Exploration of the Complex Relationship among Multilevel Predictors of PrEP Use among Men Who Have Sex with Men in the United States

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Abstract

Objective: To explore the relationships among individual-, social-, and contextual- (state-level characteristics, including LBGTQ+ and racial inequality) level factors and PrEP use.

Methods: A cross-sectional survey was conducted in 2015–2016 among a geographically diverse group of men who have sex with men (MSM). Survey data was linked to publicly available state-level data based on participant zip code. Multivariable multilevel logistic regression was used to explore the association between multilevel variables and PrEP use.

Results: Of 4,165 HIV-negative MSM, 13.4% were taking PrEP. In the regression analysis, several demographic and behavioral factors were associated with higher odds of PrEP use. Importantly, after adjusting for individual- and social-level factors, residents of states with high LGBTQ+ equality had significantly higher odds of taking PrEP (OR=1.57; 95%CI: 1.119,2.023) compared to low equality states.

Conclusions: LGBTQ+ inequality between states may hinder PrEP use. States may need to take proactive measures to reduce LGBTQ+ inequality as this may negatively impact the ability to reach the federal administration's stated goal to end the HIV epidemic in the US.

Keywords

PrEP use; contextual and individual level factors; multilevel modeling; Men who have sex with men (MSM)

Introduction

Approximately 2–3% of the United States (US) population are men who have sex with men (MSM), but in 2016, this group accounted for 67% of the 40,324 new HIV diagnoses.(1) In July 2012, the US Food and Drug Administration (FDA) approved the use of tenofovir disoproxil fumarate plus emtricitabine (TDF-FTC, Truvada) for use as pre-exposure prophylaxis (PrEP) in HIV-negative adults who are at high-risk of HIV infection.(2) Although PrEP effectively prevents HIV-infection, its impact on the HIV-epidemic is contingent on uptake among those at highest risk.

Despite the availability of PrEP, uptake has been low and unequally distributed by population subgroup and geographic region.(3–5) The majority of PrEP users in the US are male (95.3%), white (68.7%) and from the Western part of the US (29.7%).(6) However, of new diagnoses in 2016, African-American (38.0%) and Latino (29.0%) MSM accounted for the majority, and the Southern US states experienced the greatest burden of HIV incidence, illness, and deaths compared to other US regions.(7)

Some studies have found differences in PrEP uptake according to a number of individual-level factors including age (4, 8), race/ethnicity (9, 10), sexual behavior (4, 11, 12), and education (8, 12). However, which categories are associated with higher PrEP uptake has varied and does not present a clear pattern. The contradictions between the studies cited above could be due to the impact of higher-level contextual factors working as confounders or modifiers of the individual-level associations(13). One study explored the state-level structural stigma of a US state and its association with HIV prevention. The authors constructed a composite score to represent the state-level structural stigma with one of the components of the composite score being LGBTQ+ inequality. The study concluded that state-level structural stigma was associated with lower HIV prevention effort, calling attention to the importance of addressing multiple sources of stigma at various levels (14). Examining state-level factors that influence PrEP use, including a state's inequality for sexual and racial minorities, may help explain why uptake is still lagging among those at highest risk.

Few studies have examined the relationship between LGBTQ+ equality or the racism of the state and PrEP use and, to our knowledge, no studies have explored interactions between multi-level predictors. To address this gap, this paper explored the associations among individual-(demographics), social-(behavioral risks and partnerships), and contextual-(state characteristics) level factors on PrEP use with the specific hypothesis that state-level inequality for sexual and racial/ethnic minorities negatively impacts their use of PrEP.

Methods

The individual-level data for these analyses come from a cross-sectional survey conducted in 2015–2016 among a geographically-diverse sample of MSM in the US. The study methods for that survey are described elsewhere (15), but the design is briefly presented below.

Participants were eligible if they were aged 18 years or older, cisgender male, and reported sex with other men in past 5 years. Participants were recruited to complete a self-

administered online survey using several different methods, including an online sexual networking website (17.4%), gay porn websites (9.1%), a geo-social sexual networking mobile app for MSM (38.3%), a general (non-sexual) social networking website (8.9%), and street intercept outside of New York City venues frequented by MSM (6.4%). In addition, we invited participants in an ongoing national panel study to complete the survey (20.0%). Survey questions included demographics, HIV-risk/protective behaviors, partner characteristics, and zip code of residence. The survey data was then merged with the publicly available state-level data based on participant's zip code of residence.

Outcome Variable

The *outcome* for these analyses was self-reported, current PrEP use at time of survey and was determined using responses to the question: "What is your HIV status?" Response options were: (1) HIV-positive and undetectable, (2) HIV-positive, but detectable, (3) HIV-negative, on PrEP, (4) HIV-negative, not on PrEP, (5) Don't know/unsure. Participants who reported they were HIV-positive were excluded. Participants who reported don't know/ unsure of HIV status were counted as HIV-negative for the purpose of this analysis. The outcome was categorized as on PrEP versus not on PrEP.

Independent Variables

Individual- and social- level variables included demographics, behaviors, and MP factors. Demographics included age, race/ethnicity, education, and sexual identity. Due to the low numbers in some of the sexual identity categories, the variable was collapsed into an indicator for gay identity versus other than gay identity (heterosexual, bisexual, other).

For our analysis, we defined social-level factors as behaviors or interactions that pertained or occurred between persons, including the number of sex partners and drug use in the last three months, as well as diagnosis of any sexually transmitted infections (STIs) in the last six months. To assess STIs and drug history, participants were provided a list of STIs (i.e. chlamydia, Gonorrhea, Genital or anal warts, HPV, Genital Herpes, HSV1 or 2, Syphilis, Hepatitis B or C, Urethritis) and recreational drugs (i.e. Ketamine, Ecstasy, GHB, Cocaine, Methamphetamine, Marijuana, Alcohol, Prescription drugs, Injection drugs) and were asked to indicate which infection they had been diagnosed with and which drugs they used in the respective allotted time. STIs and drug use were both dichotomized into an indicator for any STI and any drug use. Number of partners was examined in four categories: 0, 1, 2–5 and >5, with categories based on the distribution of the data to ensure a sufficient number in each category and represent typical number of partners categories reported in the literature (16, 17). The main partner (MP) variable included the HIV and PrEP status of their MP and was collapsed into 5-categories: (1) does not have a MP, (2) HIV+ MP, (3) MP of unknown HIV-status, (4) HIV-negative MP on PrEP (5) HIV-negative MP not on PrEP.

State-level Data and Measures

State-level poverty and percent of residents without health insurance were continuous variables obtained from the US Census Bureau's American Community Survey Briefs for poverty (18) and the Kaiser Family Foundation (19). The HIV prevalence rate and the categorization by state for adolescent and adults was ascertained from the CDC annual HIV

Surveillance Report (20). The state LGBTQ+ equality measure was derived from the Human Rights Campaign (HRC) state scorecard, a report on statewide laws and policies affecting LGBTQ+ people and their families. The HRC ranked each state into four distinct groups, with one indicating the most equality and four the least (21). For our analysis, the variable was then dichotomized with the first two categories collapsed to indicate low LGBTQ+ equality and the last two categories collapsed to indicate high equality. To assess state-level racism, a measure was used that ranks states by the proportion of non-black residents who regard blacks more negatively than the national median.(22) The discrimination ranking results were based on stereotyping questions from the 2008 National Annenberg Election Survey (23). The variable was created using multilevel regression with post-stratification (MRP), this statistical technique has shown to yield estimates of state-level public opinion. The regression analysis modeled prejudice as a function of individual-level covariates (sex, race, age, and education) and state-level predictors (black population, percent of blacks in poverty, segregation, and income inequality) (22). Each state was ranked from 1–50 with one representing the state with the highest proportion of nonblack residents who are 'prejudiced overall' (22). For our analysis, the variable was dichotomized into an indicator for low (rankings of 26–50) versus high (rankings of 1–25) racism.

Statistical analysis

Descriptive statistics were calculated for the sample overall and by PrEP use. Statistical significance of differences in PrEP use were assessed with a chi-squared or Wilcoxon rank sum test for categorical and numerical variables respectively.

Crude and multivariable multilevel logistic regression models with random intercepts were used to assess which independent variables were associated with PrEP use. The level-1 unit was the participant and level-2 unit was the state. Pseudo-intraclass correlation coefficients (pseudo-ICC), median odds ratios (MOR), and proportional change in variance (PCV) were calculated to assess the extent that variability in PrEP use was due to state- versus individual-level factors (24). Model 1 was an 'empty' model to ascertain the overall pseudo-ICC. Model 2 included only demographic variables, Model 3 included social and behavioral risk factors, Model 4 included state-level characteristics, and Model 5, the final model, included all variables.

Interaction was examined among state-level equality measures (LGBTQ+ and racism scores) and individual-level variables (sexual and racial/ethnic identity) in predicting PrEP use. Initial analyses explored a 4-way interaction where all possible product terms (2-, 3-, and 4-way) were added to Model 5 (25). This model was compared to three other models: (1) the main effects model, (2) model with only 2-way interactions, and (3) model with 2- and 3-way interactions. Interaction was evaluated at $\alpha=0.10$, due to diminished power when assessing interaction (26). Significance for all other comparisons were assessed at $\alpha=0.05$. Analyses were conducted in SAS 9.4 with GLIMMIX (SAS Institute, Cary, NC).

Results

There were 4,165 HIV-negative participants, of whom 13.4% were taking PrEP. Overall, 35.1% were age 18–29 years old, with average age of 38.3 years. Most participants (64.8%)

were white, had a four-year degree or more (51.9%) and identified as gay (81.8%). The most common region of residence was the South (32.6%), followed by the Northeast (23.9%), the West (23.6%) and the Midwest (19.9%).

More than half of participants reported not having a MP (59.5%). Of those with a MP (N=1,686, 40.5%), the majority cited that their MP was not on PrEP (N=1,593, 94.5%) and only 5.5% (N=93) reported that their MP was taking PrEP. Most participants reported having more than two sexual partners (62.3%) and using drugs in past three months (69.4%). Lastly, over 15% of the participants reported having been diagnosed with an STI within the last six months.

The highest percentage of participants lived in states with low LGBTQ+ equality (58.5%), low state racism (53.2%), and in the second to lowest HIV prevalence range (52.1%). The mean state poverty rate of participants was 14.7% (SD=2.2), just above the 2015 national average of 13.5% (18). The mean state-level percent uninsured for participants was 9.1% (SD=3.4) which was similar to the national average.(19)

PrEP use was highest among those age 30–39 (16.6% followed by 12.8% among 18–29 years, 14.5% among 40–49, and 10.7% among those 50+ years, *P*<0.001). Participants residing in the Northeast (17.3%) were more likely to be taking PrEP than those in the West (15.0%), South (11.2%), and Midwest (10.8%; *P*<0.001). Participants with a four-year college degree or more (17.2%) were more frequent users of PrEP than participants who had some college or equivalent (9.9%) or a high school degree, GED or less (8.0%; *P*<0.001). Those who identified as gay (14.7%) used PrEP more than those who identified as bisexual, straight or other (8.0%, 0.0%, 12.5%, respectively; *P*<0.001). PrEP was highest with participants with a MP who was already taking PrEP (75.3%) followed by those with a MP who was HIV-positive (40.3%), an HIV-negative MP not on PrEP (6.1%), a MP of unknown HIV status (5.8%), and those with no MP (14.2%; *P*<0.001). Overall, 25.9% of those with 5+ partners were taking PrEP compared to 13.3% with 2–5 partners, 4.7% with only 1 partner, and 4.2% with 0 partners (*P*<0.001). Participants who had recently used drugs (15.1%) and been diagnosed with an STI (32.7%) used PrEP more than their counterparts (9.6% and 11.0%, respectively; *P*<0.001). Participants who lived in the highest LGBTQ+ equality states (17.4%) used PrEP more often compared to those in low equality states (10.7%; *P*<0.001). Similarly, participants who lived in states with lower racism used PrEP more (15.9% vs 10.7%; *P*= *P*<0.001). Lastly, those who lived in the state with the highest HIV-prevalence (20.3%) reported taking more PrEP as compared to all other HIV prevalence categories (*P*<0.001). (Table I)

Multivariable multilevel logistic regression

Table II shows the assessment of variance components for each model. Model 1 (empty model/pseudo-ICC) suggests that 2.4% of the total variance in PrEP use is due to between state differences. Models 2 (individual-level variables) and 4 (state-level variables) suggest that, after adjusting for their respective variables, less than 1% of variance is due to differences in characteristics between the states while the remaining variance is due to unmeasured differences between individual- and state -level characteristics. Model 3, which explored social/behavioral characteristics of the individual, showed the greatest variation,

with that 1.8% of the residual variation in PrEP use is persisting due to systematic differences between states. There is no pseudo-ICC nor MOR for Model 5, as there was not enough variation in the response to attribute any variation to state- or individual-level effects, controlling for all variables in the model (27).

Table III shows the crude and covariate adjusted associations between individual, interpersonal, and structural level variables and PrEP use. In model 2 (column 3), participant age, region of residence, race/ethnicity, education, and sexual identity were independently associated with PrEP use. The odds of taking PrEP decreased as age increased, with a significant association only among those age 50+ compared to those 18–29 years old (aOR= 0.77; 95%CI: 0.59, 1.00). Participants who identified as other than gay were less likely to take PrEP as compared to those who identified as gay (aOR=0.55; 95%CI: 0.41, 0.74). PrEP use was positively-associated with residence in the Northeast (aOR=1.41; 95%CI: 1.03, 1.94) and the West (aOR=1.38; 95%CI: 1.01, 1.86) as compared to the South. Those who were black (aOR=1.41; 95%CI: 1.02, 1.94) and who had a 4-year degree (aOR=2.29; 95%CI: 1.61, 3.24) had higher odds of PrEP use compared to those who were white, and had a high school diploma or less, respectively.

In model 3 (column 4), those who had an MP who was HIV-positive (aOR=4.63; 95%CI: 3.03, 7.09) and who's MP was on PrEP (aOR=16.30; 95%CI: 9.65, 27.53) had a higher odds of taking PrEP compared to those with no MP. Furthermore, those with a MP whose HIV status was unknown (aOR=0.34; 95%CI: 0.19, 0.61) and whose MP was HIV-negative and not on PrEP (aOR=0.46; 95%CI: 0.35, 0.61) had lower odds of taking PrEP compared to participants with no MP. Participants who reported 2–5 partners (aOR=3.28; 95%CI: 2.08, 5.15) and 5+ partners (aOR=6.65; 95%CI: 4.26, 10.39) had a higher odds of PrEP use compared to those with no partners. Additionally, participants who reported recent drug use (aOR=1.33; 95%CI: 1.04, 1.69) and had a recent STI (aOR=3.25; 95%CI: 2.55, 4.14) had a higher odds of taking PrEP compared to those who had not used drugs or been diagnosed with an STI.

Model 4 (column 5) shows the adjusted association of state-level characteristics with PrEP use. Residents of states with the highest LGBTQ+ equality score (aOR=1.60; 95%CI: 1.22, 2.11) and the highest state HIV-prevalence per 100,000 (aOR=1.81; 95%CI: 1.11, 2.96) had higher odds of PrEP use compared to residents of states with low LGBTQ+ equality scores and of states with less than 10.0% HIV-prevalence, respectively.

Model 5 (column 6), includes all individual-, social-, and state-level variables. Model 5 result were similar to those in the simpler models, with the exceptions of age, drug use, and HIV prevalence. In the fully adjusted model, participants aged 30–39 (aOR=1.33; 95%CI: 1.02, 1.75) and 40–49 (aOR=1.36; 95%CI: 1.00, 1.83) now had higher odds of PrEP use and those 50+ were no longer statistically different from the youngest group. Drug use was no longer significant in the final model. States with the second to lowest HIV prevalence of 10.0–19.9 per 100,000, now had lower odds of PrEP use (aOR=0.71; 95%CI: 0.51, 0.99) compared to states with the lowest HIV-prevalence and states with the highest HIV prevalence were no longer statistically significant. All other associations found in models 2, 3 and 4 retained significance in model 5.

All possible four-, three-, and two-way, interactions were tested among state-level LBGT equality, state-level racial equality and individual sexual identity and race/ethnic identity. Non-significant interactions were removed and models rerun and no significant interaction terms were identified.

We conducted sensitivity analyses to determine how our decisions to dichotomize the main contextual predictor variables, LGBTQ+ equality and state racism, may have impacted our results (data not shown). The models were re-run with the racism score modeled as a numeric variable and as a four-category variable (defined by quartiles) and in both cases the associations were not significant, similar to the model with the variable dichotomized (Racism as a numeric variable: OR=1.10; 95%CI: 0.72, 1.67. Racism in quartiles: Q1: Reference; Q2: OR=0.92; 95%CI: 0.55, 1.53; Q3: OR=0.83, 95%CI 0.44, 1.58; and Q4: OR= 0.88, 95%CI: 0.44, 1.78). In the case of LBGTQ+ equality, the variable was also modeled in four categories as it was originally defined by the HRC, with quartile 1 representing states with the lowest LGBTQ+ equality and quartile 4, representing states with the highest LGBTQ+ equality. The association was (Q1: Reference; Q2: OR=1.10, 95% CI: 0.65, 1.89; Q3: OR=1.42, 95%CI 0.86, 2.36; Q4: OR=1.76, 95%CI: 1.10, 2.81). Thus the relationship demonstrated a suggestion of a dose response, but the association was only significant for the highest category, perhaps due to insufficient statistical power, which we dealt with in the main analysis by dichotomizing the variable. In both cases (racism and LBGTQ+ equality), the overall conclusion regarding the associations did not change depending on how we modeled the variables (i.e. no association with the racism variable and a significant positive association for LBGT equality), nor did any of the other associations in the model change substantially based on the different ways of defining these variables.

Discussion

Our findings suggest that the state-level equality for LGBTQ+ people is associated with PrEP use among its residents even after adjusting for differences in the individual- and social-level characteristics of the residents within those states. This is consistent with findings in other studies examining equality and health outcomes. One study found that sexual minorities living in states without legal protections were more likely to report symptoms of depression, anxiety, and alcohol use (28). Another study looked at structural stigma, measured by a composite score addressing four dimensions of state LBGTQ+ prejudicial components with one of the dimensions including a focus on four LGBTQ+ state policies. This study found that individuals living in high-structural stigma states were less likely to have heard of or used PrEP and suggested that this low-equality environment may inhibit awareness of PrEP or prevent access to providers who can prescribe PrEP (14). Our analysis measured LGBTQ+ equality utilizing a comprehensive equality score that focused on more than seventeen state laws and policies that affect LGBTQ+ persons and their families. In addition, our analysis included and adjusted for other state-level characteristics that may also influence HIV-prevention within LGBTQ+ populations and could be confounders, such as racism, HIV-prevalence, poverty and healthcare access. All findings suggest that state LBGTQ+ inequality may impact the risk and health-seeking behaviors of sexual minorities and/or hinder access to appropriate healthcare (14). LGBTQ+ people who live in more inclusive states may also have a stronger community that can provide more

social support, which may lead to improved physical and mental health outcomes (28). In addition, states with more LGBTQ+ inclusivity may have more access to healthcare that focuses on gender/sex specific health. While we adjusted for access to healthcare via the percent uninsured in the state of residence, access is just one component toward achieving appropriate care. The patient must also feel comfortable enough with the healthcare system and their provider to discuss sensitive issues such as HIV risk/behavior in order to receive appropriate care. Future research might explore whether the quality of the patient-provider relationship is a mediator between the association between stigma and health outcomes (i.e. PrEP use).

Unlike LGBTQ+ equality, our measure of state-level racism was not associated with PrEP use. There has been a considerable amount of research showing that MSM of color often feel isolated from the broader LGBTQ+ community or have experienced racism/discrimination within that community (29). We thought that those with dual minority identities, sexual and racial/ethnic, might be more impacted by the co-occurrence of LBGTQ+ inequality and racial equality. However, our exploration of interaction between state-level inequality (LGBTQ+ and racism) and individual minority status (i.e. sexual identity and race/ethnicity) did not yield significant interaction terms, suggesting no interaction between those constructs. We suspect that the lack of significance could be due to the state-level racism variable which could either be highly variable within the state and/or that level of racism is difficult to measure, and our variable may not have captured this construct adequately.

Overall, social/behavioral variables were strongly associated with PrEP use. Participants with MP's who were HIV-positive or were currently taking PrEP were more likely to be taking PrEP themselves. This may be related to HIV-specific social support within couples. Johnson et al. found that among serodiscordant couples, HIV-specific support within the couple was associated with fewer HIV-risk behaviors and greater self-reported ART adherence (30). Participants who had HIV-negative MPs not taking PrEP or who were unaware of their MPs HIV-status were less likely to be taking PrEP than people with no MP. These findings build on others who have found that intimacy motivations may play a role in PrEP adoption for MSM couples (31) and suggest that understanding the impact of intimate relationship characteristics on sexual risk prevention decision making is an avenue for further exploration.

Participants who reported a recent STI diagnosis, were more likely to have been taking PrEP. We are unable to deduce whether the STI was the impetus to begin using PrEP or whether those on PrEP were more likely to be screened for an STI as part of their PrEP care. However, among PrEP users, high rates of STIs have been reported and concerns have been raised that PrEP use may be linked with an increase in STI incidence due to increased unprotected sex (32). Other studies have found that PrEP does not necessarily lead to increases in risky behavior, but rather that PrEP brings a population already at high-risk for HIV and STIs into more intensive care where STIs are more routinely screened for and treated.(32) Nevertheless, the results could suggest the need to increase risk-reduction counseling when prescribing PrEP.

In the final model, the only individual-level variables that remained independently significantly associated with PrEP use were age, education, and sexual identity. Participants between 30–50 years and with a college degree or more had higher odds of taking PrEP while men who identified as other than gay had lower odds of taking PrEP. Older and more educated MSM may have increased knowledge of HIV- and HIV-risk, improved access to healthcare, and may be more likely to feel at ease disclosing their sexual identity and behavior to their providers. These factors could facilitate improved knowledge and access to PrEP. Conversely, participants who identified as other than gay may be less comfortable discussing their sexual behavior with a healthcare provider and/or may be less integrated into the LGBTQ+ community, which may impact knowledge/access to PrEP.

Limitations

There are several limitations that should be mentioned. First, the data is from a cross-sectional study where the exposure and outcome were simultaneously assessed and temporal order for some associations cannot be determined. Another limitation could be misclassification of the outcome due to the question itself or social desirability bias. For example, PrEP use has been associated with the stigma related to HIV-risk and enabling increased risk behavior (33), therefore some may not have reported their use. In addition, participants were asked if they were currently taking PrEP, but were not asked if they had ever taken PrEP, and some may have discontinued use by the time of our survey leading to under-reporting of lifetime PrEP use. Furthermore, while some state-level variables were associated with PrEP use, some constructs do not have a generally accepted and validated measure and could be a marker for another causal factor. Therefore, uncontrolled or residual confounding, reliability and validity issues, including construct validity should be acknowledged as limitations. While participants were recruited from all 50 states, recruitment methods were not designed to obtain a representative sample of MSM in the US and therefore findings may lack external validity. Lastly, statistics used to quantify fitness (i.e. pseudo-R^2) of a MLM with a dichotomous outcome are often difficult to interpret (34).

Conclusion

Previous studies on PrEP use were often limited to participants in clinical trials and demonstration projects and mostly focused on high-risk populations (35). This study is one of very few which have looked at the impact of contextual (state-level) equality on PrEP use in a 'real' world setting in which PrEP is generally available. Our findings suggest that LGBTQ+ equality of the state may influence PrEP use. The LGBTQ+ equality landscape in the US varies greatly by state, and while recent laws had been moving towards increased equality country wide, in the current political environment, many LGBTQ+ rights are being rolled back at the federal and state levels (36). The findings of this study suggest that increasing inequality for LGBTQ+ people may have a negative impact on PrEP use and could limit our ability to meet the goals put forward by the US President to end the HIV epidemic in the US (37).

Acknowledgements

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Table I.

Description of individual-, social-, and state-level characteristics overall and by PrEP use

Characteristics	TOTAL	Total	non-PrEP users 3605 (86.6%)	PrEP user 560 (13.4%)	p-Value
Individual level characteristics					
Age	4165				
Mean (SD)		38.3 (13.8)	38.39 (14.0)	37.64 (12.2)	<0.001 [*]
Median (Range)		35.0 (65.0)			
Age, n (%)	4165				
18–29		1461 (35.1)	1274 (87.2)	187 (12.8)	0.001
30–39		929 (22.3)	775 (83.4)	154 (16.6)	
40–49		750 (18.0)	641 (85.5)	109 (14.5)	
>50		1025 (24.6)	915 (89.3)	110 (10.7)	
Recruitment, n (%) site	4165				
Sexual networking website		724 (17.4)	650 (89.8)	74 (10.2)	<0.001
general social networking website		372 (8.9)	326 (87.6)	46 (12.4)	
Street intercept		266 (6.4)	200 (75.2)	66 (24.8)	
Geo-social sexual networking phone app		1594 (38.3)	1362 (85.4)	232 (14.6)	
Online Gay Porn sites		378 (9.1)	340 (89.9)	38 (10.1)	
panel study participants		831 (20.0)	727 (87.5)	104 (12.5)	
US Region of residence, n (%)	4165				
Northeast		996 (23.9)	824 (82.7)	172 (17.3)	<0.001
Midwest		827 (19.9)	738 (89.2)	89 (10.8)	
South		1359 (32.6)	1207 (88.8)	152 (11.2)	
West		983 (23.6)	836 (85.0)	147 (15.0)	
Race/ethnicity, n (%)	4164				
Native American / Alaskan / Hawaiian / Pacific Islander / Other		214 (5.1)	186 (86.9)	28 (13.1)	0.266
Black		336 (8.1)	278 (82.7)	58 (17.3)	
Hispanic		748 (18.0)	656 (87.7)	92 (12.3)	
Asian		167 (4.0)	146 (87.4)	21 (12.6)	
White		2699 (64.8)	2339 (86.7)	360 (13.3)	
Education, n (%)	4165				
High School Diploma, GED, or less		528 (12.7)	486 (92.0)	42 (8.0)	<0.001
Some College, Associates Degree, or currently enrolled in college		1476 (35.4)	1330 (92.1)	146 (9.9)	
4-Year College Degree or more		2161 (51.9)	1789 (82.8)	372 (17.2)	
Sexual Identity, n (%)	4165				
Gay		3407 (81.8)	2907 (85.3)	500 (14.7)	<0.001
Bisexual		671 (16.1)	617 (92.0)	54 (8.0)	
Straight		29 (0.9)	39 (100.0)	0 (0.0)	
Other		48 (1.2)	42 (87.5)	6 (12.5)	

Characteristics	TOTAL	Total	non-PrEP users 3605 (86.6%)	PrEP user 560 (13.4%)	p-Value
Social-level Characteristics					
Main Partner Status, n (%)	4165				
No Main Partner (MP)		2479 (59.5)	2128 (85.8)	351 (14.2)	<0.001
MP is HIV-positive		124 (3.0)	74 (59.7)	50 (40.3)	
MP HIV status unknown or uncertain		244 (5.9)	230 (94.3)	14 (5.8)	
MP HIV negative and on PrEP		93 (2.2)	23 (24.7)	70 (75.3)	
MP HIV negative and not on PrEP		1225 (29.4)	1150 (93.9)	75 (6.1)	
Number of partners in past 3 months, n (%)	4165				
0		574 (13.8)	550 (95.8)	24 (4.2)	<0.001
1		995 (23.9)	948 (95.3)	47 (4.7)	
2–5		1459 (35.0)	1265 (86.7)	194 (13.3)	
>5		1137 (27.3)	842 (74.1)	295 (25.9)	
Drug use in the last 3 months, n (%)	4165				
No		1273 (30.6)	1151 (90.4)	122 (9.6)	<0.001
Yes		2892 (69.4)	2454 (84.9)	438 (15.1)	
STD in past 6 months, n (%)	3487				
No		2958 (84.8)	2632 (89.0)	326 (11.0)	<0.001
Yes		529 (15.2)	356 (67.3)	173 (32.7)	
State-level Characteristics					
Equality, n (%)					
Human Rights Campaign State Equality Index[1]	4165				
Low equality		2437 (58.5)	2177 (89.3)	260 (10.7)	<0.001
High equality		1728 (41.5)	1428 (82.6)	300 (17.4)	
State Racism[1]**, n (%)**	4165				
High state racism		1950 (46.8)	1741 (89.3)	209 (10.7)	<0.001
Low state racism		2215 (53.2)	1864 (84.2)	351 (15.9)	
HIV Prevalence Rate per 100,000, n (%)					
<10.0	4165	1094 (26.3)	961 (87.8)	133 (12.2)	<0.001
10.0% – 19.9		2170 (52.1)	1852 (85.4)	318 (14.7)	
20.0% – 29.9		738 (17.7)	662 (89.7)	76 (10.3)	
30		163 (3.9)	130 (79.8)	33 (20.3)	
Poverty Rate[3]	4165				
Mean (SD)		14.7 (2.2)	14.7 (2.2)	14.8 (2.0)	0.349[*]
Median (Range)		15.3 (13.8)	15.3 (13.8)	15.4 (13.8)	
Percent Uninsured[4]	4165				
Mean (SD)		9.1 (3.4)	9.2 (3.5)	8.7 (3.3)	0.005[*]
Median (Range)		8.6 (14.3)	8.6 (14.3)	7.1 (14.3)	

[*] Wilcoxon rank sum test p-value

[1] Human Rights Campaign (HRC) state scorecard

[2] Variable created from The Geography of Racial Stereotyping: Evidence and Implications for VRA Preclearance After Shelby County

[3] 2015 US Census Bureau's American Community Survey Briefs for poverty

[4] Kaiser Family Foundation - Health Insurance Coverage of the Total Population

Table II.

Results of multilevel logistic regression models with random intercept with variables entered in blocks by level

Model Summary	Model 1	Model 2	Model 3	Model 4	Model 5
Υ^2 of random effects	0.0803	0.0160	0.0593	0.0050	0
VPC or ICC	0.024	0.005	0.018	0.002	0
MOR	1.31	1.13	1.26	1.07	1
PCV		80.1	26.1	93.8	
Fit Statistics					
AICC	3221.9	3192.54	2658.99	3255.27	2595.47
BIC	3272.34	3223.76	2680.17	3272.61	2652.97

PCV: proportional change of the variance, VPC: variance partition coefficient, ICC: intra class coefficient, MOR: median odds ratio

Table III.

Crude and covariate adjusted associations between individual, interpersonal, and structural level variables and PrEP use.

Variables	Bivariate	Model 1	Model 2	Model 3	Model 4	Model 5
	OR (CI) P-value	ICC	OR (CI) P-value	OR (CI) P-value	OR (CI) P-value	OR (CI) P-value
Individual-level Characteristics						
Age						
18–29	REF		REF			REF
30–39	**1.33 (1.05, 1.69) 0.017**		1.18 (0.93, 1.50) 0.178			**1.33 (1.02, 1.75) 0.003**
40–49	1.21 (0.93, 1.57) 0.150		1.09 (0.84, 1.43) 0.508			**1.36 (1.00, 1.83) 0.047**
>50	0.89 (0.67, 1.11) 0.238		**0.77 (0.59, 1.00) 0.050**			0.94 (0.69, 1.28) 0.705
US Region of residence						
South	REF		REF			REF
Northeast	**1.42 (0.99, 2.03) 0.055**		**1.41 (1.03, 1.94) 0.0355**			1.33 (0.82, 2.14) 0.240
Midwest	0.93 (0.66, 1.32) 0.686		0.99 (0.72, 1.36) 0.940			1.03 (0.64, 1.64) 0.917
West	1.31 (0.93, 1.84) 0.115		**1.38 (1.01, 1.86) 0.041**			1.06 (0.65, 1.73) 0.829
Race/ethnicity						
White	REF		REF			REF
Black	1.27 (0.93, 1.74) 0.128		**1.41 (1.02, 1.94) 0.0354**			1.43 (0.99, 2.05) 0.554
Hispanic	0.85 (0.66, 1.10) 0.221		0.92 (0.72, 1.30) 0.537			0.97 (0.73, 1.31) 0.859
Asian	0.83 (0.52, 1.35) 0.456		0.69 (0.42, 1.12) 0.127			0.74 (0.43, 1.27) 0.269
Native American / Alaskan / Hawaiian /Pacific Islander / Other	0.97 (0.64, 1.48) 0.900		1.01 (0.66, 1.54) 0.971			1.08 (0.68, 1.73) 0.740
Education						
High School Diploma, GED, or less	REF		REF			REF
Some College, Associates Degree, or currently enrolled in college	1.26 (0.88, 1.82) 0.210		1.23 (0.85, 1.77) 0.273			1.02 (0.68, 1.52) 0.920
4-Year College Degree or more	**2.31 (1.64, 3.24) <0.001**		**2.29 (1.61, 3.24) <0.001**			**1.76 (1.21, 2.56) 0.004**
Sexual Identity						

Variables	Bivariate	Model 1	Model 2	Model 3	Model 4	Model 5
	OR (CI) P-value	ICC	OR (CI) P-value	OR (CI) P-value	OR (CI) P-value	OR (CI) P-value
Gay	REF		REF			REF
Other	0.52 (0.39, 0.69) <0.001		0.55 (0.41, 0.74) <0.001			0.49 (0.36, 0.67) <0.001
Interpersonal-level Characteristics						
Main Partner (MP) Status						
No MP	REF			REF		REF
MP is HIV-positive	4.09 (2.78, 6.00) <0.001			4.63 (3.03, 7.09) <0.001		4.45 (2.88, 6.88) <0.001
MP HIV status unknown/ uncertain	0.36 (0.21,0.63) <0.001			0.34 (0.19, 0.61) <0.001		0.34 (0.19,0.62) <0.001
MP HIV negative and on PrEP	18.97 (11.56, 31.13) <0.001			16.30 (9.65, 27.53) <0.001		16.50 (9.66, 28.19) <0.001
MP HIV negative and not on PrEP	0.397 (0.31,0.52) <0.001			0.46 (0.35, 0.61) <0.001		0.47 (0.35, 0.62) <0.001
Number of partners in past 3 months						
0	REF			REF		REF
1	1.12 (0.68, 1.87) 0.654			1.30 (0.76, 2.24) 0.340		1.16 (0.67, 2.01) 0.597
2–5	3.51 (2.26, 5.46) <0.001			3.28 (2.08, 5.15) <0.001		3.15(1.99, 4.97) <0.001
>5	7.90 (5.11, 12.20) <0.001			6.65 (4.26, 10.39) <0.001		6.71 (4.28, 10.53) <0.001
Drug use in the last 3 months						
No	REF			REF		REF
Yes	1.64(1.31,2.04) <0.001			1.33 (1.04, 1.69) 0.022		1.27 (0.92, 1.634) 0.058
STD in past 6 months						
No	REF			REF		REF
Yes	3.97 (3.19, 4.94) <0.001			3.25 (2.55, 4.14) <0.001		3.16 (2.46, 4.06) <0.001
State-level Characteristics						
Equality HRC state **Equality Index** [1]						
Low equality	REF				REF	REF
High equality	1.71 (1.37, 2.14) <0.001				1.60(1.22,2.11) 0.001	1.57 (1.12, 2.20) 0.010
State Racism [2]						
High state racism	REF				REF	REF

Variables	Bivariate	Model 1	Model 2	Model 3	Model 4	Model 5
	OR (CI) P-value	ICC	OR (CI) P-value	OR (CI) P-value	OR (CI) P-value	OR (CI) P-value
Low state racism	**1.44(1.12, 1.86) 0.006**				1.27 (0.98, 1.65) 0.072	1.03 (0.73, 1.47) 0.085
HIV Prevalence Rate per 100,000, n (%)						
<10.0	REF				REF	REF
10.0% – 19.9	1.05 (0.78 1.43) 0.729				0.99 (0.76, 1.29) 0.930	**0.71 (0.51, 0.99) 0.045**
20.0% – 29.9	0.82 (0.54, 1.25) 0.350				1.01 (0.656, 1.54) 0.969	0.75 (0.43, 1.30) 0.299
30	**2.00 (1.12, 3.56) 0.020**				**1.81(1.11,2.96) 0.019**	1.39 (0.73, 2.62) 0.309
Poverty Rate [3]	0.99 (0.94, 1.01) 0.743				1.02 (0.97, 1.07) 0.522	1.04 (0.97, 1.11) 0.230
Percent Uninsured [4]	0.97 (0.93, 1.01) 0.132				1.00 (0.96, 1.05) 0.872	1.02 (0.96, 1.09) 0.472
Model Summary		**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
τ^2 [*]		0.080	0.016	0.059	0.005	0
VPC or ICC		2.4	0.485	1.77	0.15	0
MOR		1.31	1.13	1.26	1.07	1
PCV			80.1	26.1	93.8	0
Fit Statistic						
AICC		3221.9	3192.54	2658.99	3255.27	2595.47
BIC		3272.34	3223.76	2680.17	3272.61	2652.97

[1] Human Rights Campaign (HRC) state scorecard

[2] Variable created from The Geography of Racial Stereotyping: Evidence and Implications for VRA Preclearance After Shelby County

[3] 2015 US Census Bureau's American Community Survey Briefs for poverty

[4] Kaiser Family Foundation - Health Insurance Coverage of the Total Population

[*] Estimated variance of random effect