

Examining Unmet Need for HIV Prevention Strategies: Syringe Services Programs (SSPs) and Pre-exposure Prophylaxis (PrEP)

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Problem Statement and Background

In 2015, there were an estimated 1.1 million people living with HIV in the United States (CDC, 2017). In 2016, there were almost 40,000 new cases of HIV with 1 in 10 new diagnoses attributable to injection drug use (CDC, 2017).

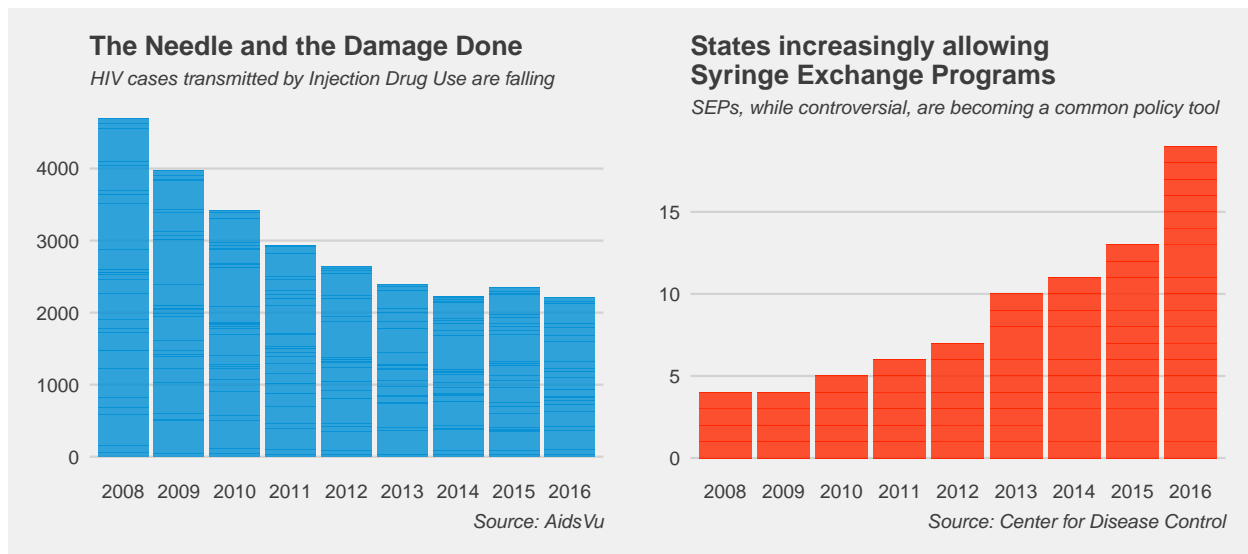
So far, there is no known cure to HIV. The main treatment for HIV is a class of drugs called antiretrovirals. These drugs don't cure HIV, but they can reduce the amount of virus in the body of the person with HIV.

Historically marginalized populations, such as men who have sex with men (MSM), injection drug users (IDU), sex workers, and African Americans, are disproportionately affected by HIV. The cyclical relationship between HIV stigmatization worsens the situation; marginalized groups who experience discrimination and stigma are at a high risk of exposure to HIV, while people with HIV are also more likely to receive unfair treatment from the society due to stigma and discrimination. Therefore, it is critical to implement HIV prevention interventions to protect these marginalized populations from exposure to HIV.

Currently, the two main HIV prevention strategies in the U.S. are pre-exposure prophylaxis (PrEP) and Syringe service programs (SSPs). PrEP is the use of drugs for people who are HIV negative but at high risk of being infected with HIV. The at-risk populations include MSM, injection drug users, and sex workers.

Syringe services programs (SSPs), also referred to as needle exchange programs (NEPs) and syringe exchange programs (SEPs) provide sterile needles and syringes to drug users and safely dispose of used needles and syringes as a preventative measure for HIV and other infections that are transmissible by blood. Many of these programs integrate other intervention strategies, such as testing, treatment, and counseling services.

Two trends that brought our research question about



As of 2014, 33 states had explicitly banned SSPs, and the federal funding of SSPs was prohibited. In 2016, the law was changed to allow jurisdictions to use federal funding to support certain components of SSPs, excluding the purchase of the actual syringe and needles (Weinmeyer 2016). Despite this new legal opportunity, SSPs remain a controversial topic with strong opposition. Opponents to SSPs believe that federal funding of these programs indicates approval of illegal drug use, will lead to an increase in drug use and will lessen the

moral and logistical barrier of access for children to become users. Despite the research and evidence that has been presented to oppose these viewpoints, adequate SSPs are still not available.

While PrEP has been proven to be an effective prevention method for those at high risk for contracting HIV, it is not adequately utilized. Barriers to access include stigmatization of users of PrEP, through negative sentiment regarding promiscuity through labels such as “Truvada whore” (Truvada being the manufacturer of PrEP) (Calabrese et al., 2015). Financial access is also a barrier, with a 30-day supply costing \$2,000. Many insurance companies cover PrEP, but out-of-pocket expenses are still prohibitive to many who would benefit from the drug (Luthra et al., 2019). Until 2018, no generic forms of Truvada were approved for use in the US, allowing Truvada to continue to charge high costs for the drug.

There is a need to understand the effectiveness of HIV prevention strategies in limiting transmission of HIV in high-risk areas and understand the potential of uptake of SSPs to decrease transmission among injection drug users (IDU) in areas where the need for SSPs is not met.

Through analyzing data on prevalence and incidence of HIV, data on levels of PrEP usage, information on legalization of SSPs by states, and locations and numbers of SSPs by states, this study explores the unmet need of the two prevention methods (SSP and PrEP) and predictors of when the state will legalize operations of SSPs.

Data

AIDSVu

Geographic HIV data is available from AIDSVu, an online interactive tool that compiles public health data made available through the Center for Disease Control and Prevention

(CDC) HIV surveillance. From the AIDSVu data, we used three separate data sets. The first is the statewide new diagnoses set (incidence data). This is fairly complete from 2008 to 2016, though some states do not report on given statistics and occasional data is suppressed for confidentiality reasons. The incidence data set includes the number of new diagnoses, new diagnoses rates, category of transmission, and demographic data at the state level. The second data set used was the 2015 prevalence data, which is aggregated at the county level. Prevalence differs from incidence in that it represents the total number of persons living with HIV, while incidence represents the new diagnoses in a given time period. County-aggregated data is only available in the prevalence data set due to confidentiality. The third data set used was the PrEP data set, which shows participation rates by state.

NASEN

Our second main source was NASEN (North American Syringe Exchange Network). NASEN provides the most (though not completely) comprehensive list of SEPs. NASEN is a non-profit whose mission is to connect people to syringe exchange locations near them. This information was scraped to build a data set of all SEP locations by city and state.

State SEP Laws

Finally, we used the CDC’s list of state laws that allow or mandate state-sponsored syringe exchange programs. Using their citations of state statutes, a longitudinal dataset of State laws (allow or not) from 2008 to 2016 was created.

Data Limitations

The AIDSVu data is sourced from the CDC reports on HIV surveillance. The CDC compiles public health records from all reporting jurisdictions and attempts to deduplicate cases across

jurisdictions (persons living with HIV may cross state lines and be counted multiple times). This de-duplication process is not perfect, and many duplicate cases exist within the data, which may overestimate the burden of HIV in certain regions. Efforts are underway to improve this deduplication process. The NASEN data on SEPs is not a comprehensive list, and therefore the unmet need may be overestimated.

Research Design/Approach

The goal of this project was to create a tool for policymakers and stakeholders to use in order to understand where there is the highest unmet need of proven effective prevention methods, in order to make decisions on the allocation of funds and policy decision making. Since this is a geographic issue, as laws and stigma in certain areas have prevented the uptake of SEPs and PrEP usage, we have created an interactive dashboard to explain the geographical relationship between HIV burden (incidence and prevalence), and intervention uptake (PrEP usage, SEP locations, and state laws). A series of interactive maps, tables, and graphs are a great way to allow stakeholders to learn more about trends nationally and in their own communities.

Additionally, one might wonder whether it can be predicted when a state allows SEPs. In an effort to answer this question, supervised machine learning techniques were used in an attempt to model the decision to have a SEP. If we know what factors are most important in anticipating a law, perhaps new diagnoses of a certain demographic group, then governments can be proactive rather than reactive in their SEP policy.

Methods and Tools

Mapping and Shiny Apps

The dashboard (<https://annmarie.shinyapps.io/Shiny-Apps/>) is presented via a Shiny application. The Shiny app allows users to interact with the maps, tables, and graphs that we created. Rather than a static representation, Shiny allows users to be more involved in learning about these trends.

The maps were created with `urbnmapr` and longitude/latitude coordinates.

Sub-Objective 1: Communicating the unmet need of PrEP usage

The AIDSVu statewide incidence and PrEP participation data sets were used to create a map which compares the need (incidence per state) and the utilization (PrEP participation per state) in order to understand the unmet need for PrEP usage.

Sub-Objective 2: Communicating the unmet need of SEPs

The AIDSVu countywide prevalence data set was used to map the HIV prevalence due to injection drug use at the county level. The NASEN SEP location data were used to plot all SEP locations over the prevalence map. Finally, the CDC state law data were used to indicate whether or not a state has legislation in place legalizing SEPs.

Machine Learning

Sub-Objective 3: Predicting State SEP Laws with Machine Learning

The `caret` package was the main driver of the machine learning portion of our project. First, the statewide new diagnoses data need to be combined with the data on state laws.

Most of this data cleaning and wrangling was done with `tidyverse` packages like `dplyr` and `tidyr`. When possible, the pipe `%>%` was used regularly. Once cleaned, this data needed to be preprocessed with a recipe. Three different machine learning algorithms were experimented with. K-nearest neighbors (knn), regression trees, and random forests. As discussed below, the random forest was the most successful model and the strongest predictors were examined in more detail. To do so, we used the interactive nature of the `ggiraph` package.

Results & Discussion

Sub-Objective 1: Communicating the unmet need of PrEP usage

Through our analysis, we found that there is an unmet need for PrEP in states such as Texas, Louisiana, Georgia, and Florida. Although there is an increasing trend of usage for PrEP. The new diagnosis cases in states by year still exceed the increase of PrEP users in states. Further, overall the south has more cases of HIV new diagnosis by year than other regions. However, states in the south have lower levels of PrEP participation compared to other states. The severity of HIV incidence seems to have not been addressed enough in southern states. Our results suggest that state governments, especially those in the south, should invest more resources in promoting and supporting PrEP participation to prevent high-risk populations from contracting HIV.

Sub-Objective 2: Communicating the unmet need of SEPs

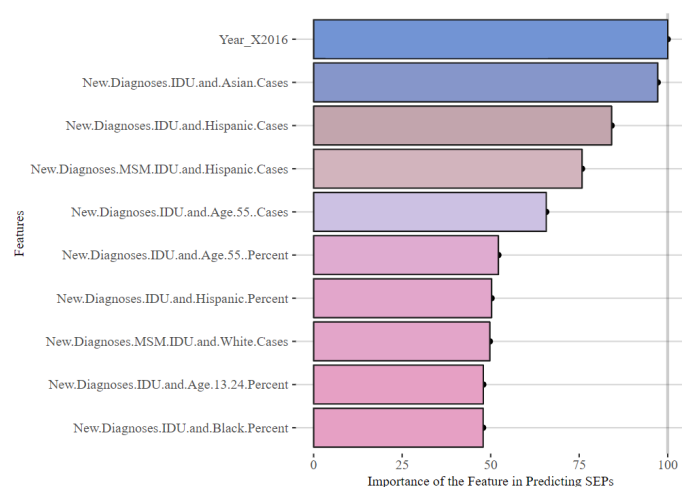
Through our analysis of HIV prevalence data and SEP locations/state legislation, we were able to identify the following trends regarding the unmet need for SEPs. Mapping the county IDU prevalence as a percent of total HIV cases allowed us to identify clusters of the country where IDU transmission is most severe. Clusters of high IDU transmission exist in the

southeast (particularly in Southern FL and LA), the Northeast (NY/NJ/PA/CT), and the West (particularly in CA/AZ). By plotting the SEP locations on top of the prevalence map, we found that SEPs visually appear to be lacking in the Southeast and Southwest regions of the country. We were able to quantify the unmet need for SEPs per state by calculating the total number of IDU transmission cases over the total number of SEPs in that state, which we defined as SSP burden. For states with zero SEPs, the total number of cases were plotted as a transparent column to represent the unmet need in a state with zero SEPs. Through this analysis, we found that TX, FL, GA, and PA have the highest unmet need for SEPs. By adding the legal status to this analysis, we identified that none of these states have passed legislation legalizing SEPs. In fact, of the 15 states that we found to have the highest unmet need, only 4 of them have legislation in place legalizing SEPs. We concluded that the data show that states with legislation in place to legalize SEPs are more likely to have adequate SEPs in place to serve the IDU population in the state. While we were unable to attribute an increase in SEPs to a decrease in HIV transmission among IDU due to limited availability of data, it is hopeful that the evidence in literature of the success of SEPs combined with our geographical and legislation based analysis will compel policymakers in states with high IDU HIV transmission to devote resources towards SEPs.

Sub-Objective 3: Predicting State SEP Laws with Machine Learning

From the machine learning perspective, the random forest model had the most predictive accuracy of the three models employed. A random forest model with `extratrees` and `mtry = 32` correctly predicts the SEP law status in more than 80% of state-years.

Static Version of ggiraph plot of importance



More interestingly the most important factors in prediction were related to Hispanic incidence of HIV from IDU, Hispanic incidence of HIV and MSM/IDU, and incidence in those over 55 years and older. These and other factors are demonstrated in the interactive model (shown in static form) below. The year was given as the most important factor, but this makes sense in that it is the last year available in the data set.

Next Steps

For the PrEP data, it would be useful to do a deeper dive in the data and aggregate by demographic and socioeconomic indicators and transmission category to further understand the unmet need among specific population groups in order to more directly target interventions. For the SEP location and IDU transmission analysis, next steps would include doing a time series analysis to see if states exhibited a downward trend following the passing of legislation legalizing SEPs.

For future machine learning exploration, the inclusion of more data sources such as demographics and political affiliation may be worth adding to our model. We also might want to think about other predicted variables. For example, predicting if a state has an HIV outbreak

in a given year would be worthwhile and of interest to policymakers going forward.

References

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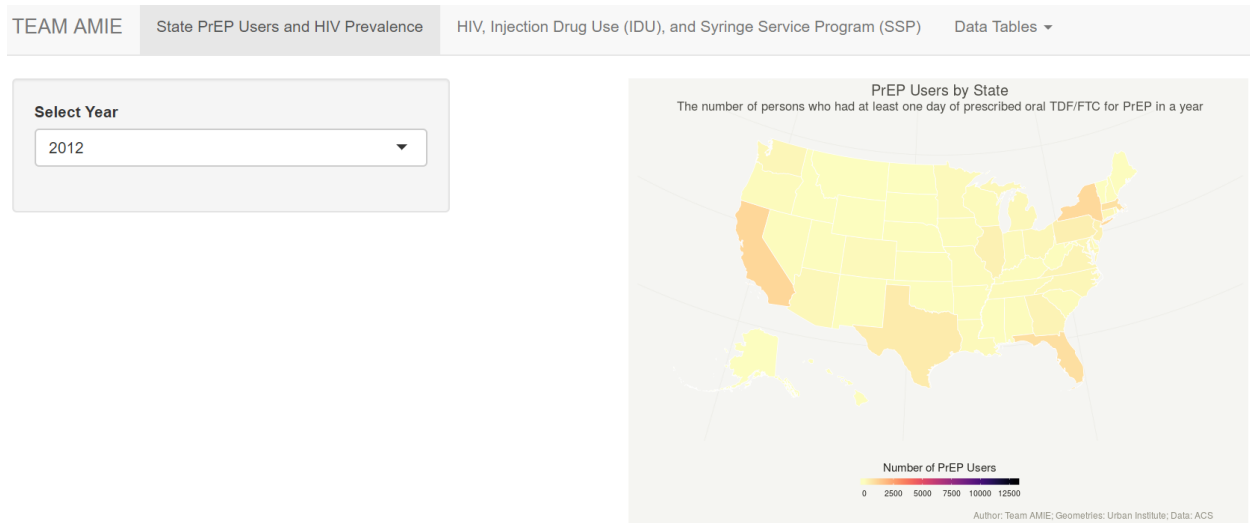
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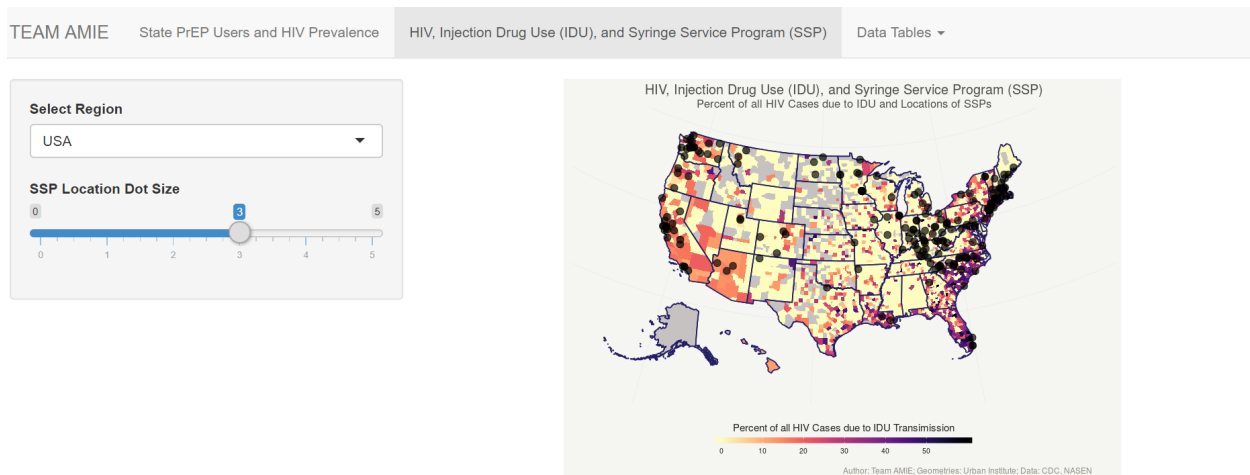
Appendix

Shiny App Visualizations

PrEP by State Visualizations



Mapping SSPs in comparison to HIV due to IDU



Searchable Table of PrEP Users

TEAM AMIE State PrEP Users and HIV Prevalence HIV, Injection Drug Use (IDU), and Syringe Service Program (SSP) Data Tables ▾				
Show 10 ▾ entries		Search: <input type="text"/>		
	State	Year	New Diagnosis	State.PrEP.Users
1	Alabama	2012	665	63
2	Alaska	2012	28	8
3	Arizona	2012	626	171
4	Arkansas	2012	250	41
5	California	2012	5055	1063
6	Colorado	2012	375	98
7	Connecticut	2012	291	180
8	Delaware	2012	138	46
9	Washington, D.C.	2012	584	
10	Florida	2012	4473	838
Showing 1 to 10 of 265 entries			Previous	1 2 3 4 5 ... 27 Next

Searchable Table of Percentage of HIV Cases due to IDU

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State PrEP Users and HIV Prevalence

HIV, Injection Drug Use (IDU), and Syringe Service Program (SSP)

Data Tables

Show

10

entries

Search:

	State	State Total IDU	State SSP Burden	Legal	SSP Exist	County	Percent HIV Cases due to IDU
1	TX	18469	18469	Not Legal	At least one SSP in state	Anderson County	17.6
2	TX	18469	18469	Not Legal	At least one SSP in state	Andrews County	0
3	TX	18469	18469	Not Legal	At least one SSP in state	Angelina County	43.5714285714286
4	TX	18469	18469	Not Legal	At least one SSP in state	Aransas County	16.1290322580645
5	TX	18469	18469	Not Legal	At least one SSP in state	Archer County	
6	TX	18469	18469	Not Legal	At least one SSP in state	Armstrong County	
7	TX	18469	18469	Not Legal	At least one SSP in state	Atascosa County	0
8	TX	18469	18469	Not Legal	At least one SSP in state	Austin County	18.1818181818182
9	TX	18469	18469	Not Legal	At least one SSP in state	Bailey County	
10	TX	18469	18469	Not Legal	At least one SSP in state	Bandera County	0

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Plot of “Burden of SSPs” by State

