 6: Quasi-First Stage: Effect of MSS $\times$ Post on the PrEP Rate, Excluding Kansas, Maine, and Idaho

The PrEP rate is the number of patients with a PrEP prescription per 100,000 Medicaid beneficiaries aged 15 and older in the state, measured annually. Sample excludes Kansas, Maine, and Idaho. Specifications marked “Yes” in the Demographic Controls row include controls, from ACS 1-year PUMS, for the shares of the state population who are Black non-Hispanic, White non-Hispanic, and Hispanic and below 130% of the federal poverty level. They also include the shares of the state population who are in each of four age groups (15–24, 25–34, 35–44, and 45–64) and below 130% of poverty, the male share of the population below 130% of poverty, and an indicator for Medicaid expansion. The unit of observation is the state-year, 2010–2022, excluding DC. All specifications include state and year fixed effects. Standard errors clustered at the state level are reported in parentheses.

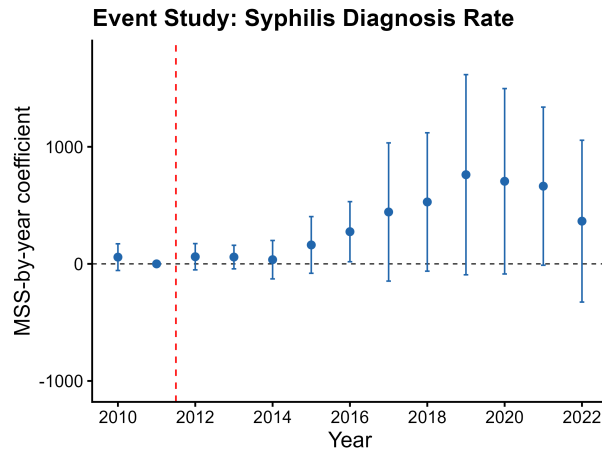


Figure 12: Event Study: Syphilis Diagnosis Rate, Excluding Kansas, Maine, and Idaho

The diagnosis rate is the number of syphilis cases per 100,000 Medicaid beneficiaries aged 15 and older in the state, measured annually. A case is a test followed within 30 days by a syphilis diagnosis, counted at most once per beneficiary in any 90-day period. Sample excludes Kansas, Maine, and Idaho. Coefficients and 95% confidence intervals are from the event-study specification in Equation (3), with 2011 as the omitted reference year. Event-study estimates shown are from the specification with demographic controls.

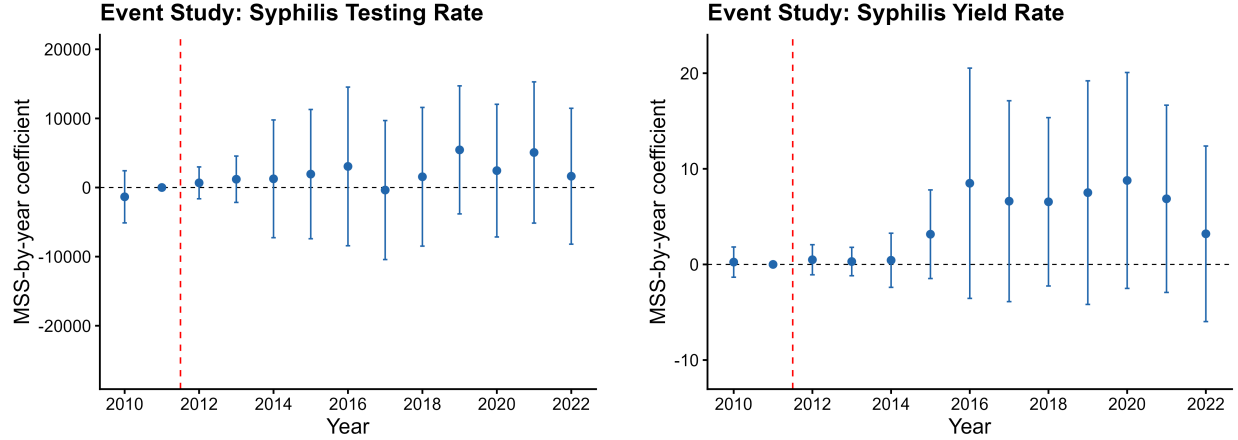


Figure 13: Event Studies: Syphilis Testing and Yield Rates, Excluding Kansas, Maine, and Idaho

The testing rate is the number of syphilis test events per 100,000 Medicaid beneficiaries aged 15 and older in the state, measured annually. The yield rate is the number of syphilis cases divided by the total number of syphilis test events in the state, multiplied by 100, measured annually. A case is a test followed within 30 days by a syphilis diagnosis, counted at most once per beneficiary in any 90-day period. Sample excludes Kansas, Maine, and Idaho. Coefficients and 95% confidence intervals are from the event-study specification in Equation (3), with 2011 as the omitted reference year. Event-study estimates shown are from the specification with demographic controls.

Table 7 shows that the syphilis estimates are very similar to the full-sample results. With demographic controls, the diagnosis-rate coefficient is 247.5, compared with 240.8 in the full sample, and remains statistically significant at the 10% level. The testing-rate coefficient is 2,539.9, compared with 2,549.3, and remains statistically imprecise in both specifications. The yield-rate coefficient is 3.587, compared with 3.553, and as in the full sample is not statistically significant with controls. Without controls it is 4.823, significant at the 10% level. The close similarity of the estimates and event-study patterns across samples indicates that the main syphilis results are not driven by the incomplete claims observations for Kansas, Maine, or Idaho.

Dependent Variables: Model:	Diagnosis Rate		Testing Rate		Yield Rate	
	(1)	(2)	(3)	(4)	(5)	(6)
<i>Variables</i>						
MSS $\times$ Post	325.9** (145.1)	247.5* (144.0)	4,055.7 (3,565.9)	2,539.9 (3,002.5)	4.823* (2.417)	3.587 (2.510)
Demographic Controls	No	Yes	No	Yes	No	Yes
2011 Baseline Mean	32.98	32.98	4,339.27	4,339.27	0.61	0.61
<i>Fixed-effects</i>						
State	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
<i>Fit statistics</i>						
Observations	611	611	611	611	611	611

Clustered (State) standard-errors in parentheses
*Signif. Codes: ***, 0.01, **, 0.05, *, 0.1*

Table 7: Effect of MSS $\times$ Post on Syphilis Outcomes, Excluding Kansas, Maine, and Idaho

The diagnosis rate is the number of syphilis cases per 100,000 Medicaid beneficiaries aged 15 and older in the state, measured annually. A case is a test followed within 30 days by a syphilis diagnosis, counted at most once per beneficiary in any 90-day period. The testing rate is the number of syphilis test events per 100,000 Medicaid beneficiaries aged 15 and older in the state, measured annually. The yield rate is the number of syphilis cases divided by the total number of syphilis test events in the state, multiplied by 100, measured annually. Sample excludes Kansas, Maine, and Idaho. Specifications marked “Yes” in the Demographic Controls row include controls, from ACS 1-year PUMS, for the shares of the state population who are Black non-Hispanic, White non-Hispanic, and Hispanic and below 130% of the federal poverty level. They also include the shares of the state population who are in each of four age groups (15–24, 25–34, 35–44, and 45–64) and below 130% of poverty, the male share of the population below 130% of poverty, and an indicator for Medicaid expansion. The unit of observation is the state-year, 2010–2022, excluding DC. All specifications include state and year fixed effects. Standard errors clustered at the state level are reported in parentheses.

6.3 Leave-One-Out

The identifying variation in the main specification comes from cross-state differences in the pre-treatment MSS share, so it is also important to verify that the estimated effects are not driven by a single influential state. I therefore re-estimate the preferred specification 50 times, excluding one state from the sample in each iteration. Figures 14 and 15 report the resulting coefficient estimates with 90% and 95% confidence intervals for the diagnosis, testing, and yield rates.

The diagnosis and yield rate point estimates remain positive in every specification, and for most exclusions they lie close to the full-sample estimates of 240.8 and 3.553. The largest declines occur when Delaware is omitted, which roughly halves the diagnosis-rate estimate and reduces the yield-rate estimate by more than half. Omitting Nevada produces the next-largest declines. Both states have among the highest MSS shares in the sample and therefore carry substantial leverage. Omitting California produces the largest estimates for both outcomes. Because the full-sample diagnosis estimate is significant at the 10% level but not the 5% level, the figures show both 90% and 95% intervals. The 90% intervals correspond to the significance stars in the tables. The 90% interval for the diagnosis rate excludes zero for most exclusions, includes zero when Delaware or Nevada is omitted, and lies at or just

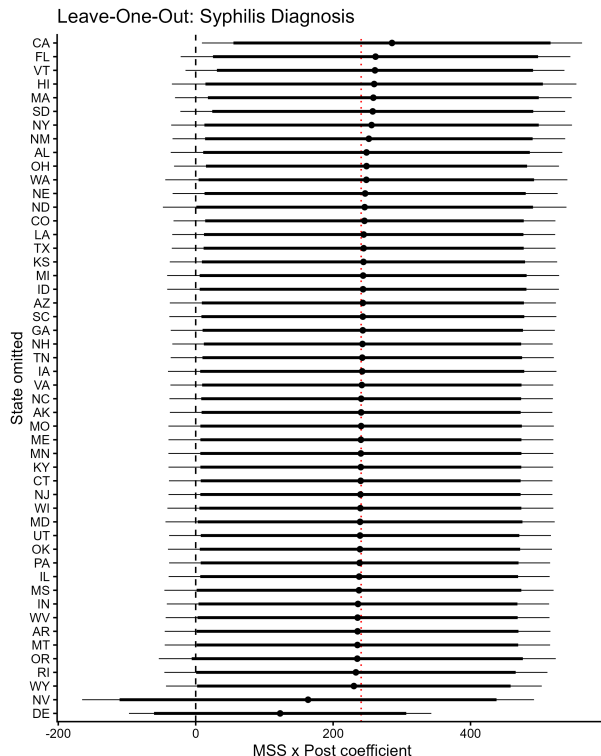


Figure 14: Leave-One-Out Estimates: Syphilis Diagnosis Rate

The diagnosis rate is the number of syphilis cases per 100,000 Medicaid beneficiaries aged 15 and older in the state, measured annually. A case is a test followed within 30 days by a syphilis diagnosis, counted at most once per beneficiary in any 90-day period. Each row reports the $\text{MSS} \times \text{Post}$ coefficient from the preferred specification with demographic controls, re-estimated after excluding the labeled state. Thick bars show 90% confidence intervals and thin lines show 95% confidence intervals, using critical values from a t distribution with $G - 1$ degrees of freedom. The dotted vertical line marks the full-sample estimate.

below zero for a few others, such as Oregon. The full-sample yield estimate with controls is not statistically significant, so most yield intervals include zero. Appendix A.3 repeats the exercise for the male subsample.

The testing-rate point estimates are also positive across all state exclusions. They range from their smallest value when Nevada is omitted to their largest when Florida is omitted. Every 95% confidence interval includes zero. This suggests that the imprecision of the testing estimates is not attributable to any single state. Overall, the leave-one-out exercise shows that the sign of the diagnosis and yield effects does not depend on any single state, while also showing that their magnitude is sensitive to the inclusion of Delaware and Nevada.

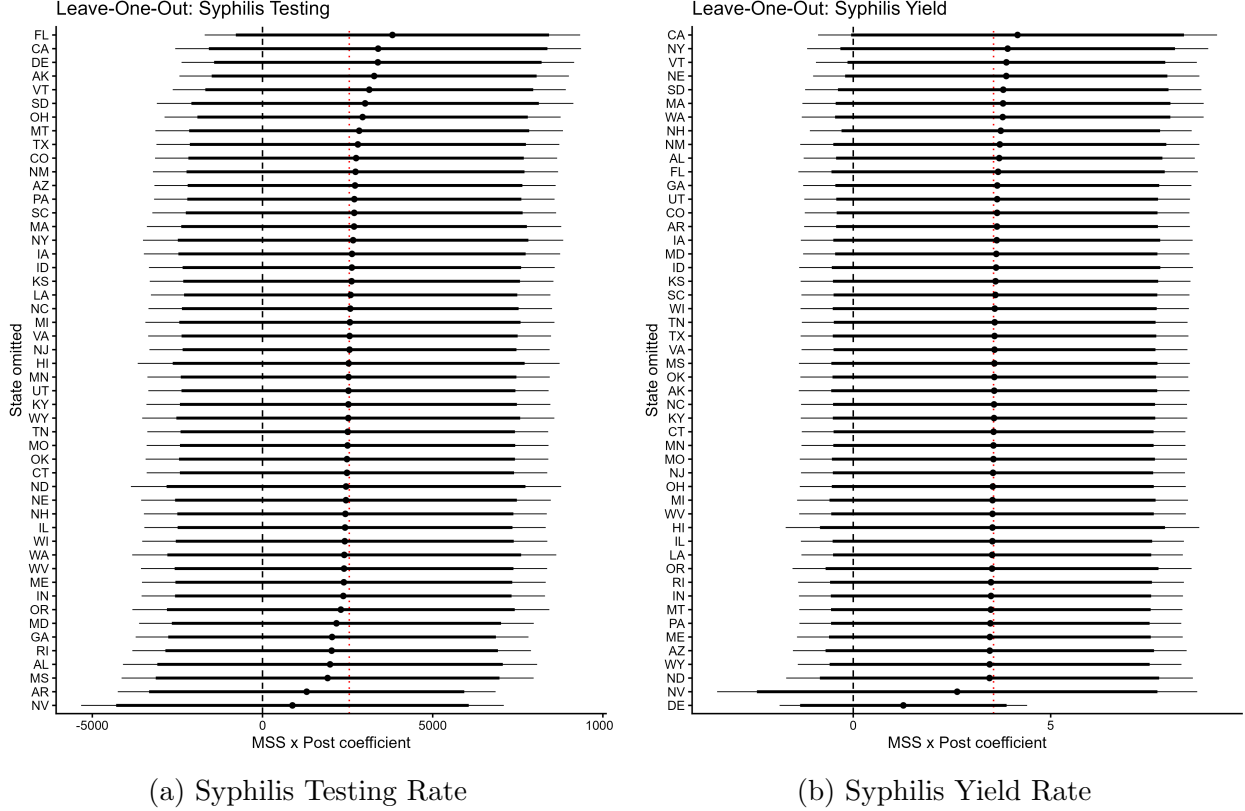


Figure 15: Leave-One-Out Estimates: Testing and Yield Rates

The testing rate is the number of syphilis test events per 100,000 Medicaid beneficiaries aged 15 and older in the state, measured annually. The yield rate is the number of syphilis cases divided by the total number of syphilis test events in the state, multiplied by 100, measured annually. A case is a test followed within 30 days by a syphilis diagnosis, counted at most once per beneficiary in any 90-day period. Each row reports the $MSS \times Post$ coefficient from the preferred specification with demographic controls, re-estimated after excluding the labeled state. Thick bars show 90% confidence intervals and thin lines show 95% confidence intervals, using critical values from a t distribution with $G - 1$ degrees of freedom. The dotted vertical line marks the full-sample estimate.

7 Conclusion

PrEP has transformed HIV prevention by substantially reducing the risk of acquiring HIV, but this may lead to risk compensation where individuals who are less afraid of getting HIV are more likely to engage in risk sexual behavior. Because PrEP does not prevent bacterial STIs an increase in risky behavior induced by PrEP may lead to increased syphilis spread. At the same time, PrEP users are recommended to undergo more frequent screening for syphilis meaning there could have been a coinciding increase in the detection previously undiagnosed syphilis. In this paper, I address that distinction by

I exploit cross-state variation in the pre-treatment share of cohabiting male same-sex couple households as a proxy for differential exposure to PrEP following its 2012 FDA approval. The quasi-first-stage results show that states with higher MSS experienced greater subsequent PrEP uptake, with a substantially stronger relationship among men. I then

estimate effects on the syphilis diagnosis rate, testing rate, and yield rate using a difference-in-differences framework with state and year fixed effects.

The results show increases in syphilis diagnoses in states with greater PrEP exposure. Greater PrEP exposure, measured as a one-standard-deviation higher MSS, raises the syphilis diagnosis rate by 66.2% relative to its 2011 baseline mean, an estimate significant at the 10% level in the preferred specification. The estimated effect on testing is small, about 5%, not statistically significant, and too small to account for the rise in diagnoses. The point estimate for the yield rate is a 52.9% increase, large but imprecise and not statistically significant in the preferred specification. Taken together, the estimates suggest that most of the rise in diagnosed syphilis reflects a higher share of positive tests rather than more testing, consistent with an increase in underlying incidence. At the same time, the imprecision of the yield estimate means that the analysis cannot determine precisely how much increased screening contributed to the observed increase in diagnoses.

Several additional results support this interpretation. The event-study estimates show no differential change between 2010 and 2011, and show diagnosis and yield effects emerging after 2014, in step with the delayed rise in PrEP uptake. The relationship between MSS and both PrEP uptake and syphilis diagnoses is substantially stronger among men, consistent with the concentration of PrEP use among men. The estimates are nearly unchanged after excluding states with incomplete claims observations, and leave-one-out specifications show that the positive diagnosis and yield point estimates do not depend on any single state, although their magnitude is sensitive to the inclusion of Delaware.

The analysis is limited to Medicaid beneficiaries, so the magnitude of these effects may differ in populations covered by private insurance or other sources of care. In addition, MSS is a proxy for differential PrEP exposure rather than a direct measure of access. Although the relationship between MSS and observed PrEP uptake supports its use in the empirical design. Future work using broader claims data could test whether similar patterns appear in other insured populations and further characterize how changes in preventive technologies affect both health behavior and the detection of related conditions.

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A Appendix

A.1 Balance of Controls

The identifying assumption requires that post-2012 changes in outcomes would not have differed with MSS in the absence of PrEP. Level differences in controls between high- and low-MSS states are absorbed by the state fixed effects, so the relevant balance check is whether MSS predicts post-2012 *changes* in the controls. Table 8 reports estimates from regressing each control on $\text{MSS} \times \text{Post}$ with state and year fixed effects, using the same sample and clustering as the main specifications. MSS does not predict post-2012 changes in most of the controls. The exceptions are the low-income Hispanic share, the shares aged 15–24 and 35–44, and Medicaid expansion. For a one-standard-deviation higher MSS, the

Hispanic share falls by 0.31 percentage points, about 9% of its mean of 3.39, and the two age shares each fall by less than 0.1 percentage points, about 2–3% of their means. A one-standard-deviation higher MSS is also associated with an 11.1 percentage-point higher probability that Medicaid expansion is in effect. Each of these variables is included as a control in the preferred specification.

	MSS $\times$ Post	(SE)	1-SD effect	Mean
Black non-Hispanic, below 130% FPL	0.537	(0.802)	0.047	3.21
White non-Hispanic, below 130% FPL	1.513	(0.934)	0.133	9.71
Hispanic, below 130% FPL	-3.577***	(0.870)	-0.314	3.39
Ages 15–24, below 130% FPL	-0.809**	(0.387)	-0.071	3.32
Ages 25–34, below 130% FPL	-0.281	(0.310)	-0.025	2.45
Ages 35–44, below 130% FPL	-0.656**	(0.323)	-0.058	1.97
Ages 45–64, below 130% FPL	-0.083	(0.380)	-0.007	3.56
Male share of population below 130% FPL	-0.396	(1.234)	-0.035	45.08
Medicaid expansion in effect	125.992**	(49.016)	11.063	45.29
Observations	647			
<i>Signif. Codes: ***: 0.01, **: 0.05, *: 0.1</i>				

Table 8: Balance of Controls: Effect of MSS $\times$ Post on Each Control

Each row reports the coefficient on MSS $\times$ Post from a separate regression of the listed control on MSS $\times$ Post with state and year fixed effects, with standard errors clustered at the state level. Controls are measured in percentage points: the demographic shares are percentages of the state’s total population from ACS 1-year PUMS, and Medicaid expansion is an indicator multiplied by 100. The 1-SD effect is the coefficient multiplied by the cross-state standard deviation of MSS (0.0878 percentage points). The mean is the sample mean of the control. The sample is the pooled analysis panel of state-years, 2010–2022, excluding DC.

A.2 Medicaid and All-Payer PrEP Rates

Because sexually transmitted infections are spread through communities and I argue that the male same-sex couple share is a measure of PrEP access, it is important to know how all-payer PrEP use compares to the PrEP use among Medicaid beneficiaries. To check this, I use all-payer PrEP rates from AIDSvu, which reports the number of PrEP users in each state-year using IQVIA prescription data (AIDSvu, 2026). Figure 16 compares PrEP rates among Medicaid beneficiaries with all-payer PrEP rates. Both series are unweighted averages across the 50 states. The two graphs show similar trends. PrEP use is near zero in 2012 and 2013, then it begins rising around 2014 and grows steadily through 2022. Men also account for the majority of PrEP users in both the Medicaid and all-payer data. The rate of PrEP use is higher in the all-payer data. This is unsurprising because others have documented that the majority of PrEP users are not covered by Medicaid (Huang et al., 2018).

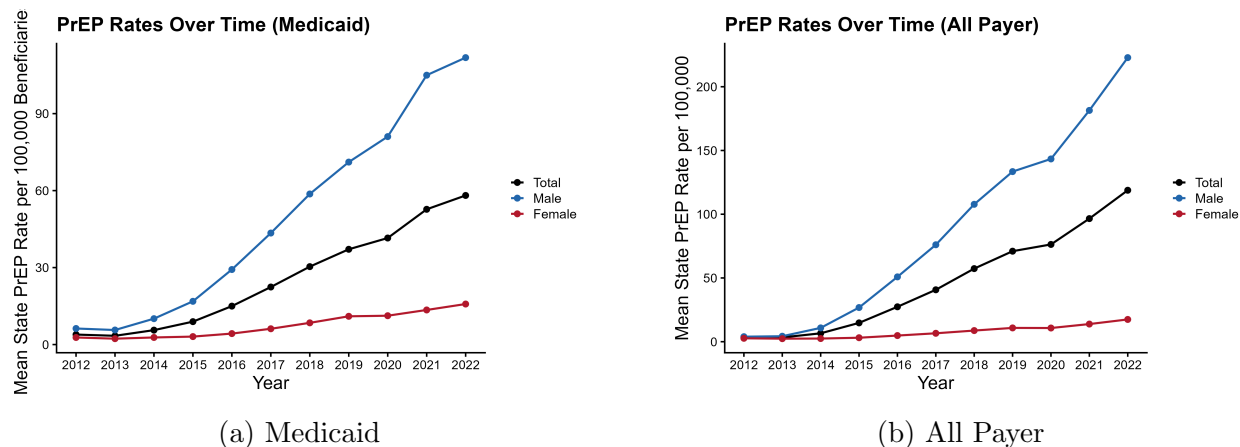


Figure 16: PrEP Rates Over Time: Medicaid vs. All Payer

Panel (a) shows the average across the 50 states of the Medicaid PrEP rate, defined as PrEP patients per 100,000 Medicaid beneficiaries aged 15 and older. Panel (b) shows the average across the 50 states of the all-payer PrEP rate from AIDSvu, defined as PrEP users per 100,000 residents aged 13 and older. AIDSvu identifies PrEP users from IQVIA prescription data, using an algorithm that excludes prescriptions for HIV treatment, chronic hepatitis B, and post-exposure prophylaxis, and adjusts for prescriptions not captured in the data. DC is excluded from both series.

A.3 Leave-One-Out Estimates, Male Beneficiaries

Figures 17 and 18 repeat the leave-one-out exercise in Section 6 for the male subsample, using the preferred specification with demographic controls. All 50 male diagnosis-rate estimates are positive. Excluding any single state other than Nevada or Delaware leaves the estimate between roughly 380 and 440 which is close to the full-sample estimate of 392.8. As in the pooled sample, omitting Nevada or Delaware produces the largest declines, to roughly 300 and 250. The 90% interval includes zero when Nevada is omitted, and the 95% interval includes zero when Delaware is omitted. The male testing and yield rate point estimates are also positive for every exclusion. The yield estimates are again smallest when Delaware or Nevada is omitted. Additionally, the testing and yield intervals generally include zero, as in the full male sample.

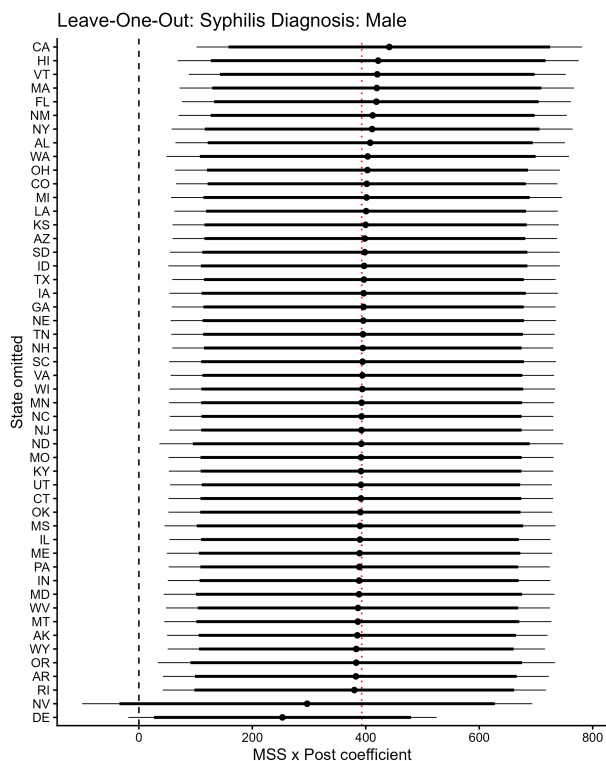


Figure 17: Leave-One-Out Estimates, Male: Syphilis Diagnosis Rate

The diagnosis rate is the number of syphilis cases per 100,000 Medicaid beneficiaries aged 15 and older in the state, measured annually. A case is a test followed within 30 days by a syphilis diagnosis, counted at most once per beneficiary in any 90-day period. Sample restricted to male beneficiaries. Each row reports the $MSS \times Post$ coefficient from the preferred specification with demographic controls, re-estimated after excluding the labeled state. Thick bars show 90% confidence intervals and thin lines show 95% confidence intervals, using critical values from a t distribution with $G - 1$ degrees of freedom. The dotted vertical line marks the full-sample estimate.

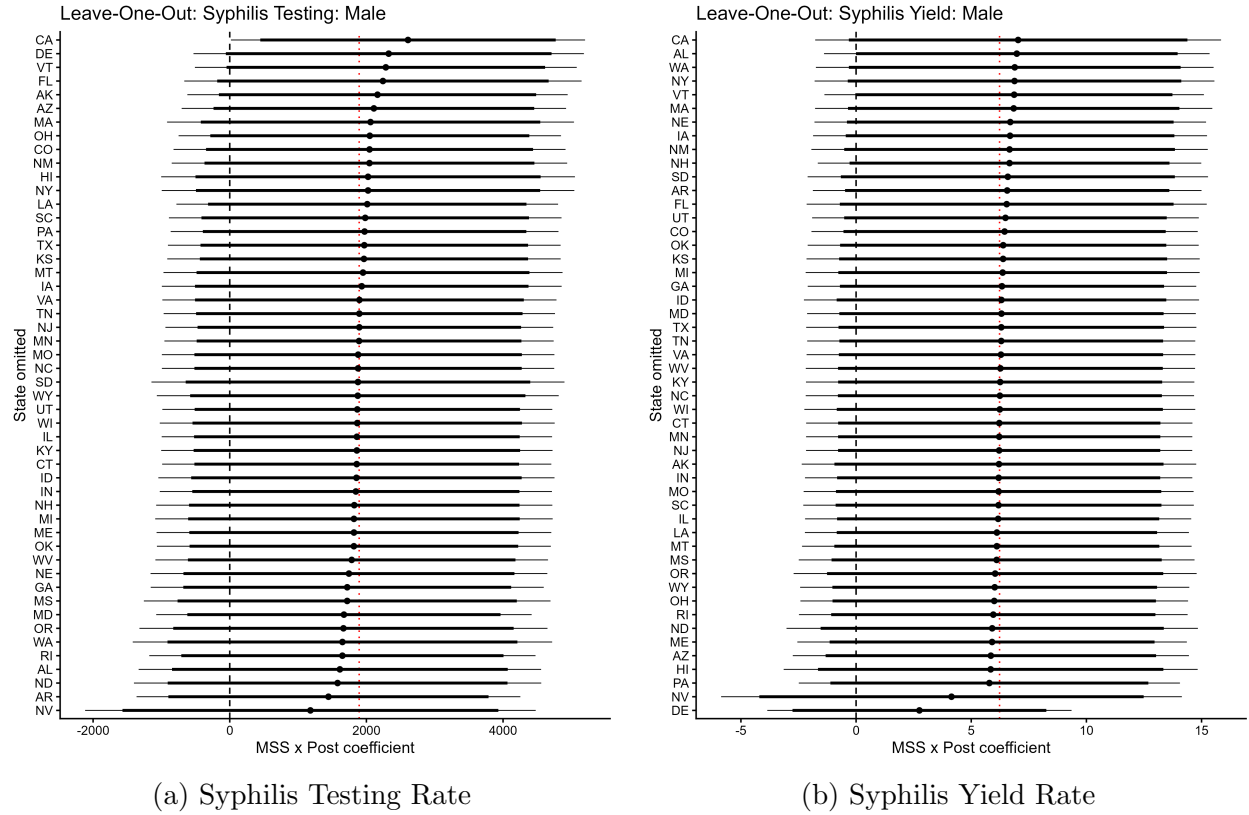


Figure 18: Leave-One-Out Estimates, Male: Testing and Yield Rates

The testing rate is the number of syphilis test events per 100,000 Medicaid beneficiaries aged 15 and older in the state, measured annually. The yield rate is the number of syphilis cases divided by the total number of syphilis test events in the state, multiplied by 100, measured annually. A case is a test followed within 30 days by a syphilis diagnosis, counted at most once per beneficiary in any 90-day period. Sample restricted to male beneficiaries. Each row reports the $MSS \times Post$ coefficient from the preferred specification with demographic controls, re-estimated after excluding the labeled state. Thick bars show 90% confidence intervals and thin lines show 95% confidence intervals, using critical values from a t distribution with $G - 1$ degrees of freedom. The dotted vertical line marks the full-sample estimate.