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Shannon Rossiter Date

Assessing Geographic and Urban Disparities in Pre-exposure Prophylaxis (PrEP) Access and Care Among a Cohort of Men Who Have Sex with Men

By

Shannon Rossiter
Master of Public Health

Epidemiology

_____

Jeb Jones PhD, MPH, MS
Committee Chair

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Pace University
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Thesis Committee Chair: Jeb Jones PhD, MPH, MS

An abstract of
A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
in partial fulfillment of the requirements for the degree of
Master of Public Health
in Epidemiology
2020

Abstract

Assessing Geographic and Urban Disparities in Pre-exposure Prophylaxis (PrEP) Access and Care Among a Cohort of Men Who Have Sex with Men

By

Shannon Rossiter

Men who have sex with men (MSM) have been recognized by the Centers for Disease Control and Prevention (CDC) as a high-risk group for HIV, making up approximately 67% of new infections in 2017. Pre-exposure prophylaxis (PrEP) has been established as a particularly highly effective preventative treatment against HIV in MSM. Despite this, there is low uptake of PrEP among MSM. There are known geographic differences that exist between new HIV diagnoses and PrEP uptake: the South experiences the greatest HIV burden, and urban areas have better access to HIV care and resources, including access to PrEP. However, prior studies have not assessed geographic disparities in HIV care and PrEP use on a national scale. To assess whether there were geographic and urban disparities among MSM, we used data from a cohort of 10,127 participants from the American Men's Internet Survey (AMIS) from 2018 and employed conditional margin regression and spatial analyses. Most participants resided in the South (38.2%) and participants living in urban counties were 2.4 times more likely than their rural counterparts to have ever used PrEP (PR = 2.40, 95% CI = [1.06, 5.43]). Additionally, more participants in the West had ever used PrEP (27.8% - 42.6%), while more MSM in the South and Midwest were willing to use PREP (53.9%-60.1%). Based on these results, there is a disconnect between who wants access to PrEP care and who is able to access it, suggesting the need for large-scale regional interventions in the areas showing lower prevalence of MSM and these PrEP outcomes.

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INTRODUCTION

Despite substantial achievements and advancements in HIV treatment and care over the past two decades, HIV still remains an urgent public health problem in the United States, particularly among men who have sex with men (MSM). As of 2017, approximately 67% of new infections of HIV were attributed to male-to-male sexual contact (1). Daily pre-exposure prophylaxis (PrEP) with oral emtricitabine and tenofovir disoproxil fumarate (FTC-TDF) has been established as an effective preventative treatment against HIV in multiple clinical trials (2,3,4) when taken as a once-daily tablet, with MSM showing particularly high effectiveness against HIV infection with a 95% reduced relative risk among those who have detectable drug levels (2). The FDA approved use of PrEP to reduce HIV acquisition risk among HIV-negative individuals in 2012 (5), and as of 2015, the Centers for Disease Control and Prevention (CDC) reported 24.7% of MSM had indications for PrEP (6). However, it is estimated that approximately only 8.7% of those with indications are actually using PrEP (7). This slow uptake suggests the need for improvements in large-scale interventions and addressing barriers to implementation. Multiple barriers to PrEP initiation have been identified in qualitative studies, including lack of awareness of the medication itself and how to obtain it (7), stigma (8,9), medical mistrust (10), and provider's perceived barriers to prescribing PrEP (12,13).

Factors that drive the HIV epidemic are known to differ geographically: coastal, urban areas were originally the epicenter of HIV infections during early stages of the epidemic, but that burden has now shifted to the South, though still highly concentrated in urban areas. This region now experiences the greatest HIV burden and number of deaths in the United States, with black MSM experiencing the highest rate of new HIV diagnoses (13). The main drivers of this shift are socioeconomic factors, as geographic location is closely integrated with structural and systematic barriers contributing to substandard HIV care and lack of awareness of PrEP. Socioeconomic factors such as education level, income, and poverty may be related to HIV outcomes (14) and can differ by region: according to a 2018 U.S. census estimate, the South was the only region that had an increase in poverty level when compared to 2007 (15). Additionally, counties that surround large metropolitan areas in the South have higher rates of people living with HIV (16), and people that live in

the South are less likely to know they may be at risk for HIV, have HIV, and how or where to access HIV care and other health care services (13). The geographic shift in HIV disparities from urban, coastal areas to rural, Southern regions shows the need to expand HIV care access in this part of the country. However, most studies examining geographic disparities in HIV risk among MSM are conducted among urban populations, ignoring the experiences of those that live in more rural areas (17). Among studies that have focused on MSM populations living in rural areas, themes have emerged that suggest the role of stigma, the resources at their disposal, and PrEP integration into daily life are major barriers to PrEP uptake (17); similar themes have emerged in studies conducted in urban settings (18). PrEP awareness and uptake have also been shown to differ by geographic location, and access to PrEP is different in urban versus rural areas: a study that examined patterns and awareness of PrEP in MSM in Atlanta, New York City, and Chicago found that Atlanta participants were less aware of PrEP (7). Atlanta had the highest poverty rate of the three cities, suggesting that socioeconomic factors may be affecting access to care and ability to cover costs of the medication(19).

While there does not appear to be a significant difference in awareness of PrEP by race (20), structural barriers such as lack of health insurance have been cited as a major barrier in actually accessing PrEP by black MSM (7). Other structural barriers may contribute that are unique to the South, such as lack of Medicaid expansion (21), the need to travel great distances to access care (22), and need for PrEP payment assistance programs (23). Additionally, Southern states receive less funding from the Ryan White Program (24), which provides HIV care and support services to those who have limited health insurance (25). Disparities in HIV prevalence have been attributed to several geospatial factors (18), and populations most indicated for PrEP usage in the South are not the ones actively seeking PrEP care (26). All of this suggests the need to develop PrEP intervention strategies and campaigns that cater to the specific needs of communities in the South. While there is prior evidence of the existence of HIV disparities and different PrEP-related outcomes focused on specific regions, to our knowledge there has been no analysis that investigates geographic disparities in HIV care and PrEP use on a national scale.

The American Men's Internet Survey (AMIS) is a yearly web-based cross-sectional survey administered to approximately 10,000 MSM in the United States to identify trends in sexual health among MSM in the US, including access to PrEP. To better understand the role of urbanicity we will examine whether there are differences (or similarities) in urban versus rural MSM by state with respect to PrEP awareness, interest, discussions with healthcare providers, and uptake. Additionally, we will examine whether there is significant spatial heterogeneity and/or spatial dependence in PrEP awareness and uptake among the 2018 AMIS sample. Spatial heterogeneity suggests there may be significant differences by location of the various PrEP outcomes; spatial dependence assesses whether neighboring counties see the same outcomes in PrEP events when compared to counties that are further away. Looking at these relationships will allow us to understand how PrEP awareness, interest, and access differ by urbanicity and region to inform specific prevention and intervention strategies to cater to the need of the communities living in these specific areas.

METHODS

Study Design

Data from the 2018 cycle of AMIS were analyzed. AMIS is a cross-sectional survey conducted in annual cycles, with seven cycles completed as of December 2019. Detailed methods have been described previously (27,28). Briefly, participants were recruited between September 2018 and November 2018 through convenience sampling on a variety of websites using banner ads and blast emails to website members. If the ad was clicked, the participant was redirected to the survey website hosted on a secure server administered by SurveyGizmo (Boulder, CO, USA). Some participants were also recruited if they had completed prior cycles of AMIS and consented to be contacted again about future studies. There was no incentive provided to participants to complete the survey. The survey was self-administered and could be taken on either a computer or mobile device. Question topics included demographics, sexual behaviors, HIV and STI testing and diagnosis, substance use, and use of HIV prevention services, including questions about PrEP. Eligible participants had to be at least 15 years of age, assigned male sex at birth, residing in the United States, and reported oral or anal sex with a man at least once in their lifetime. Participants who met the eligibility criteria and provided informed consent were able to start the survey immediately. All study procedures were approved by the Emory University Institutional Review Board.

Measures

All answers to survey questions were self-reported. For demographic characteristics, age, race/ethnicity, education level, annual household income, and whether the participant had ever tested for HIV were reported for the overall study population and then stratified on urbanicity. Whether a participant was classified as living in an urban versus rural county was determined based on the participant's self-reported zip code and matched to the CDC's 2013 NCHS Urban-Rural Classification Scheme for counties (29). Based on this classification scheme, urban counties were those defined as large central metro, large fringe metro, medium metro or small metro while rural counties were those defined as micropolitan or non-core.

Four PrEP outcomes were assessed: whether a participant had ever heard of PrEP before taking the survey, if they were willing to use PrEP, if they had discussed PrEP with a healthcare provider in the last year, and

whether they had ever taken PrEP. If participants answered that they were HIV negative or had never had a negative HIV test, then they were shown subsequent questions on ever hearing about PrEP, if they had ever used PrEP, and if they would be willing to use PrEP. Those that answered that they had heard of PrEP were asked if they had discussed PrEP with a healthcare provider [Figure 1]. None of these outcomes was a required question in the survey; therefore, participants who did not answer the relevant questions were counted as missing and not included in the final analysis. These dependent measures were stratified based on state and U.S. geographic region (South, Northeast, Midwest, West) as defined by the U.S. Census Bureau (30). Participants who lived in Puerto Rico or the U.S. Virgin Islands were excluded from analyses.

Statistical Analyses

Eligible participants were included in the analyses if they fit the eligibility criteria as described above, resulting in 10,127 total participants. Descriptive statistics (numbers and percentages) were calculated for age, race/ethnicity, education, annual household income, and ever testing for HIV. Age was categorized into participants aged 15-24, 25-39, and 40+. Race/ethnicity was categorized as 'white non-Hispanic', 'black non-Hispanic', 'Hispanic', or 'other'. Education was dichotomized into participants who have a high school diploma or less and participants with at least some college education. Column percentages were calculated for descriptive data by urban versus rural county to distinguish how many participants within each variable considered were located in an urban versus a rural county. Overall Chi-square tests were used to assess whether these participants characteristics differed based on urbanicity. Logistic regression models were estimated using the conditional margins method (31) to obtain prevalence ratios for each of the PrEP outcomes, stratified by urbanicity and region. Unadjusted models included only the relevant PrEP outcome and the appropriate urban region as the independent variable/exposure, while adjusted models additionally included education, household income, and race/ethnicity to address potential confounding bias. These three variables were identified as potential confounders using a directed acyclic graph (DAG) approach. All non-spatial statistical analyses were conducted using SAS software, Version 9.4 (Cary, NC, USA).

Spatial Analyses

Numerator and denominator counts of the four main PrEP outcomes were calculated for each United States region, state, and county to determine prevalence for spatial analyses. Numerator counts were determined based on which participants selected 'Yes' for all four of the outcomes while denominator counts differed while denominators were determined based on the survey's skip logic. For ever heard of PrEP, all participants who completed the survey were included as the denominator; participants who answered that they had heard as PrEP were included as the denominator for whether the participant had discussed PrEP with a healthcare provider; and all participants who answered that they were HIV negative were included as the denominator for willing to use PrEP or have ever taken PrEP [Figure 1]. These counts were calculated using SAS software, Version 9.4.

Counts for the main outcomes were exported from SAS and then imported into R3.6.1 software. Cartographic geographic boundaries for contiguous states were obtained from the U.S. Census Bureau. Raw prevalence percentages were calculated based on counts in Figure 1. To gain better insight into whether spatial dependence truly exists, smoothed prevalence percentages were calculated by spatial Empirical Bayes. We used spatial (compared to aspatial) because we hypothesize regional differences in PrEP outcomes and that neighboring states have more characteristics in common than states that are further away. The prevalence of neighboring states was used as a prior, and neighbors were defined as queen contiguity to remain consistent with analyzing the contiguous United States. Once prevalence percentages were smoothed, they were mapped using the same criteria that was used to map raw prevalence percentages, using the *tmap* package in RStudio. County level data was not mapped due to scarcity of responses across most counties.

RESULTS

Demographic Characteristics

In total, 10,127 MSM completed the survey, with urban/rural categorization available for 10,012. Most participants were between 15-24 years old (n=4,230), non-Hispanic white (n=7,099), attended at least some college (n=2,498), had an annual household income higher than $75,000 (n=3,294), and had ever been tested for HIV (n=7,454) [Table 1]. Differences were statistically significant when comparing differences in urban and rural counties for age ($p=0.0008$), race/ethnicity ($p < 0.0001$), household annual income ($p < 0.0001$), and ever tested for HIV ($p < 0.0001$). Most participants (38.2%) resided in the South and across all U.S. regions the majority of participants who answered questions regarding the different PrEP outcomes resided in urban counties [Tables 2,3].

Regression Analyses

Conditional margin regression was used to obtain prevalence ratios (PR) and corresponding 95% confidence intervals (CI) for each of the different PrEP outcomes. For each model, the relevant PrEP outcome was the dependent variable and each urban geographic region was the independent variable, using rural counties as the reference. As shown in Table 2, there were no significant differences between urban and rural counties in regard to whether patients had ever heard of PrEP in any U.S. region. Participants who lived in urban Midwest counties were 41% more likely to have discussed PrEP with a healthcare provider (PR = 1.41, 95% CI = [0.87, 2.31]) and those living in urban West counties were 47% more likely to have discussed PrEP with a healthcare provider when compared to their rural counterparts after adjusting for education, income, and race/ethnicity, though these differences were also not significant (PR = 1.47, 95% CI = [0.87, 2.47]) [Table 2]. Table 3 shows the characteristics of participants who were willing to use PrEP and those who had ever used PrEP. No significant differences were reported between urban and rural MSM in those willing to use PrEP, but in the South, participants living in urban counties were 2.4 times more likely than their rural counterparts to have ever used PrEP, after adjusting for education, income, and race/ethnicity (PR = 2.40, 95% CI = [1.06, 5.43]. The magnitude of this difference was not seen in any other geographic region.

Spatial Analyses

Figure 2 shows the raw prevalence percentages of the four PrEP outcomes by state. Most MSM (57.7% - 93.1%) had heard of PrEP. Out of those MSM who had heard of PrEP, more participants had discussed PrEP with a healthcare provider in the West and Northeast (33.4% - 54.3%) compared to the South and Midwest. Of those who had never tested positive for HIV, prevalence for those willing to use PrEP ranged from 27.6% to 67.3% and 11.8% to 42.6% for those who have ever used PrEP, respectively. After smoothing, clear patterns of spatially dependent clustering arose. More MSM in the Northeast had heard of PrEP (79.1% – 90.9%) compared to any other geographic region [Figure 3]. Among MSM who had discussed PrEP with a healthcare provider in the last year, most (33.7 – 39.7) lived in the Northeast and West [Figure 3]. More MSM in the South and Midwest were willing to use PrEP (53.9 % - 60.1%), while more MSM on the West coast had ever used PrEP (27.8% - 42.6%) [Figure 3].

DISCUSSION

We sought to determine whether geographic differences exist among MSM in accessing and utilizing PrEP care. HIV remains an important public health issue in many areas across the United States, especially among MSM (1) and in areas in the South (13). Prevention is the first step in effective care, and there are many strategies aimed at HIV prevention, both behavioral and biomedical. PrEP is an FDA-approved, effective treatment to prevent HIV transmission, especially among MSM who are at high-risk of acquiring the virus (2), however PrEP use has not yet reached levels that models suggest will be necessary to meaningfully reduce HIV incidence(32,33), particularly among populations that are at the highest risk. In 2016, the South accounted for more than half of all new HIV infections in the United States, but about only 30% of all PrEP users nationwide (34). Additionally, disparities in HIV prevalence have been attributed to several geospatial factors (18), and populations most indicated for PrEP usage in the South are not the ones actively seeking PrEP care (26). The states and regions that bear the greatest burden of the epidemic require greater access to preventive care but are often unable due to higher poverty rates and factors contributing to inability to access healthcare (19). We performed multiple analyses to determine if four PrEP outcomes – ever hearing of PrEP, discussing PrEP with a healthcare provider, willing to use PrEP, and ever using PrEP – differed by urbanicity as well as geographic region in the United States. Knowing where MSM may not have access to PrEP or are not utilizing PrEP to its maximum extent can allow public health professionals to divert resources and money to these areas to ensure those at the highest risk of HIV are able to receive proper preventive treatment and care.

Each individual PrEP outcome yielded different results. Overall, more than half of all the participants who completed the survey had ever heard of PrEP [Figure 2], with prevalence ranging from 57.7% to 92.1% and no significant differences between urban and rural counties across all regions [Table 2]. After smoothing, the data show that most MSM who had heard of PrEP are congregated in the Northeast, with the lowest percentages in the South [Figure 3]. More MSM living in the West had discussed PrEP with a healthcare provided in the last year and had ever taken PrEP compared to the other regions, with urban MSM being more likely to discuss PrEP compared to rural MSM, especially in the West (PR = 1.47, 95% CI = [0.87,

2.47]. MSM in the South and Midwest were more willing to take PrEP [Figure 3], with no difference between urban and rural counties [Table 3]. More MSM in the West and Northeast had used PrEP [Figure 3], but urban MSM in the South were over twice more likely to have used PrEP than their rural counterparts (PR = 2.40, 95% CI = [1.06, 5.43]. Overall, PrEP outcomes related to MSM who have already had contact with some sort of PrEP care were more concentrated in the Northeast and West, while MSM living in the South were less likely to have heard of PrEP, have discussed PrEP with a healthcare provider, and ever used PrEP. These results are similar to prior studies(7,13).Our study adds spatial analyses that investigate the location of clusters of geographic disparities in HIV and PrEP use on a national scale. Although we are unable to make conclusions regarding reasons for these patterns, the disconnect between who is willing and able to take PrEP and who is actually accessing PrEP care is cause for concern. Among MSM in the South and Midwest, there was similar awareness and willingness to use PrEP among men in rural and urban areas; however, men in urban areas were much more likely to have ever discussed PrEP with a provider or to have used PrEP. Factors such as stigma (8,9,35), lack of awareness of how to obtain the medication (7), being physically unable to travel to specialized healthcare (22), or less funding for HIV care programs in these areas (25) might contribute to this disparity. The results of the current study show the need for an increase in PrEP awareness and uptake, especially in the South and other areas with lower prevalence in our defined PrEP outcomes.

This study has several limitations. First, data were obtained from a cross-sectional survey, so we cannot make any inferences about causality. Second, AMIS survey participants were recruited via convenience sampling and therefore results may not be generalizable to all MSM in the United States. Third, county-level data for each PrEP outcome was unavailable for many counties. Due to lack of county-level data, we are unable to make assessments about urban and rural differences from a spatial perspective.

HIV is still an important public health problem in the United States, despite incredible advancements and achievements over three decades. However, the number of new HIV infections will never hit zero unless national prevention programs focused on behavioral interventions and instituting PrEP are promoted in areas that are still seeing high rates of infections. Future studies to add to this one should use qualitative methods to focus on what factors are contributing to why fewer MSM in the South and Midwest are accessing and

utilizing PrEP care. Additionally, we hope that future studies will further explore the role of urbanicity in a spatial analysis. While we were able to calculate differences in prevalence ratios between urban and rural counties by region generally, mapping counties was not possible due to the sparseness of the available data. It would be beneficial to map prevalence of each of the different outcomes by county, as there are hypothesized differences between urban and rural counties in HIV outcomes due to structural and systematic barriers, such as stigma (8,9) and medical mistrust (10). Mapping these differences would allow local health departments in counties with lower prevalence to divert resources in creating programs to make sure more high-risk populations are able to access PrEP care.

CONCLUSIONS

We found that there were differences in four major PrEP outcomes among MSM by urbanicity and geographic region. Our findings suggest that MSM residing in the South are more willing to use PrEP but are experiencing some sort of barrier to being able to actually access PrEP. Our findings also suggest that MSM residing in urban counties are more likely to have heard of PrEP, have discussed PrEP with a healthcare professional, and have ever used PrEP compared to MSM residing in rural areas. Future studies should focus on mapping these differences by urbanicity to gain a sense of regional differences in PrEP outcomes at the county level. To mitigate these disparities, local health departments and other stakeholders should invest in PrEP care in areas where awareness and uptake remains low.

FIGURES AND TABLES

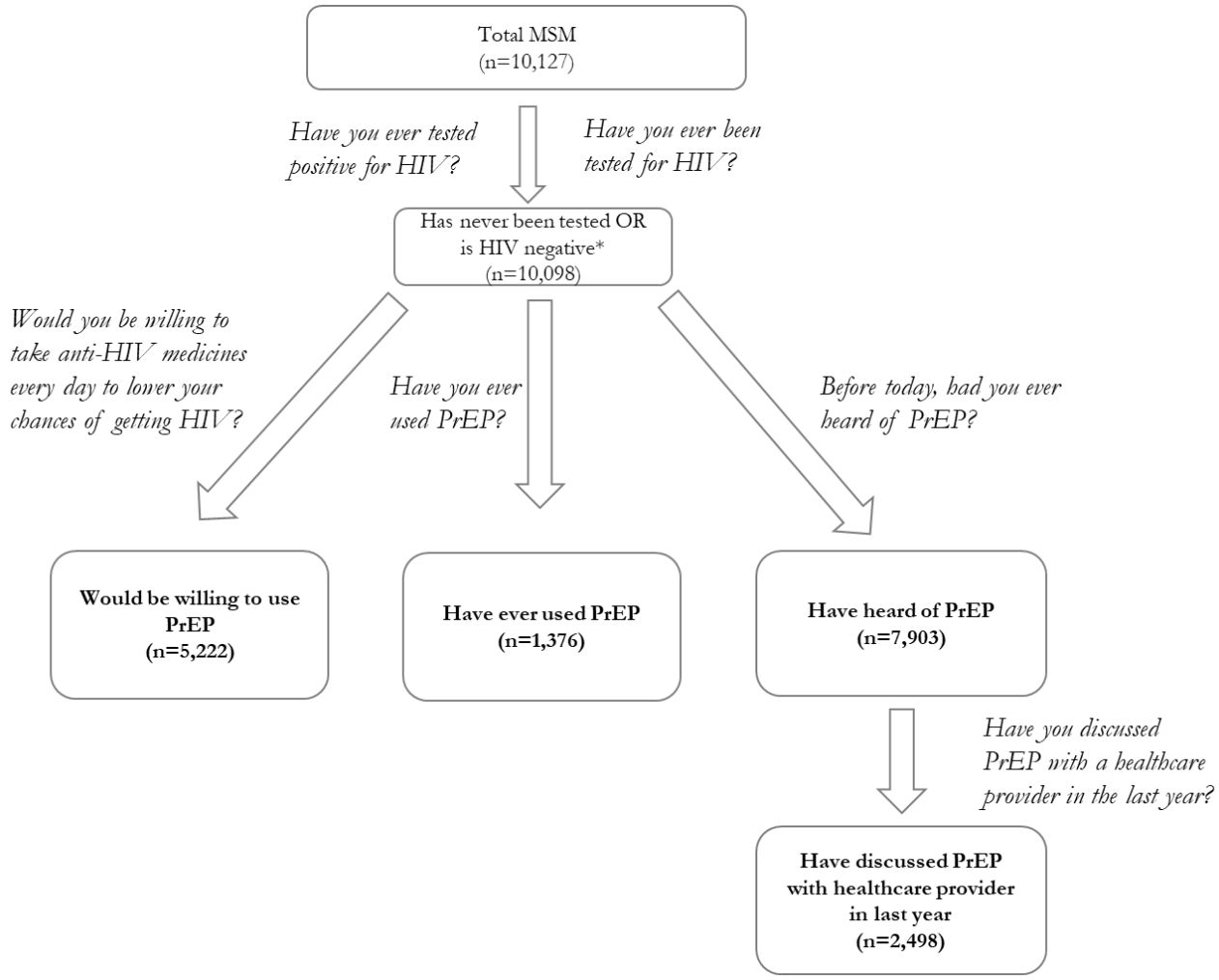

Figure 1: Flow chart of simplified version of survey skip pattern to assess which participants were eligible to be included in final PrEP outcome analyses (shown in bold). Sentences in italic are the questions posed to participants in the survey.
* HIV negative is defined as answering "No", as well as "Indeterminate results", "Prefer not to answer" and "Don't know"

Table 1: Characteristics of a cohort of men who have sex with men (MSM) in the United S

	Overall Study Population *n*	Resides in Urban County[a] *n (%)*	Resides in Rural County[a] *n (%)*	p-value
Age				0.0008
15-24	4,230	3,782 (41.8)	444 (43.8)	
25-39	2,811	2,578 (27.7)	231 (22.8)	
40+	3,086	2,745 (30.5)	338 (33.4)	
Race/Ethnicity				<0.0001
White, non-Hispanic	7,099	6,310 (69.3)	787 (77.7)	
Black, non-Hispanic	553	523 (5.7)	29 (2.9)	
Hispanic	1,630	1,521 (16.7)	104 (10.3)	
Other[b]	671	608 (6.7)	62 (6.1)	
Education				0.7531
High school or less	1,900	1,680 (18.5)	218 (21.5)	
At least some college	2,498	2,216 (24.3)	279 (27.5)	
Household Annual Income				<0.0001
< $20,000	1,356	1,172 (12.9)	182 (18.0)	
$20,000 - $39,999	1,864	1,635 (17.9)	226 (22.3)	
$40,000 - $74,999	2,510	2,250 (24.7)	257 (25.4)	
$75,000+	3,294	3,078 (33.8)	215 (21.2)	
Ever Tested for HIV				<0.0001
Yes	7,454	6,783 (75.5)	663 (66.6)	
No	2,535	2,201 (24.5)	333 (33.4)	

a: defined by the Centers for Disease Control and Prevention's 2013 NCHS Urban-Rural Classification Scheme for Counties

b: American Indian/Alaska Native, Asian, Native Hawaiian/Pacific Islander, or multiracial

Table 2: Comparisons of MSM who have ever heard of PrEP and discussed PrEP, by urbanicity and region

	Ever heard of PrEP			Discussed PrEP with HCP[b] (in last year)		
	n (%)	*Unadjusted PR[a] (95% CI[b])*	*Adjusted PR* (95% CI)*	*n (%)*	*Unadjusted PR (95% CI)*	*Adjusted PR* (95% CI)*
South						
Urban (n=3,486)	2,706 (77.6)	1.07 (1.01, 1.15)	1.08 (0.97, 1.20)	795 (22.8)	1.39 (1.10, 1.76)	1.23 (0.82, 1.83)
Rural (n=379)	274 (72.3)	Ref.	Ref.	58 (15.3)	Ref.	Ref.
Northeast						
Urban (n=1,497)	1193 (79.7)	1.08 (0.97, 1.19)	1.03 (0.88, 1.22)	412 (27.5)	1.38 (0.97, 1.95)	1.15 (0.67, 1.96)
Rural (n=135)	100 (74.1)	Ref.	Ref.	25 (18.5)	Ref.	Ref.
Midwest						
Urban (n=1,848)	1,461 (79.1%)	1.08 (1.01, 1.15)	1.04 (0.92, 1.18)	465 (25.2)	1.49 (1.16, 1.90)	1.41 (0.87, 2.31)
Rural (n=350)	257 (73.4%)	Ref.	Ref.	55 (15.7)	Ref.	Ref.
West						
Urban (n=2,276)	1,805 (79.3%)	1.10 (1.00, 1.22)	1.10 (0.94, 1.30)	664 (29.2)	1.63 (1.14, 2.33)	1.47 (0.87, 2.47)
Rural (n=149)	107 (71.8%)	Ref.	Ref.	24 (16.1)	Ref.	Ref.

a: PR = prevalence ratio

b: 95% CI = 95% confidence interval

c: HCP = healthcare provider

* Adjusting for education, household income, and race/ethnicity

Table 3: Comparisons of MSM who are willing to use PrEP and have ever used PrEP, by urbanicity and region

	Willing to use PrEP			Ever used PrEP		
	n (%)	*Unadjusted PR (95% CI)*	*Adjusted PR* (95% CI)*	*n (%)*	*Unadjusted PR (95% CI)*	*Adjusted PR* (95% CI)*
South						
Urban (n=2,317)	1,867 (53.6)	1.00 (0.94, 1.07)	1.07 (0.97, 1.19)	424 (18.3)	1.59 (1.11, 2.28)	2.40 (1.06, 5.43)
Rural (n=222)	222 (58.6)	Ref.	Ref.	28 (12.6)	Ref.	Ref.
Northeast						
Urban (n=1,012)	703 (47.0)	0.98 (0.88, 1.11)	0.95 (0.80, 1.13)	231 (22.8)	1.77 (1.00, 3.12)	1.03 (0.88, 1.22)
Rural (n=87)	77 (57.0)	Ref.	Ref.	11 (12.6)	Ref.	Ref.
Midwest						
Urban (n=1,199)	939 (50.8)	0.99 (0.92, 1.07)	0.99 (0.89, 1.10)	258 (21.5)	2.52 (1.59, 3.98)	1.04 (0.92, 1.18)
Rural (n=210)	194 (55.4)	Ref.	Ref.	17 (8.1)	Ref.	Ref.
West						
Urban (n=1,570)	1,138 (50.0)	1.05 (0.94, 1.18)	1.12 (0.92, 1.36)	373 (23.8)	1.52 (0.93, 2.49)	1.10 (0.94, 1.30)
Rural (n=91)	82 (55.0)	Ref.	Ref.	14 (15.4)	Ref.	Ref.

*Adjusting for education, household income, and race/ethnicity

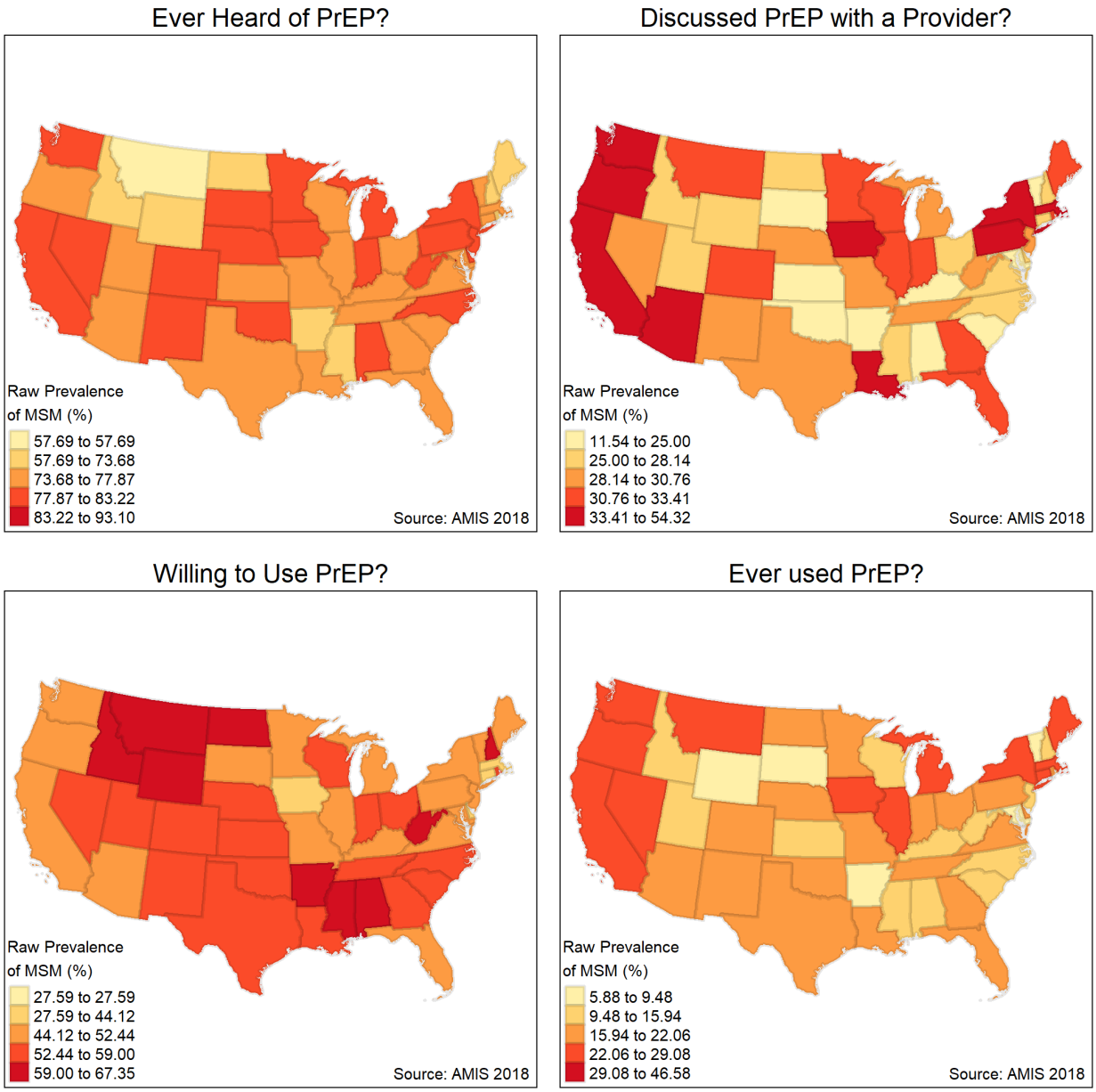

Figure 2: Raw prevalence percentages of each PrEP outcome among MSM in the contiguous United States. Percentages shown per 100 MSM.

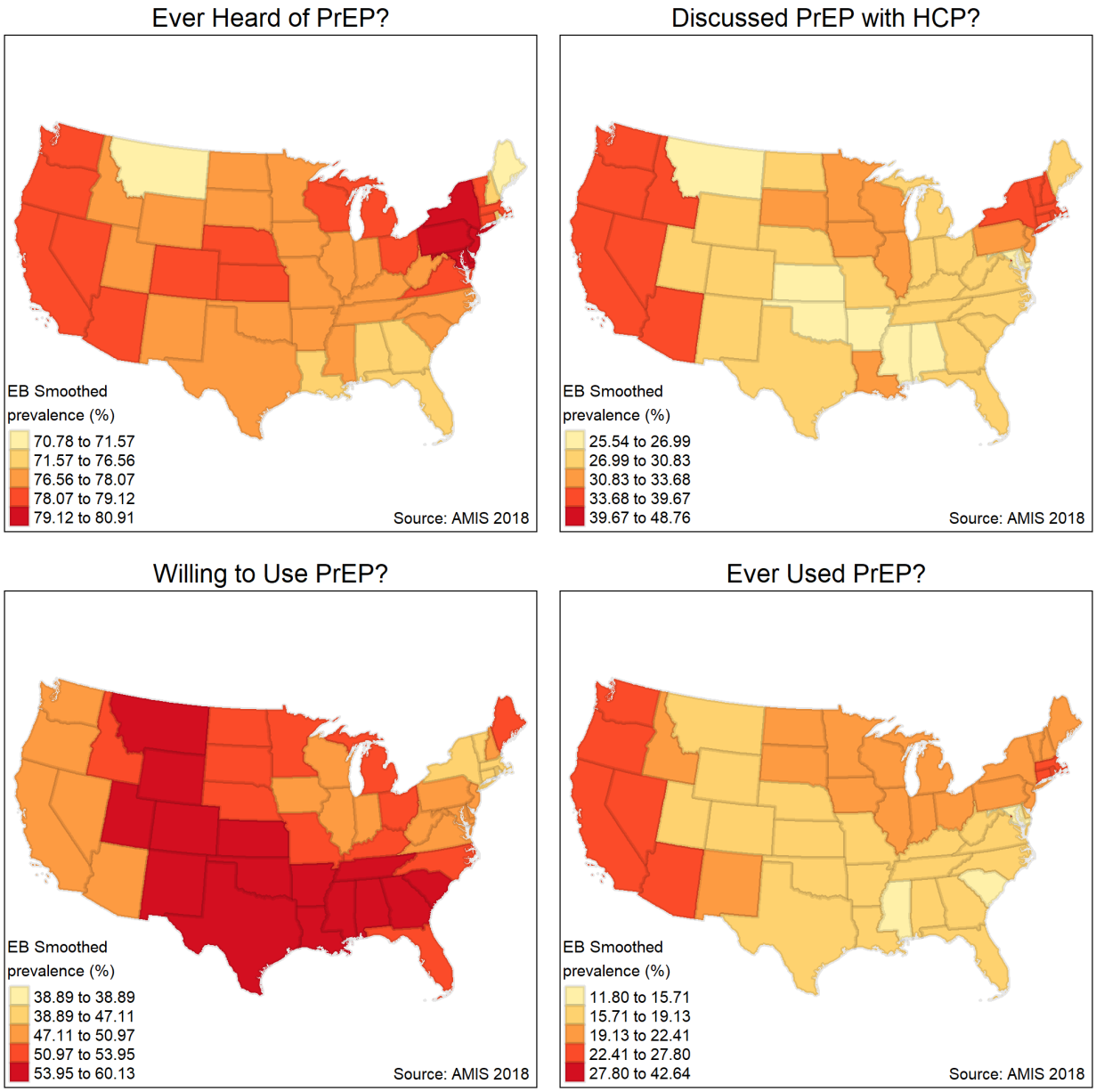

Figure 3: Smoothed [spatial Empirical Bayes] prevalence percentages of each PrEP outcome among MSM in the contiguous United States. Percentages shown per 100 MSM.

REFERENCES

1. Centers for Disease Control and Prevention. *HIV Surveillance Report 2017*. 29:129. (http://www.cdc.gov/hiv/library/reports/hiv-surveillance.html). Published November 2018

2. Grant RM, Lama JR, Anderson PL, et al. Preexposure Chemoprophylaxis for HIV Prevention in Men Who Have Sex with Men. *N Engl J Med*. 2010;363(27):2587–2599.

3. Grohskopf LA, Chillag KL, Gvetadze R, et al. Randomized Trial of Clinical Safety of Daily Oral Tenofovir Disoproxil Fumarate Among HIV-Uninfected Men Who Have Sex With Men in the United States: *JAIDS Journal of Acquired Immune Deficiency Syndromes*. 2013;64(1):79–86.

4. McCormack S, Dunn DT, Desai M, et al. Pre-exposure prophylaxis to prevent the acquisition of HIV-1 infection (PROUD): effectiveness results from the pilot phase of a pragmatic open-label randomised trial. *The Lancet*. 2016;387(10013):53–60.

5. U.S. Food and Drug Administration. *Truvada for PrEP Fact Sheet: Ensuring Safe and Proper Use*. (https://www.fda.gov/media/83586/download). (Accessed November 30, 2019)

6. Vital Signs: Estimated Percentages and Numbers of Adults with Indications for Preexposure Prophylaxis to Prevent HIV Acquisition — United States, 2015. (https://www.cdc.gov/mmwr/preview/mmwrhtml/mm6446a4.htm). (Accessed November 30, 2019)

7. Strauss BB, Greene GJ, Phillips G 2nd, et al. Exploring Patterns of Awareness and Use of HIV Pre-Exposure Prophylaxis Among Young Men Who Have Sex with Men. *AIDS Behav*. 2017;21(5):1288–1298.

8. Smallwood SW, Spencer SM, Ingram LA, et al. Examining the Relationships Between Religiosity, Spirituality, Internalized Homonegativity, and Condom Use Among African American Men Who Have Sex With Men in the Deep South. *Am J Mens Health*. 2017;11(2):196–207.

9. Mustanski B, Ryan DT, Hayford C, et al. Geographic and Individual Associations with PrEP Stigma: Results from the RADAR Cohort of Diverse Young Men Who have Sex with Men and Transgender Women. *AIDS Behav*. 2018;22(9):3044–3056.

10. Cahill S, Taylor SW, Elsesser SA, et al. Stigma, medical mistrust, and perceived racism may affect PrEP awareness and uptake in black compared to white gay and bisexual men in Jackson, Mississippi and Boston, Massachusetts. *AIDS Care*. 2017;29(11):1351–1358.

11. Krakower D, Ware N, Mitty JA, et al. HIV providers' perceived barriers and facilitators to implementing pre-exposure prophylaxis in care settings: a qualitative study. *AIDS Behav*. 2014;18(9):1712–1721.

12. Zhang HL, Rhea SK, Hurt CB, et al. HIV Preexposure Prophylaxis Implementation at Local Health Departments: A Statewide Assessment of Activities and Barriers. *J Acquir Immune Defic Syndr*. 2018;77(1):72–77.

13. Centers for Disease Control and Prevention. HIV in the Southern United States. (https://www.cdc.gov/hiv/pdf/policies/cdc-hiv-in-the-south-issue-brief.pdf) Accessed November 29, 2019.

14. Economically Disadvantaged | HIV by Group | HIV/AIDS | CDC. 2019;(https://www.cdc.gov/hiv/group/poverty.html). (Accessed March 2, 2020)

15. Bureau UC. Income and Poverty in the United States: 2018. *The United States Census Bureau*. (https://www.census.gov/library/publications/2019/demo/p60-266.html). (Accessed March 2, 2020)

16. Gray SC, Massaro T, Chen I, et al. A county-level analysis of persons living with HIV in the southern United States. *AIDS Care*. 2016;28(2):266–272.

17. Hubach RD, Currin JM, Sanders CA, et al. Barriers to Access and Adoption of Pre-Exposure Prophylaxis for the Prevention of HIV Among Men Who Have Sex With Men (MSM) in a Relatively Rural State. *AIDS Education and Prevention*. 2017;29(4):315–329.

18. Mustanski B, Birkett M, Kuhns LM, et al. The Role of Geographic and Network Factors in Racial Disparities in HIV Among Young Men Who have Sex with Men: An Egocentric Network Study. *AIDS Behav*. 2015;19(6):1037–1047.

19. Bishaw A, Benson C. American Community Survey Briefs. :14.

20. Krakower DS, Mimiaga MJ, Rosenberger JG, et al. Limited Awareness and Low Immediate Uptake of Pre-Exposure Prophylaxis among Men Who Have Sex with Men Using an Internet Social Networking Site. *PLoS One* [electronic article]. 2012;7(3). (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3314648/). (Accessed November 30, 2019)

21. Gai Y, Marthinsen J. Medicaid Expansion, HIV Testing, and HIV-Related Risk Behaviors in the United States, 2010–2017. *Am J Public Health*. 2019;109(10):1404–1412.

22. Siegler AJ, Bratcher A, Weiss KM. Geographic Access to Preexposure Prophylaxis Clinics Among Men Who Have Sex With Men in the United States. *Am J Public Health*. 2019;109(9):1216–1223.

23. Arnold T, Brinkley-Rubinstein L, Chan PA, et al. Social, structural, behavioral and clinical factors influencing retention in Pre-Exposure Prophylaxis (PrEP) care in Mississippi. *PLoS One* [electronic article]. 2017;12(2). (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5319650/). (Accessed December 1, 2019)

24. Reif SS, Whetten K, Wilson ER, et al. HIV/AIDS in the Southern USA: a disproportionate epidemic. *AIDS Care*. 2014;26(3):351–359.

25. The Ryan White HIV/AIDS Program: The Basics. *The Henry J. Kaiser Family Foundation*. 2019;(https://www.kff.org/hivaids/fact-sheet/the-ryan-white-hivaids-program-the-basics/). (Accessed November 30, 2019)

26. ELOPRE L, KUDROFF K, WESTFALL AO, et al. The Right People, Right Places, and Right Practices: Disparities in PrEP access among African American Men, Women and MSM in the Deep South. *J Acquir Immune Defic Syndr*. 2017;74(1):56–59.

27. Sanchez T, Zlotorzynska M, Sineath C, et al. The Annual American Men's Internet Survey of Behaviors of Men Who have Sex with Men in the United States: 2014 Key Indicators Report. *JMIR Public Health Surveill*. 2016;2(1):e23.

28. Zlotorzynska M, Sullivan P, Sanchez T. The Annual American Men's Internet Survey of Behaviors of Men Who Have Sex With Men in the United States: 2016 Key Indicators Report. *JMIR Public Health*

Surveill [electronic article]. 2019;5(1). (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6401665/). (Accessed March 2, 2020)

29. Urban Rural Classification Scheme for Counties. 2019; (https://www.cdc.gov/nchs/data_access/urban_rural.htm). (Accessed March 2, 2020)

30. United States Census Bureau. *Census Regions and Divisions of the United States* (https://www2.census.gov/geo/pdfs/maps-data/maps/reference/us_regdiv.pdf). (Accessed March 2, 2020)

31. Muller CJ, MacLehose RF. Estimating predicted probabilities from logistic regression: different methods correspond to different target populations. *Int J Epidemiol*. 2014;43(3):962–970.

32. Sullivan PS, Carballo-Diéguez A, Coates T, et al. Successes and challenges of HIV prevention in men who have sex with men. *Lancet*. 2012;380(9839):388–399.

33. Jenness SM, Goodreau SM, Rosenberg E, et al. Impact of the Centers for Disease Control's HIV Preexposure Prophylaxis Guidelines for Men Who Have Sex With Men in the United States. *J. Infect. Dis.* 2016;214(12):1800–1807.

34. May 07 H gov | P, 2018. State-level PrEP Utilization Data Now Available from AIDSVu. *HIV.gov*. 2018;(https://www.hiv.gov/blog/state-level-prep-utilization-data-now-available-aidsvu). (Accessed April 19, 2020)

35. Eaton LA, Kalichman SC, Price D, et al. Stigma and Conspiracy Beliefs Related to Pre-exposure Prophylaxis (PrEP) and Interest in Using PrEP Among Black and White Men and Transgender Women Who Have Sex with Men. *AIDS Behav*. 2017;21(5):1236–1246.