Restrictive Syringe Access Laws and their Effects on HIV Rates

Undergraduate Research Thesis

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by

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Abstract

To prevent the spread of HIV among people who inject drugs, governments may implement Syringe Exchange Programs (SEPs/SSPs) that provide sterile syringes to reduce the prevalence of high-risk injection behaviors. In the United States, there is a patchwork of varying state laws that govern the operation of SEPs. Using a difference-in-difference analytical framework, I estimate the causal effect of changes in state-level legal frameworks governing syringe access on county-level new HIV case rates. This analysis includes laws that allow SEPs to operate or restrict their operations. I further investigate how the legal frameworks affect HIV rates in small and large counties. The results show that allowing for SEP operation at the state level is associated with a decrease in the reported county-level HIV rate. In those counties that allow for SEPs, increasing the restrictiveness of the laws governing how they can operate appears to also lower the reported HIV rate; however, this result is complicated by extending this investigation specifically to counties containing SEPs. Finally, the reduction in HIV rates associated with law changes that allow for SEPs to open appear to be exclusively concentrated in counties with populations below the national median. Public policy changes that influence how people who use drugs access sterile syringes can influence HIV outcomes.

Introduction

Human Immunodeficiency Virus (HIV) is a communicable disease that remains a relevant public health concern in the United States (US) with over 1.2 million people living with the virus and approximately 35,000 new infections in 2019 (HIV.gov, 2021). Since HIV can be spread by contact with infected blood, people who inject drugs are especially susceptible when engaging in high-risk injection behaviors, such as syringe sharing or reuse. In the US, approximately 10% of new HIV diagnoses are among people who inject drugs and sharing syringes is the second-riskiest behavior for acquiring HIV (CDC, 2022). Given the vulnerability of injection drug users to HIV, public policies and programs that aim to reduce the prevalence of high-risk injection behaviors could reduce HIV rates. Syringe Exchange Programs (SEPs/SSPs) are an example of one such policy.

Syringe exchange programs provide people who inject drugs with sterile syringes, often in exchange for the return of used syringes, which are then safely discarded. The USA contains over 250 SEPs, with most run by local governments or nonprofit organizations (NASEN, 2021). Public health research has supported the efficacy of these programs at reducing HIV spread; yet several states continue to prohibit them. Across the country, there is a patchwork of varying state laws that govern the operation of syringe exchange programs, with some states allowing relatively unfettered operation of the programs, and others banning their operation. Despite this, the broad implications of these differing legal frameworks on HIV rates are largely unknown. In this thesis, I address this gap in the literature by estimating the causal impact of the legal framework governing SEP existence and operation on county-level HIV rates.

Syringe access laws are dynamic and have changed in many states between 2012 and 2019. Since 2012, 17 states have implemented laws allowing the operation of syringe exchanges,

27 have removed restrictive syringe access laws, and 6 have introduced more restrictive policies (Fernández-Viña, 2020). This inquiry aims to initially investigate the effect on county-level HIV rates of state laws that allow for the operation of SEPs. Using a difference-in-difference analytical framework that controls for time-invariant differences in HIV rates across states, as well as national trends in HIV rates, I estimate the causal effect of changes in state-level legal frameworks governing syringe access on county-level new HIV case rates. Then, among the states that do allow for SEPs, I further analyze the effects of laws that restrict how an SEP can be implemented on HIV rates. Finally, I explore how the SEP legal framework affects HIV rates in large and small counties.

The results of the analysis show that allowing for SEP operation at the state level is associated with a decrease in the reported county-level HIV rate. In those counties that allow for SEPs, increasing the restrictiveness of the laws governing how they can operate appears to also lower the reported HIV rate; however, this result is complicated by extending this investigation specifically to counties containing SEPs. Finally, the reduction in HIV rates associated with law changes that allow for SEPs to open appear to be exclusively concentrated in counties with populations below the national median.

Literature Review

SEPs have become widespread across the United States as a tool to prevent the spread of HIV. The current public health and public policy literatures have investigated these programs using multiple methodologies and the results have broadly supported their efficacy at preventing HIV spread. A nationwide analysis of HIV rates in counties that opened SEPs compared to

counties that did not, found that the introduction of an SEP is associated with a reduction in the HIV rate and that effect grows over time (Packham, 2019).

On a behavioral level, the openings of SEPs are associated with significant changes in drug injecting behaviors that are known to spread disease, such as sharing or reusing syringes. In a comprehensive analysis of the drug injecting behaviors of people arrested in 24 large cities, researchers found that the presence of a SEP in a city is associated with a 20% decrease in needle sharing and a 13% reduction in overall drug injecting (DeSimone, 2005). Similarly, closing SEPs and making syringe access more restrictive, as was done in Kanawha County, West Virginia, is associated with increased engagement in high-risk behaviors (Allen et al., 2019). This confirms Packham's (2019) broader analysis as these behavioral changes on a mass scale could affect county-level HIV rates.

While the studies reviewed above illustrate that the existence of an SEP is associated with safer injecting behaviors and lower HIV rates, there is no existing large-scale evidence about the best legal framework for syringe access to lower HIV rates. Several small-scale studies show that enforcement of drug paraphernalia laws can influence the behaviors of people who inject drugs and subsequently, the utilization of SEPs. An investigation with a qualitative research design found that those who live in regions with stricter drug paraphernalia laws were more likely to report syringe sharing or reuse (Koester, 1994). Another small qualitative research study found that 35% of intravenous drug users shared concerns about drug paraphernalia law enforcement for the possession of syringes and these participants were subsequently more likely to report sharing syringes (Blumenthal et al., 1999). A quantitative study comparing the behaviors of people who inject drugs in three major cities found that legal prohibition of SEPs was associated with more dangerous injection practices (Nassau et al., 2020). Additionally, a comparison of the

injection behaviors in two nearby jurisdictions in the United States with differing laws found an increased likelihood of high-risk behaviors in Newark, New Jersey, which legally prohibited SEPs, than in New York City where they were allowed (Neaigus, 2008). While these small-scale studies suggest that legal frameworks may affect HIV rates, they do not use causal research designs. The correlations exhibited in them may therefore reflect pre-existing differences between drug users living in jurisdictions with differing legal environments.

Small-scale studies have also demonstrated that laws affect how and whether SEPs operate. An analysis of a California law requiring local approval of SEPs found that there was an increased number of programs in operation following passage; however, this increase was primarily attributable to counties that chose to authorize it and did not result in any openings in high-need counties (Bluthenthal et al., 2008). Those who operate SEPs also express concerns over restrictive laws. Interviews from those running 23 programs found broad agreement that laws prohibiting SEPs are the primary obstacles to opening a program while other restrictive laws, such as the requirement for local authorization, make operation more difficult (Jones, 2019). Given the known efficacy of SEPs in HIV prevention, this would suggest that more restrictive laws governing syringe access at the state-level can have detrimental effects on HIV outcomes. Repeatedly, the literature has demonstrated that legal restrictions to syringe access has effects on the operation of an SEP and the behaviors of injection drug users; however, there is not clear data to suggest the effects of these laws on HIV rates on a broader scale. The present study addresses this gap in the literature by estimating the relationship between state-level legal frameworks governing SEP operation and HIV rates across all US counties.

Further, while the existing studies discussed above demonstrate an association between the operation of SEPs and HIV rates, their methods have a potential drawback if the existence of

an SEP in a community is related to HIV rates through noncausal pathways. For instance, if SEPs are better able to operate in communities with other supports for HIV prevention, then the association between SEPs and HIV rates may be driven by these other factors rather than by the existence of the SEPs themselves. Similarly, the estimates described above may be biased if there are pre-existing differences in injecting behaviors between drug users living in jurisdictions with differing legal environments governing SEPs. The present study therefore adds to the existing evidence on this question by using policy-induced state-level variation in the legal framework governing SEP operation. Policy variation in the legal framework governing SEPs is an important determinant of program operation in a county; however, such policy-variation is relatively less likely to be a driver of county-level HIV rates through other channels. In this respect, the "natural experiment" presented by changing state-level laws offers a good opportunity to study the causal effect of SEPs on HIV rates.

Methods

Data

This study uses three primary data sources. First, data on county-level HIV rates were obtained from the "AtlasPlus" database available from the Centers for Disease Control and Prevention. This database summarizes data available from HIV surveillance reports generated annually by the CDC (CDC, 2022). These data document new HIV cases in a given year from 2012-2019 in all US counties. The use of new HIV infections, rather than a sum of all existing infections in a county, allows for a more accurate picture of the effects a particular law change

has on the spread of HIV. From these data, I obtain my primary outcome variable – new HIV cases per 100,000 people in each county and year.

To protect the confidentiality of people who test positive for HIV, especially in smaller counties, the CDC HIV data is censored. In particular, if a county has between 1 and 4 new HIV cases in a year, or if the county's total populations is less than 100, HIV case data are censored for that county-year. About 34% of the county-year HIV rates are censored. For these censored counties, I assume that there were three new cases of HIV in that year and calculate a rate per 100,000. Three was chosen because it would be close to the average number of cases in a large dataset if a random value between one and four was assigned. This does reduce the variability in the outcome variable, which should cause me to underestimate the effect of the policy change. Furthermore, I omitted observations in the top 1% of HIV rates to remove outliers that may influence the data, which are primarily driven by large outbreaks in small counties.

Figures 1 and 2 show descriptive time and geographic trends in county HIV rates. As shown in Figure 1, from 2012 to 2019 the average HIV rate across all county-year observations did not change drastically. While there was a mild spike leading into 2016, there was a decline back to near-2012 levels by 2018 and an even further reduction in 2019. However, the range on the mean county HIV rates, a value of approximately 0.8 cases per 100,000 people, is not very large. Figure 2 demonstrates the geographic variation of changes in the HIV rate from 2012 to 2019. There does appear to be some clustering in the South and the West, especially in Arizona and California. However, it appears that in many places the HIV rates did not change during this period and only declined in a small number of counties.

Information on the state-level legal frameworks around the US from 2012-2019 were obtained from two legal databases available from LawAtlas. These data provided information on

state laws that govern syringe access and SEPs, and the years when laws change. The first database includes information on years 2012-2017 (Burris, 2017) while the second database only has information from August 2019 (Policy Surveillance Program Staff, 2019). This leaves a gap in my policy timeseries. To address this, I only investigated laws that were present in both databases and these laws are described below. The data in these databases were downloaded and coded in a binary manner, where the presence of a certain law was coded one and the absence of it was coded zero. Many laws change mid-year. Thus, to assign each policy change to a treatment year, I use the following rule: If a law changed in January through June of year *t,* I assign the change to year *t*; if the policy change occurred in July or later of year *t*, I assign the policy change to year *t+1*. This was done as it would likely take some time for the law to be implemented and internalized by SEPs and affect HIV rates.

Unfortunately, since each year only has one set of laws assigned to it for a given state, if a state underwent several law changes in one year, which occurred in a small number of instances, laws that were only in place for less than six months in the middle of a year were not included; instead, the previous law or subsequent legal framework was utilized. The law data is additionally limited in that data for Ohio from 2012-2015 was not available, resulting in the omission of several datapoints.

I construct two primary treatment variables from the law data. The first is a binary indicator of whether or not a state allowed SEPs to operate. The second variable captures the restrictiveness of the laws governing how an SEP could operate. This was done by creating a "restrictiveness index" which captures restrictions from a variety of different laws to measure the cumulative restrictiveness of the legal framework. As mentioned previously, all laws were coded

in a binary fashion. Therefore, if a state had a restrictive law, it was coded one and if it did not it was coded zero.

The restrictions included in the index include whether local authorization is required for an SEP to open; whether there are exceptions to the drug paraphernalia law for syringes; whether information is required to access syringes; and whether one-for-one exchange is required, meaning an SEP participant only receives the number of sterile syringes equal to the number they return. The exceptions to the drug paraphernalia law for syringes include exceptions for syringes obtained at a pharmacy, obtained at an SEP, obtained for a medical reason, and for syringes obtained below a certain number. The value for this was therefore a sum of all the exception restrictions, where a value of five means there are no exceptions, one means there is a drug paraphernalia law but all four of those exceptions are included, and zero means there is no drug paraphernalia law. The information that may be required include name, address, age, and purpose for acquiring syringes. If no information is required, this was coded zero and if all that information was required or there is no retail sale of syringes allowed at all, this was coded four. Furthermore, for restrictions governing the operation of SEPs, if there are no requirements for local authorization or one-for-one exchange, this was coded zero; if both were required this would be coded two, and if SEPs are not allowed at all this was coded three. The cumulative restrictiveness index was generated as a sum of all binary variables capturing these laws and takes on values between two (least restrictive) and eleven (most restrictive).

Figure 3 describes how the laws change over time. From 2012 to 2019, state laws are generally becoming less restrictive. Individual states may have legal changes that increase restrictiveness during this time, but the overall trend points to less restrictive legal frameworks around the US. This trend appears to be driven by a significant increase in the proportion of

states that allow for syringe exchange. From 2012 to 2019, the proportion of states allowing exchanges rises from approximately 30% to 60%. This helps to explain why the average restrictiveness index falls from approximately 7 to 5.5 during that same time.

The third dataset used in the present study is a list of active US SEPs in 2021, obtained from the North American Syringe Exchange Network (NASEN, 2021). This includes the name of the SEP and the city in which it operates. Unfortunately, this dataset does not have information on the years in which an SEP opened and only contains SEPs that reported their existence to NASEN. Lacking opening date information limits my ability to do an effective difference-in-difference design with accurate groups of counties that contain a syringe exchange program in a given year. Furthermore, this data is limited in that there may be active underground SEPs not included in NASEN's database.

In addition to the three primary data sources used above, I also use county-level annual population gathered from the National Cancer Institute Surveillance, Epidemiology, and End Results Program, and county-level annual unemployment data gathered from the Bureau of Labor Statistics Local Area Unemployment Statistics Program. Table 1 displays means. The average HIV rate among counties that allow SSPs is higher than in those that do not. A much higher proportion of counties that allow SSPs have an operational program in 2021; however, there is still a significant number of counties where an SSP is operational in 2021 despite their illegality in 2012-2019.

Approach

Packham (2019) explored the effects that opening syringe exchanges have on HIV rates across the country using a difference-in-difference framework to compare counties with an SEP

opening to those without. This design controlled for time-invariant differences in the HIV rate across counties and incorporated year fixed effects to control for factors that may influence the HIV rate that are relevant to all counties in a specific year. Like Packham (2019), I employ a difference-in-difference (DD) design that controls for time-invariant differences in HIV rates across states, as well as national trends in HIV rates, to estimate the causal effect of changes in state-level legal frameworks governing syringe access on county-level new HIV case rates. The logic behind the DD design is that I utilize existing policy variation between the state legal frameworks to create "treatment" and "control" groups, in which the treatment groups include all county-year observations in which a particular law or set of laws are in effect and the control group includes county-year observations where the law is not in effect. This allows for an analysis of the differential effect of the law on the treatment group relative to the control group. Under the assumption that no other factors changed simultaneously with the laws changing, this approach produces an unbiased estimate of the causal treatment effect of the law. To implement, the DD, I estimate the following equation:

Equation 1

$$HIVRate_{yc} = \beta_1 SEPAllowed_{ys} + \lambda_y + \alpha_c + X_{cy}'\beta + \varepsilon_{yc}$$

Equation 1 estimates the effect that changing a state law to allow for SEP operation has on the county-level annual HIV rate. The regression was estimated using Equation 1 above in which $HIVRate_{yc}$ is the HIV rate in county *c* in year *y*, $SEPAllowed_{ys}$ is an indicator variable for whether the law allows for SEPs to operate in a state *s* during *y*, λ_y are year fixed effects to control for shocks to the HIV rate occurring in all counties in a particular year, α_c are county fixed effects to control for time-invariant differences across counties, X_{cy} includes time-varying

controls including the unemployment rate and county population size, and ε_{yc} represents the error term. I estimate Equation 1 both with and without controls for county population size and the unemployment rates to investigate the robustness of the findings. I cluster all standard errors at the state level.

To compliment the DD analysis described above, I also estimate event study regressions that break the overall treatment effect of the laws into annual effects. This was done by creating a standardized Event Time variable, where "year 0" reflects the year that an SEP law changes for each county, and then counting the years before and after the law change. I then estimate a version of Equation 1, where the *SEPAllowed* variable is replaced by a series of indicators for each event time period. I estimate coefficients on each event time indicator and plot the results in event study figures, shown in Figures 4, 5, and 6, to explore both the trajectory of treatment effects after law changes, and also to test for pre-trends in HIV rates in states that do and do not change their legal frameworks.

Equation 2

$$HIVRate_{yc} = \beta_2 RestrictLaw_{ys} + \lambda_y + \alpha_c + X_{cy}'\beta + \varepsilon_{yc}$$

In a second analysis, the restrictiveness index was used to determine the causal effect of raising the restrictiveness of a state legal framework governing syringe access and exchange on HIV rates. This was estimated using Equation 2 in which most of the variables resemble Equation 1; however, the index variable, $RestrictLaw_{ys}$ represents the restrictiveness index in a state in a given policy year. I estimate Equation 2 conditional on a state allowing SEPs, meaning that I only include in the sample county-year observations where SEPs were allowed.

Equation 3

$$HIVRate_{yc} = \beta_2 RestrictLaw_{ys} + \beta_3 RestrictLaw_{ys} * SEPPresent_c + \lambda_y + \alpha_c + X_{cy}'\beta + \varepsilon_{yc}$$

The analysis was furthered by investigating whether there was an additional effect of the legal restrictiveness on HIV rates in counties that contained a syringe exchange program compared to those that did not. To the extent that other legal restrictions affect the operation of SEPs, I hypothesized that their effect should be larger in counties with SEPs than in those without. This was estimated using Equation 3, which adds a $RestrictLaw_{ys} * SEPPresent_c$ term representing the interaction between the restrictiveness of the state law and whether there is an active SEP in the county. However, as mentioned previously, since opening dates are not available for SEPs, this analysis is somewhat limited, but it still provides some insights into how the legal landscape may be affecting SEP services, and in-turn, HIV rates.

Finally, I estimate Equations 1 and 2 on the samples of small and large counties. I define large counties as those where the population size was larger than the median county population, while small counties had populations less than that median. It is possible that the legal frameworks governing SEPs have differential effects in larger and smaller counties. For instance, larger counties are more likely to have underground SEPs in operation even when they are illegal, meaning that a change in the legal framework would be less effective than in smaller counties.

Results

Main Regression Results

The results of the regressions are summarized in Tables 2, 3, and 4. In Table 2, I show the results of estimating Equation 1 on the data. The estimate in Column (1) of Table 2 suggests that changing the state law such that SSPs become allowed is associated with an average reduction of approximately 0.86 HIV cases per 100,000 people in a county. On a base HIV rate in the sample of approximately 8.12 cases per 100,000 people, the law change results in a 10% average reduction to approximately 7.26 cases per 100,000 people. After including controls for county population and the unemployment rate, a general economic indicator, the estimated effect decreases slightly in magnitude (0.781 cases per 100,000) but remains statistically significant at the 10 percent level (results in Column (2)). This demonstrates the robustness of the regression results, suggesting that the law changes are not correlated with other county-level characteristics that may bias the results.

In Table 3, I show the results of estimating Equations 2 and 3 on the sample of county-years where SSPs are legally allowed. Among this conditional sample, I estimate that increasing the restrictiveness index by a value of one is associated with a 0.58 reduction in HIV cases per 100,000 in a county – an approximately 9% reduction in the HIV rate. This means that increasing the restrictiveness index by a value of 1 could decrease the HIV rate in a county that allows SSPs from the sample mean of 6.76 to 6.18 cases per 100,000 people. When including county population and unemployment rate controls, the estimated effect size increases, but remains around 9%, indicating robustness of these results. In Columns (3) and (4) of Table 3, I show results of estimating the DD interaction model, testing for differential effects of law restrictions in counties with and without SSPs in 2021. In both models, with and without covariates, I

estimate similar main effects of the restrictiveness index; however, I do not find a statistically different effect of the laws in counties with an operational SSP in 2021 (although the estimated effect is negative).

Event Study Results

In order for DD estimates to capture causal policy effects, the parallel trends assumption must hold. This means that there is no pre-trend in the data and that in the absence of the law change, there would be no conditional difference between the treatment and control group outcomes. Estimating event studies allows for a test of the parallel trends assumption. In Figure 4, I demonstrate that the parallel trend assumption is satisfied. It shows that in the years leading up to a state legal change, there is no differential trend in HIV rates in counites affected by the change relative to counties unaffected by a change. Furthermore, in Figure 4, the general effect of changing the law to allow for SEPs to open has a clear reduction in the HIV rate within two years of this law change. However, there is a fade out of this effect over time so that by year five, there is an HIV rate that is approximately similar to what it was in year zero – the year of the law change.

Results by County Population: Large vs. Small Counties.

The results in Table 4 and Figures 5 and 6 demonstrate how changing the legal framework governing SSPs affects HIV rates in large versus small counties. This is shown in the regression estimates shown in Table 4, in which Equation 1 was estimated on two conditional samples: one including only counties with populations below the median, and the other including counties with populations above the median. In large counties, there is no statistically significant effect observed of changing the state law to allow for SSPs; however, in small counties the

results reveal a statistically significant reduction of 1.2 HIV cases per 100,000 people after SSPs become legal at the state level. With an average sample HIV rate of 7.47 cases per 100,000, this policy change results in an average reduction of approximately 16% in the HIV rate in small counties, to 6.27 cases per 100,000 people.

Figures 5 and 6 shows the same results using the event study framework. Figure 5 shows that changing the law to allow for SSPs is not significantly related to trends in county-level HIV rates in large counties. However, the law changes are associated with a significant and persistent decrease in the HIV rate in small counties. This decrease appears in the first full year after a law change (year 0 in event time). It also appears that HIV rates eventually increase in large counties where states have changed the legal framework to allow for SSPs. This increase explains the apparent fadeout of the overall effect reflected in Figure 4 and may not necessarily be related to the law changes.

Discussion

Public policy changes that influence how people who use drugs access sterile syringes can influence HIV outcomes. It appears that changing state laws to allow for the operation of SEPs is an impactful policy change that can lower the spread of HIV. There remain several states that do not permit the operation of these programs. The results of this study show that allowing SSPs could lower county HIV rates by as much as 10%. The event study analysis appears to satisfy the parallel trends assumption as there does not appear to be a pre-trend in HIV rates prior to the law changes. This strengthens the finding of an association between the event of the law change and the subsequent decrease in the average HIV rate.

However, the analysis of the effects of restrictive laws on HIV rates in counties that already allow syringe exchange illustrates a more complicated relationship. Contrary to the initial hypothesis that more restrictive laws would increase the spread of HIV by limiting access to sterile syringes, the regression performed here seems to suggest the opposite, that once SSPs are allowed in a state, more restrictive laws governing their operation lower HIV rates. The restrictiveness is intended, in most instances, to restrict the activities of SSPs. Therefore, it is important to test whether there is an additional effect of restrictive laws in counties with an active SSP. Results of this analysis did not detect statistically significant differences in the effects of restrictive laws in counties with operational SSPs relative to counties without. However, given that the data used herein on SSP locations was collected in 2021 and therefore may not reflect the location of SSPs at the time of the law changes, results of this analysis should be interpreted with caution.

To further explore the protective effect of restrictive SSP laws, I conducted an auxiliary analysis estimating the effects of each individual law captured by the restrictiveness index. When doing so, the cumulative restrictiveness of laws that very directly govern how an SEP operates, including mandating one-for-one exchange and requiring local authorization, have no statistically significant effect on the HIV rate. By contrast, the laws concerning exceptions to the drug paraphernalia law, and to a much lesser extent, laws regulating the information that must be provided by a client to obtain syringes, do have statistically significant effects on the HIV rate. In fact, the removal of an exception to the drug paraphernalia law, such as an exception for the possession of a number of syringes below a specific quantity, appears to lower the HIV rate by approximately 2.43 cases per 100,000, an average reduction of around 36% from the mean HIV rate of 6.76. This would suggest that exceptions to the drug paraphernalia law are what drive the

general result observed with the restrictiveness index. Logically, one would think that providing more exceptions to the drug paraphernalia law would encourage people to obtain sterile syringes and engage in less high-risk behaviors due to a diminished fear of legal consequences. That hypothesis is not confirmed by this data and other factors may be at play here requiring further investigation.

There appears to be some conflicting conclusions between some investigations in the literature and the results from my analysis. Packham (2019) found that opening an SEP was associated with a reduction in the HIV rate and that this effect grew over time. This result contrasts what would be expected from my findings. While a reduction in the HIV rate is observed in Figure 4 after allowing for SEP operation at the state level, this result appears to diminish over time, not grow. This warranted an investigation into the differential effects of a law change allowing for SEPs to open on small and large counties and the results were informative. The differential influence on large and small counties seems to suggest that the reduction in HIV associated with changing the law to allow for SEPs is almost exclusively attributable to small counties. Therefore, changing the law in this manner could be very beneficial to small counties.

There are several reasons why this may be the case. Firstly, in a small proportion of counties that do not allow SEPs, an underground program exists illegally. This is more likely to occur in urban or politically progressive counties where prosecution for these actions is less likely. However, for small counties, this is not often politically feasible. Therefore, changing state laws to allow for SEPs can finally allow for syringe exchange in rural counties, while large counties may have been doing it regardless. Furthermore, existing studies suggest that underground programs may be more effective in preventing HIV spread. A comparison of two

SEPs in Vancouver, one run by the city and the other an unsanctioned program run by people who inject drugs, found significant differences between the participants accessing each program. The unsanctioned and grassroots program was reaching more people with the highest risk of HIV based on their use and injecting behaviors relative to the city-run exchange (Wood et al., 2003). If such underground programs are more likely in larger counties, then the sudden opening of sanctioned programs may be especially ineffective in large counties.

Another potential explanation is that large counties may be more likely to have robust HIV prevention infrastructure, including access to antiretrovirals, Pre-exposure prophylaxis (PrEP), HIV testing resources, and many other programs that can prevent the spread of HIV. Therefore, it is possible that allowing for SEPs to open would not have a significant impact on HIV compared to smaller counties that may lack many of these other resources.

The previously described limitations to the datasets represent some shortcomings with my analysis. An improved analysis could include the opening dates of the syringe exchange programs to truly see how the legal landscape affects the operation of SEPs in achieving their desired objectives during the years they are open. Furthermore, an investigation of the true number of underground SEPs and the counties they operate in could help confirm the hypothesis regarding why large counties are not affected by law changes allowing for SEP operation. Despite these limitations, the results of this study show the potential for state level legal frameworks to significantly affect HIV transmission.

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Tables and Figures

Table 1

Results of model relating county-level annual HIV rates to state level law allowing SSPs.

Column Number	1	2
	Allows SSPs	Does not allow SSPs
	Mean (SD)	Mean (SD)
HIV Rate	8.411 (11.650)	7.696 (9.644)
Restrictiveness Index	5.436 (1.705)	8.006 (1.249)
SSP Present	12.70%	4.30%
County Population	182,570 (507,940)	74,550 (232,850)
Unemployment Rate	5.17% (2.30)	5.7% (2.50)
N	6,353	18,150

Table 2

Equation 1 estimates for the effect of changing a state law to allow for SEP operation on county-level annual HIV rates

Column Number	1	2		
	SSP Allowed			
	without controls	with controls		
SSP Allowed	-0.858*	-0.781#		
	(0.403)	(0.406)		
F-Statistic	1.94#	2.87**		
N	24,503			
Sample	Full			
Mean HIV Rate	8.117			
Legend:	***= P<0.001	**= P<0.01	*= P<0.05	#= P<0.1

Table 3

Equation 2 and 3 estimates for the effect of raising the restrictiveness of a state legal framework governing syringe access and exchange on HIV rates

Column Number	1	2	3	4
	Restriction Index		Restriction Index *Existing SSP	
	without controls	with controls	without controls	with controls
Restriction Index	-0.581**	-0.603**	-0.526*	-0.548*
	(0.211)	(0.219)	(0.223)	(0.228)
Restriction Index * Existing SSP	-	-	-0.317	-0.314
	-	-	(0.313)	(0.312)
F-Statistic	2.83*	7.47***	2.58*	7.84***
N	6,353		6,353	
Sample	Conditional		Conditional	
Mean HIV Rate	6.759		6.760	
Legend:	***= P<0.001	**= P<0.01	*= P<0.05	#= P<0.1

Table 4

Equation 1 and 2 estimates for large and small counties

Column Number	1	2	3	4
	SSP Allowed		Restriction Index	
	large counties	small counties	large counties	small counties
SSP Allowed	-0.452	-1.200*	-	-
	(0.409)	(0.571)	-	-
Restriction Index	-	-	-0.489**	-0.959
	-	-	(0.192)	(0.757)
F-Statistic	1.86#	2.20**	6.98***	19.39***
N	12,250	12,253	4,137	2,216
Sample	Above median population	Below median population	Above median population	Below Median Population
Mean HIV Rate	8.980	7.472	8.222	6.713
Legend:	***= P<0.001	**= P<0.01	*= P<0.05	#= P<0.1

Figure 1

Mean county-level HIV rates over time across the entire sample

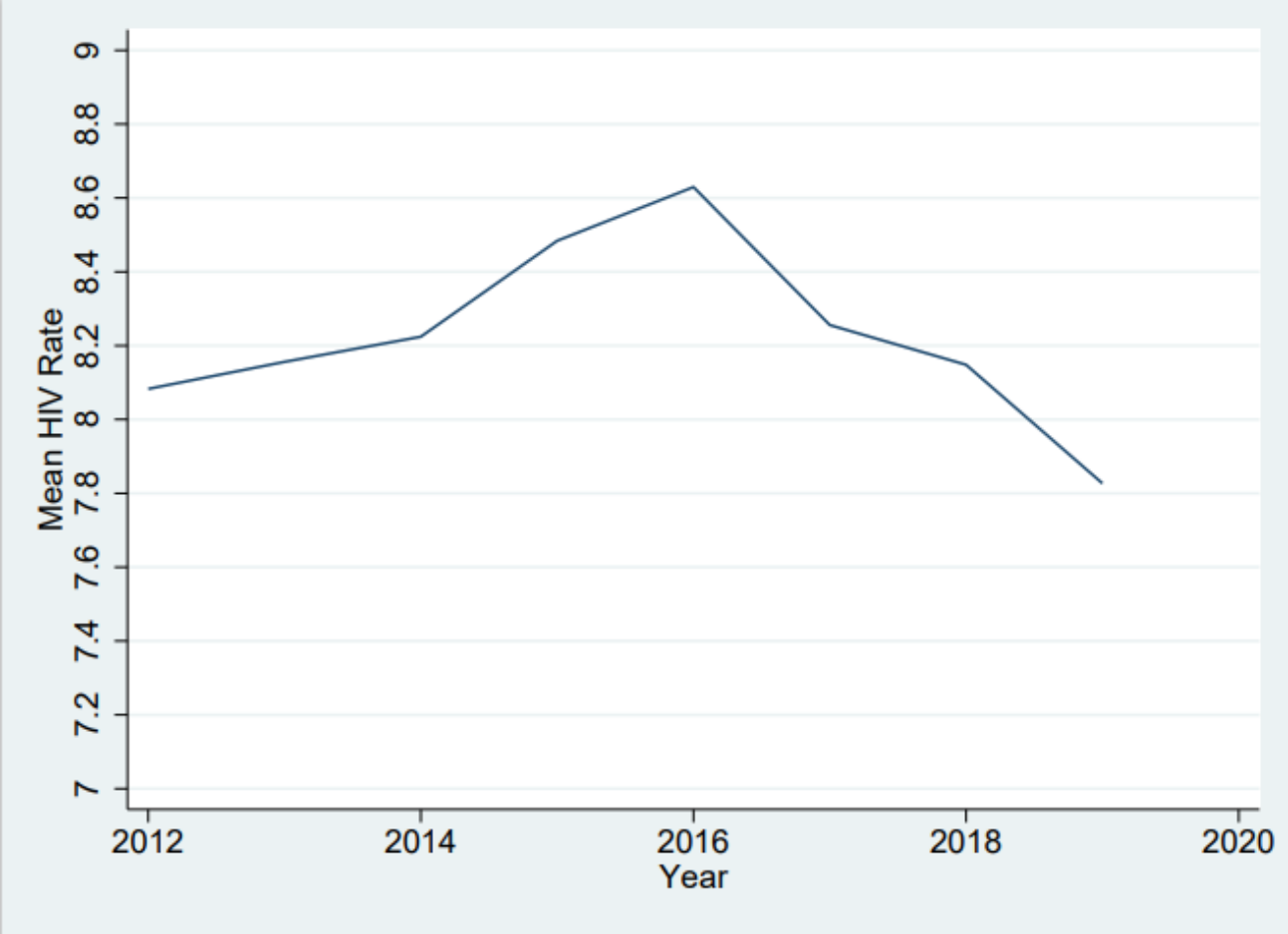

Figure 2,

Change in HIV Rate (2019-2012) by County

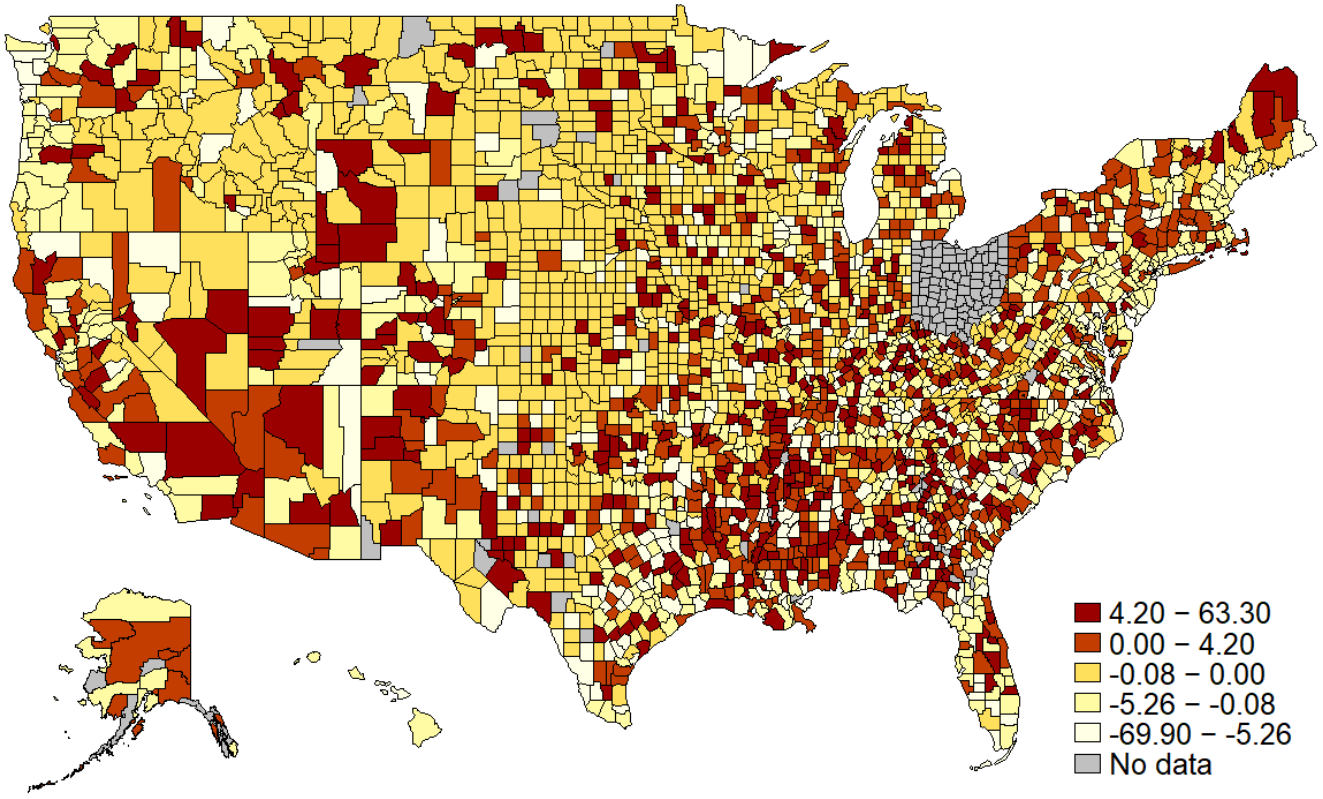

Figure 3

Change in the proportion of states allowing SEP operation and average restrictiveness of state legal frameworks from 2012-2019

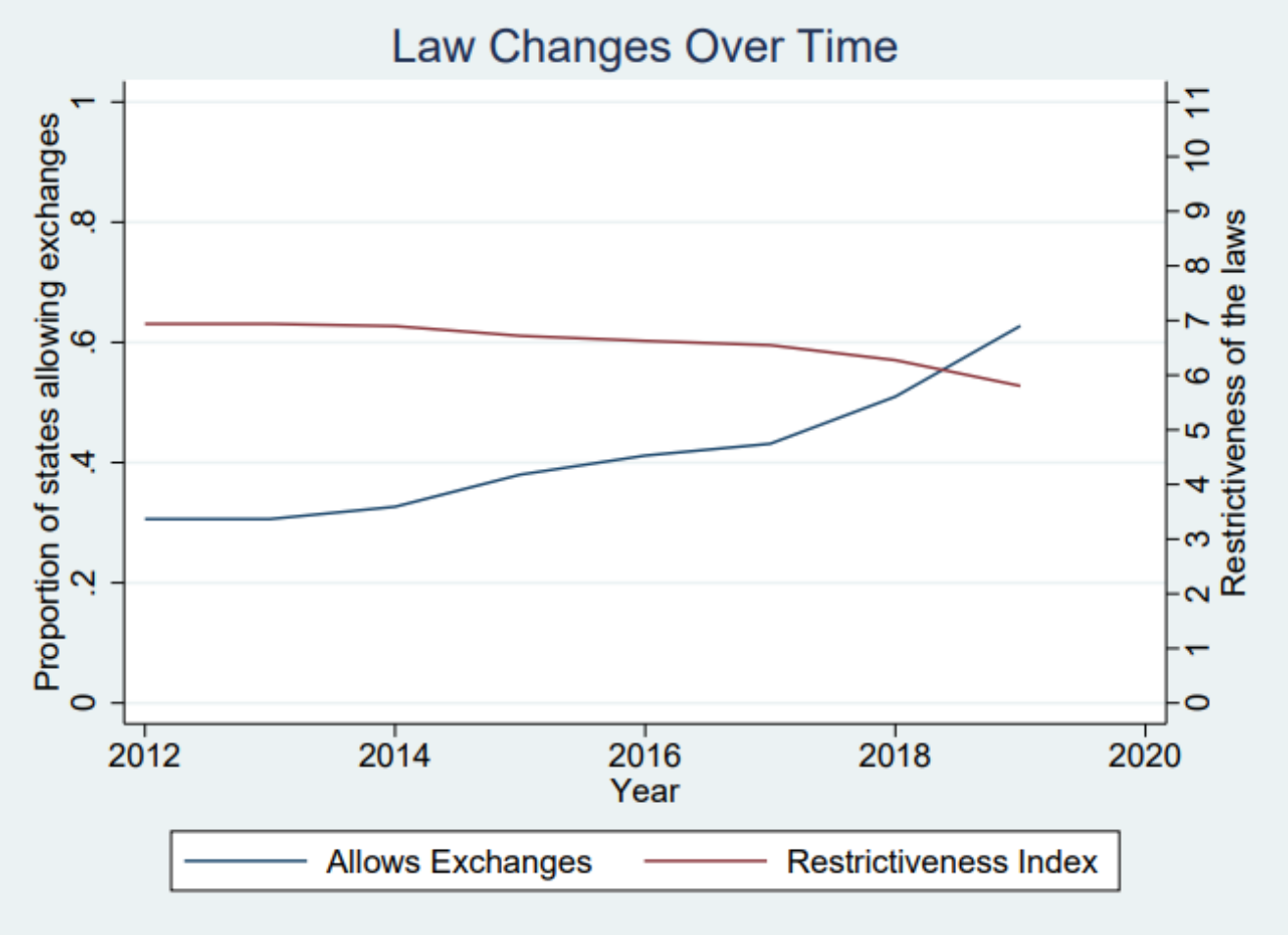

Figure 4

Change in county-level HIV rates after allowing SEP operation at the state level

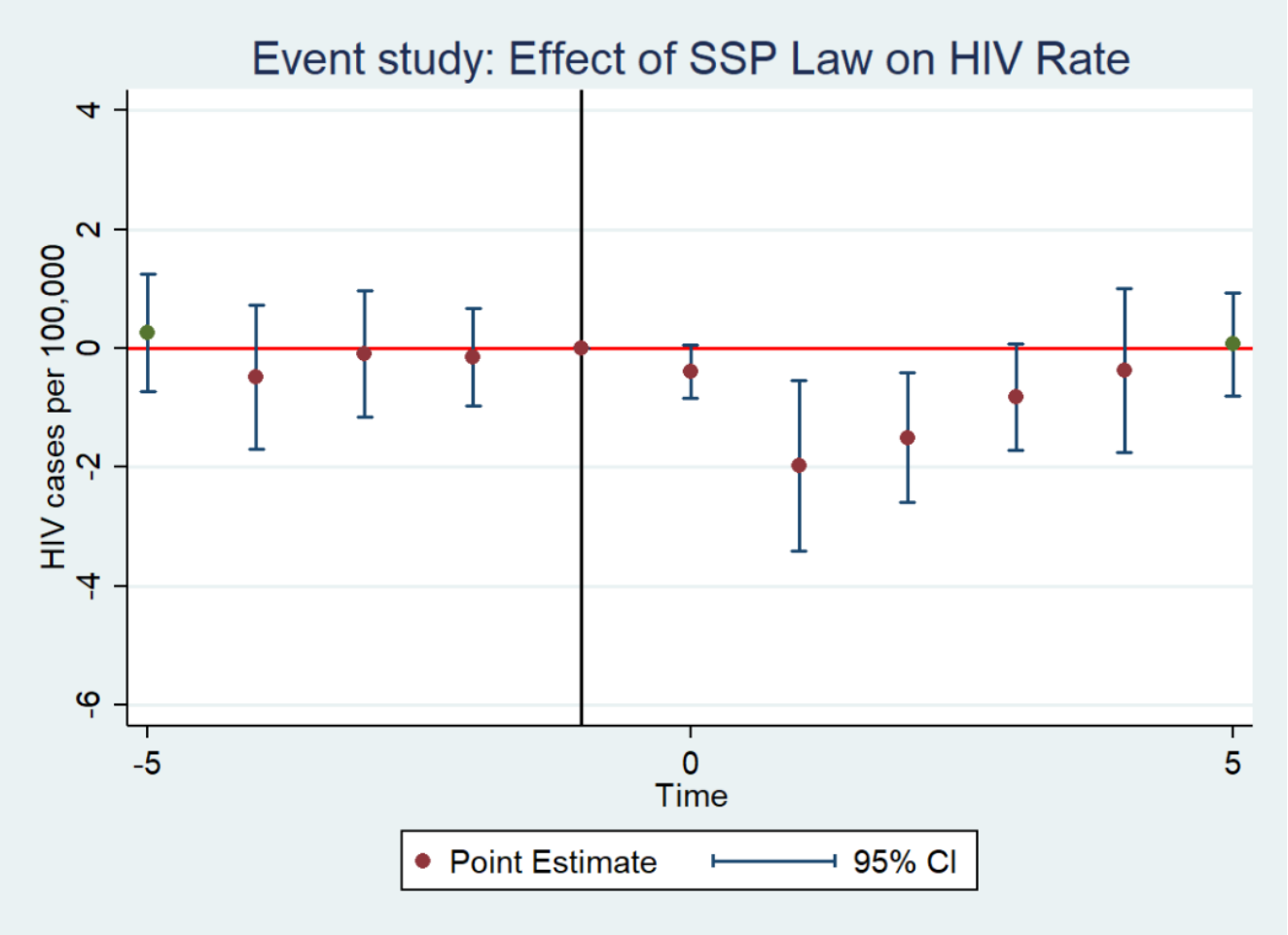

Figure 5

Change in county-level HIV rates after allowing SEP operation at the state level in large counties

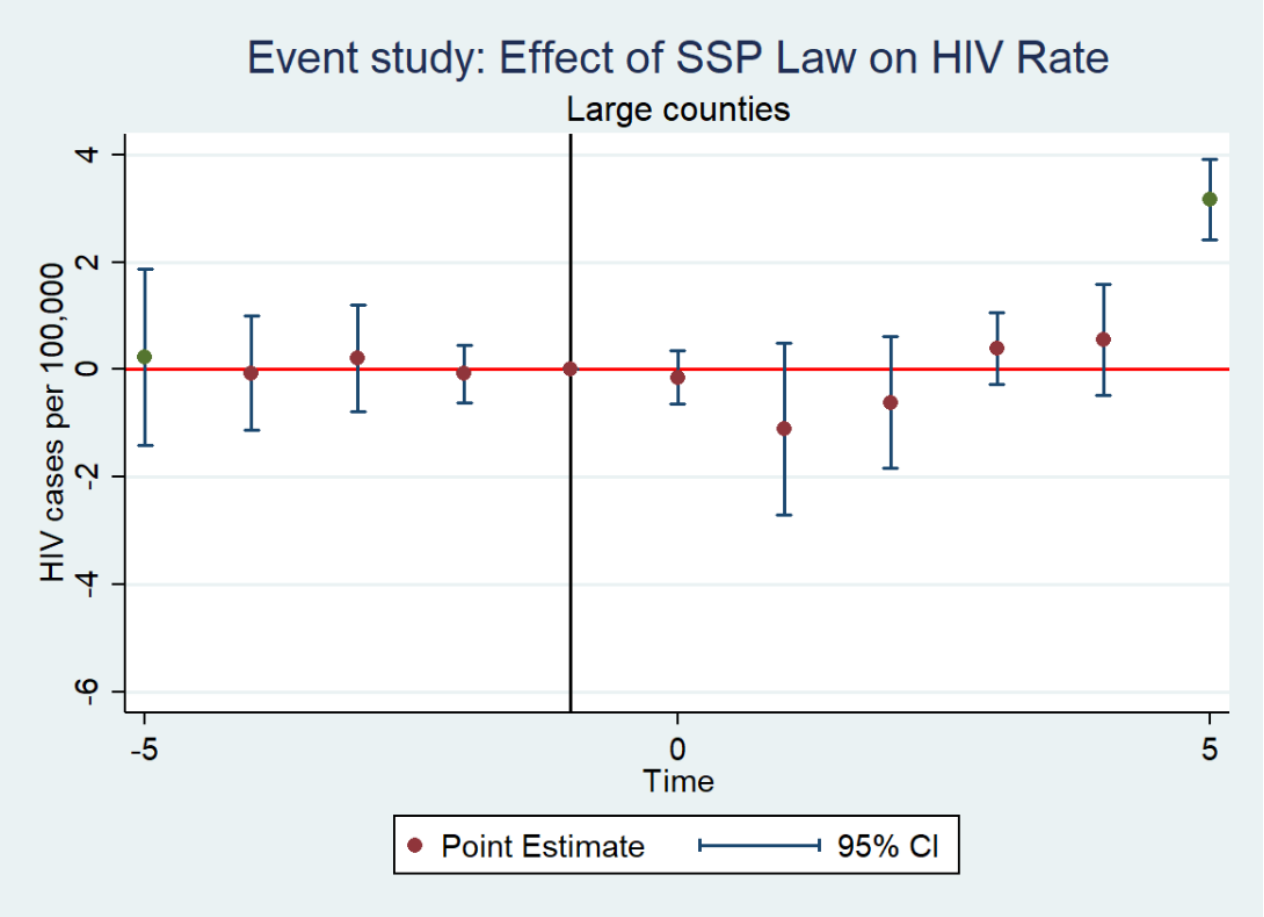

Figure 6

Change in county-level HIV rates after allowing SEP operation at the state level in small counties