HHS Public Access

Author manuscript

J Acquir Immune Defic Syndr. Author manuscript; available in PMC 2024 August 26.

Published in final edited form as:

J Acquir Immune Defic Syndr. 2023 May 01; 93(1): 34–41. doi:10.1097/QAI.0000000000003160.

HIV pre-exposure prophylaxis persistence and adherence among men who have sex with men in 4 U.S. cities

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Abstract

Background: HIV pre-exposure prophylaxis (PrEP) persistence and adherence are critical to ending the HIV epidemic in the United States.

Setting: In 2017 National HIV Behavioral Surveillance, HIV-negative men who have sex with men (MSM) in 4 U.S. cities completed a survey, HIV testing, and dried blood spots (DBS) at recruitment.

Methods: We assessed three PrEP outcomes: persistence (self-reported PrEP use at any time in the past 12 months and had tenofovir, emtricitabine, or tenofovir diphosphate (TFV-DP) detected in DBS), adherence at ≥4 doses/week (self-reported past-month PrEP use and TFV-DP concentration ≥700 fmol/punch), and adherence at 7 doses/week (self-reported past-month PrEP use and TFV-DP concentration ≥1250 fmol/punch). Associations with key characteristics were examined using log-linked Poisson regression models with generalized estimating equations.

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Disclaimer: The findings and conclusions in this report are those of the author(s) and do not necessarily represent the official position of the Centers for Disease Control and Prevention. Use of trade names is for identification only and does not imply endorsement by the U.S. Department of Health and Human Services, the Public Health Service, or the Centers for Disease Control and Prevention.

Previous Meeting Presentations: Conference on Retroviruses and Opportunistic Infections, Boston/Virtual, March 8–11, 2020

Conflicts of Interest and Source of Funding: None declared.

Results: Among 391 MSM who took PrEP in the past year, persistence was 80% and was lower among MSM who were younger, had lower education, and had fewer sex partners. Of 302 MSM who took PrEP in the past month, adherence at ≥4 doses/week was 80% and adherence at 7 doses/week was 66%. Adherence was lower among MSM who were younger, were Black, and had fewer sex partners.

Conclusions: Although persistence and adherence among MSM were high, 1 in 5 past-year PrEP users were not persistent and 1 in 5 past-month PrEP users were not adherent at levels that would effectively protect them from acquiring HIV (i.e., ≥4 doses/week). Efforts to support PrEP persistence and adherence should include MSM who are young, are Black, and have less education.

Keywords

HIV; HIV pre-exposure prophylaxis; PrEP; PrEP persistence; PrEP adherence; men who have sex with men

Introduction

HIV pre-exposure prophylaxis (PrEP) is a key component to the Ending the HIV Epidemic (EHE) initiative in the United States.[1] In 2019, 70% of new HIV diagnoses were among gay, bisexual, and other men who have sex with men (MSM; 4% also reported injection drug use).[2] PrEP can reduce the risk of sexual acquisition of HIV by 99% among MSM and is therefore an important HIV prevention strategy.[3] Awareness of PrEP among MSM is high; approximately 9 in 10 MSM had ever heard of PrEP in 2017.[4] Yet, use of PrEP is substantially lower at 20–35% of MSM.[4,5]

Surveillance of PrEP has focused predominantly on awareness and use. Yet, PrEP persistence (continued use) and adherence (effective use) are also critical to prevent new HIV transmissions. PrEP persistence and adherence among MSM have mainly been reported from clinical and observational studies. Previous studies have noted that most PrEP discontinuations occurred within 1 year of starting PrEP. In a Kaiser Permanente cohort, 73% of those who began PrEP were persistent on PrEP after 1 year.[6] In the open-label PrEP Demo Project among MSM, about 78% remained on PrEP at 48 weeks.[7] One observational study of young Black MSM in the South noted that about 70% of participants had at least one period of discontinuation within the first year of initiating PrEP with the median time to first discontinuation at 5 months and final discontinuation at 7 months.[8] Pharmacy-based data on PrEP prescriptions suggest lower persistence, with only 54% of commercially insured men remaining on PrEP after 1 year.[9] While pharmacy-based data can contribute to timely ongoing monitoring of PrEP coverage in the U.S., these sources are limited in informing on demographic and risk behavior characteristics associated with persistence. To date, PrEP persistence and associated characteristics have not been widely studied as part of population-based surveillance to fill this gap.

PrEP studies have consistently signaled the importance of adherence to effectively prevent HIV acquisition.[10,11] For MSM, daily adherence to oral PrEP has been associated with a 99% HIV risk reduction and adherence at ≥4 doses per week with a 96% HIV risk

reduction.[12] In several studies including the iPrEX trial, Kaiser Permanente cohort, and PROUD study, nearly all HIV infections among MSM persistent on PrEP occurred as a result of suboptimal adherence.[10,13–15] The open-label iPrEX extension study detected any level of PrEP in 71% of participants and the Demo Project detected levels of PrEP at ≥4 doses per week among 80–86% of participants.[7,15] Despite adherence being critical to PrEP effectiveness, there is no existing national data source for monitoring PrEP adherence.

To inform on PrEP persistence and adherence among MSM, we used National HIV Behavioral Surveillance (NHBS) to pilot antiretroviral testing for PrEP in dried blood spots (DBS) in a sample of HIV-negative MSM in 4 U.S. cities. We aimed to measure prevalence of PrEP persistence, adherence at ≥4 doses per week, and adherence at 7 doses per week. We also sought to identify key characteristics associated with these outcomes and use the measures to inform a PrEP continuum for MSM.

Methods

In 2017, MSM were recruited via venue-based, time-space sampling to participate in NHBS, a cross-sectional bio-behavioral surveillance system.[16] NHBS eligibility criteria included reporting male sex at birth, identifying as male, ever having sex with another man, being 18 years of age or older, currently residing in a participating metropolitan statistical area (MSA), not having previously participated in NHBS during that year's survey, and being able to complete the interview in English or Spanish. This activity was reviewed by the Centers for Disease Control and Prevention (CDC) and was conducted consistent with applicable federal law and CDC policy (see e.g., 45 C.F.R. part 46.102(l)(2), 21 C.F.R. part 56; 42 U.S.C. §241(d); 5 U.S.C. §552a; 44 U.S.C. §3501 et seq.). NHBS activities were approved by local institutional review boards in participating cities. All participants provided informed consent and participation in NHBS was anonymous.

At the time of recruitment, eligible, consenting participants were interviewed using a standardized behavioral questionnaire and offered rapid HIV testing. DBS were also collected at this time from HIV-negative participants for antiretroviral testing for PrEP in 4 participating cities (Los Angeles, CA; San Francisco, CA; Philadelphia, PA; and Washington, DC). During 2017 data collection, the once-daily Truvada oral pill (tenofovir disoproxil fumarate (TDF) / emtricitabine (FTC)) was the only FDA-approved and CDC-recommended PrEP medication. DBS were tested by liquid chromatography mass spectrometry at the CDC's HIV Laboratory Branch. DBS from participants self-reporting PrEP use in the past 12 months were tested for extracellular tenofovir (TFV) and FTC. DBS from participants self-reporting PrEP use in the past month (i.e., last dose in past 1 month, 5 weeks, or 31 days) were also tested for intracellular tenofovir diphosphate (TFV-DP) concentrations. Our analytic dataset was limited to eligible MSM participants who consented to and completed the survey and HIV testing, reported having at least 1 male sex partner in the past year (i.e., were sexually active), did not self-report being HIV-positive, and tested HIV-negative in NHBS. Persistence and adherence outcomes also relied on participants having consented to DBS storage, provided DBS, and had valid DBS test results. Persistence was defined as having self-reported taking PrEP in the past 12 months AND having had any TFV, FTC, or TFV-DP detected in DBS. Adherence at ≥4

doses/week was defined as having self-reported taking PrEP in the past month AND having had a TFV-DP concentration of ≥700 fmol/punch in DBS (consistent with an average of 4–7 daily doses/week).[17,18] Adherence at 7 doses/week was defined as having self-reported taking PrEP in the past month AND having had a TFV-DP concentration of ≥1250 fmol/punch in DBS (consistent with an average of 7 daily doses/week).[17,18]

We evaluated associations between key covariates including demographic and sexual behavior characteristics and these outcomes. Persistence and associated characteristics were assessed among those who reported taking PrEP in the past 12 months to determine which characteristics may support or hinder continued use as detected via biological testing. Adherence and associated characteristics were assessed among those who reported taking PrEP in the past month to understand effective use for those actively on PrEP. Further, we restricted analyses of persistence and adherence to MSM who were likely indicated for PrEP and therefore may have ongoing need for PrEP. Likely indications for PrEP were based on CDC guidance circa 2017 and required meeting two self-reported criteria in the survey: 1) having an HIV-positive male sex partner at last sex or ≥2 male sex partners in the past 12 months AND 2) having condomless anal sex in the past 12 months or a bacterial STI in the past 12 months.[4,19] Log-linked Poisson regression with generalized estimating equations (GEE) that accounted for clustering by venue recruitment event and adjusted for city were used to obtain prevalence ratios (PR) and their 95% confidence intervals (CI). Three Poisson GEE multivariable models were also developed, one for each outcome. A "multiple exposures" approach was used to develop each model such that variables that had a p-value ≤0.10 in the respective city-adjusted models were included in the initial multivariable model.[20] Manual backwards elimination was then implemented to determine significant covariates that remained in the model, using an alpha level of 0.05.[20] All analyses were conducted in SAS 9.4 (SAS Institute Inc., Cary, NC).

Finally, we examined prevalence of multiple PrEP-related outcomes to inform a PrEP continuum: PrEP awareness, visit to healthcare provider in the past year, discussion of PrEP with a healthcare provider in the past year, PrEP use in the past year, PrEP persistence, PrEP adherence at ≥4 doses/week, and PrEP adherence at 7 doses/week. These outcomes were calculated for two analytic groups: (A) MSM in the analytic dataset that were likely indicated for PrEP and (B) all MSM in the analytic dataset (regardless of PrEP indications).

Results

In the 4 cities, 1,432 HIV-negative, sexually active MSM were included in the analytic dataset. Of all sexually active MSM, 71% (1,009/1,429) were considered likely indicated for PrEP, 35% (496/1,431) reported using PrEP in the past 12 months, and 28% (384/1385) reported using PrEP in the past month. Nearly all MSM likely indicated for PrEP (96%) had both condomless anal sex and ≥2 male sex partners in the past 12 months. Of MSM likely indicated for PrEP, 44% (447/1,009) reported using PrEP in the past 12 months and 37% (355/969) reported using PrEP in the past month.

There were a total of 391 MSM likely indicated for PrEP who reported taking PrEP in the past 12 months and provided DBS that had a valid result. Of these participants, 80%

were persistent on PrEP (Table 1). In bivariate analyses, MSM who were younger, had less education, had public (e.g., Medicaid) health insurance, and had fewer male sex partners experienced significantly lower PrEP persistence (Table 1). In the final multivariable model, younger age (adjusted prevalence ratio (aPR) (18–29 vs. ≥40 years)=0.9, 95% CI: 0.8–1.0), having less education (aPR(Some college or technical degree vs. College or higher)=0.8, 95% CI: 0.7–0.9), and having fewer male sex partners (aPR(1–4 vs. ≥10)=0.7, 95% CI: 0.6–0.8; aPR(5–9 vs. ≥10)=0.8, 95% CI: 0.7–1.0) remained statistically significant (Table 3).

Of 302 MSM likely indicated for PrEP who reported taking PrEP in the past month and provided DBS that had a valid result, 80% were adherent at ≥4 doses/week on average (Table 2). In bivariate analyses, MSM who were younger, were Black, had less education, and lived in Philadelphia were less likely to be adherent to PrEP at ≥4 doses/week. In the final multivariable model, only younger age (aPR(18–29 vs. ≥40 years)=0.8, 95% CI: 0.7–0.9); aPR(30–39 vs. ≥40 years)=0.8, 95% CI: 0.7–0.9) remained statistically significant (Table 3). Race/ethnicity remained in the final model because it was borderline significant at 0.05 and removing it resulted in more than a 10% change in the city prevalence ratios suggesting that both city and race/ethnicity were important factors to remain in the final model for this adherence outcome. Approximately 66% (200/302) of MSM were adherent to PrEP at 7 doses/week on average (Table 2). Similar bivariate associations were found for being adherent at 7 doses/week; MSM who were younger, were Black, had less education, and lived in Philadelphia were less likely to be adherent to PrEP at 7 doses/week. In addition, MSM who were Hispanic/Latino or had fewer male sex partners experienced lower adherence at 7 doses/week. In the final model, younger age (aPR(18–29 vs. ≥40 years)=0.8, 95% CI: 0.6–0.9), Black race/ethnicity (aPR(Black vs. White)=0.7, 95% CI: 0.5–1.0), and having fewer number of partners (aPR(1–4 vs. ≥10)=0.7, 95% CI: 0.5–1.0) remained statistically significant (Table 3).

In the context of the overall PrEP continuum, among MSM likely indicated for PrEP, 94% were aware of PrEP, 88% visited a healthcare provider in past year, 57% discussed PrEP with provider in past year, 44% used PrEP in the past year, 33% were persistent on PrEP, 27% were adherent at ≥4 doses/week, and 22% were adherent at 7 doses/week (Figure 1). Among all sexually active MSM, 91% were aware of PrEP, 85% visited a healthcare provider in past year, 47% had discussed PrEP with a healthcare provider in the past year, 35% had used PrEP in the past year, 24% were persistent on PrEP, 20% were adherent at ≥4 doses/week, and 16% were adherent at 7 doses/week.

Discussion

In our study of MSM likely indicated for PrEP in 4 U.S. cities, 80% of MSM taking PrEP in the past year were persistent on PrEP. In addition, 80% of MSM taking PrEP in the past month were adherent at ≥4 doses/week and 66% were adherent at 7 doses/week. Our results for PrEP persistence were similar to previous clinical and observational studies of MSM with estimates at 70–80%.[6–8] Collectively this may suggest that at least 1 in 5 MSM discontinue PrEP within 1 year, thus ensuring continuity of PrEP care over the first year of use could be particularly important. Our findings for adherence at ≥4 doses/week concurred with the middle range of open-label PrEP studies that noted 71–86% adherent at

this level.[7,15] While encouraging, it is still important to note that 1 in 5 MSM who reported past-month PrEP use did not have levels that would protect them from acquiring HIV.

Interventions to support ongoing communication with PrEP patients to re-assess indications and address barriers to PrEP persistence and adherence are needed, and although several are in development, only two evidence-based and two evidence-informed interventions specifically target PrEP persistence and/or adherence.[21–23] Additional strategies such as urine-based point-of-care testing could be helpful to prompt additional counseling from providers if adherence levels are below effective levels.[24] Furthermore, 1 in 3 MSM were not adherent to daily PrEP as prescribed, indicating a 14 percentage point drop from those that were adherent at ≥4 doses/week. This result may suggest needs to integrate alternative effective dosing strategies for MSM such as on-demand PrEP (i.e., PrEP 2–1-1) when patients experience persistent challenges to daily dosing and can plan for sex.[25] Understanding whether new PrEP pill regimens including tenofovir alafenamide/emtricitabine will confer effective protection from HIV infection at less-than-daily dosing will also be important. Long-acting forms of PrEP such as injectable cabotegravir may also prove useful for increasing effective use of PrEP and avoiding barriers to daily pill use.[26] Yet, such strategies would also need to be accessible and acceptable to persons who may benefit most from their use.

Our study was able to inform on key characteristics associated with PrEP persistence and adherence. Lower persistence and adherence was observed among those with fewer male sex partners which was expected; however, even MSM with 5–9 recent partners were less likely to continue PrEP and could need support restarting PrEP during periods of greater exposure or new partnerships. We also found that younger MSM experienced both lower persistence and adherence. Over the past decade, young MSM have experienced an increasing burden of new HIV diagnoses globally.[27] Although positive strides have been made in FDA approval of PrEP for young adult and adolescent MSM, clinical and public health practitioners' ability to support ongoing and effective use of PrEP among young MSM will remain paramount.[28,29] In addition, MSM who had some college or technical degree had lower persistence compared to those with a college education. Peer-to-peer networks that could increase knowledge and support for navigating barriers to PrEP use over time could be useful to reaching this group of MSM. We also observed differences by race/ethnicity. Black MSM were significantly less likely to be adherent at 7 doses/week compared to their White counterparts, though this association was only borderline significant for adherence at ≥4 doses/week. It may also be important to note that although differences by race/ethnicity were observed for adherence, they were not observed for persistence. This could suggest that Black MSM may be equally likely to continue using PrEP (i.e., have any TFV/FTC/TFV-DP detected), but may be slightly less likely to take at least 4 doses/week and less likely to take PrEP every day. Alternatively, this sample may not have been sufficiently powered to detect racial/ethnic differences in persistence. Nevertheless, these results indicate that greater adherence support for Black MSM may be needed in PrEP programs and interventions. Further, our findings highlight how alternative effective dosing strategies or additional long-acting PrEP options may have an important role to support young MSM and Black MSM in being effectively protected. Finally, though not significant in final models, we did observe some heterogeneity by city, as found in other studies.[7] As EHE initiatives are implemented

in health departments across the nation, city-specific contexts and challenges may need to be considered in local efforts to support MSM in their PrEP use and adherence.

When placed in the context of the PrEP continuum, 27% of MSM likely indicated for PrEP were adherent to PrEP at levels that would effectively prevent sexual HIV acquisition. Modeling studies have suggested that about a quarter of HIV infections could be averted among MSM over a 10-year period at the proportions we observed; and yet, this would still fall short of meeting EHE goals.[1,30,31] The largest drop in our PrEP continuum occurred between visiting a healthcare provider and discussing PrEP with a healthcare provider in the past year, signaling significant missed opportunities to inform all sexually active adults and adolescents about PrEP during provider visits. There is a need to improve patient-provider communication about PrEP, encourage providers to take regular sexual histories in a culturally-sensitive manner to assess PrEP indications, and increase providers' knowledge of and willingness to prescribe PrEP.[32] These efforts will promote discussion and uptake of PrEP and build the foundation for conversations about persistence and adherence in routine clinical monitoring for PrEP patients.

Our study had several limitations. First, our findings are not generalizable to all MSM or all venue-attending MSM in the 4 cities, as participants were recruited using venue-based sampling and data were not weighted. Second, our study was cross-sectional and cannot inform on causality or time to non-persistence or non-adherence. We acknowledge efforts to streamline taxonomy and terminology of persistence and adherence to medications, yet due to our cross-sectional design, our measure of persistence may differ from that used in cohort studies; for example, we did not observe when participants initiated PrEP and it is possible some participants started PrEP shortly before participating in NHBS and were considered persistent on PrEP but may not have been taking PrEP over the entire course of the past year.[33] Similarly, our persistence measure was based on a past-12-month timeframe and we were not able to inform on durations of continued use over longer periods. However, one strength of the design was that DBS were collected at unanticipated recruitment events unlike previous cohorts that collected samples at anticipated follow-up visits. Third, our sample size in the 4 cities was small, limiting stratified results such as by city and race/ethnicity. Fourth, self-reported behaviors are subject to social desirability and recall biases. Further, some sexual behaviors were based on last sex or past-12-month measures, which may not have overlapped in time with PrEP persistence or adherence outcomes; we used last sex measures when possible to most closely relate behaviors and DBS concentrations. Another limitation was that we did not ask about specific alternative dosing strategies, therefore we could not distinguish between those who were non-adherent and those who used a 2–1-1 strategy effectively but infrequently. Many of these areas we intend to expand upon in future data collection. Lastly, these data are from 2017 and PrEP outcomes and sexual behaviors may have changed since then, particularly as a result of new PrEP modalities that have become available and impacts of the COVID-19 pandemic; we plan to update these findings when more recent data become available.

In conclusion, persistence and adherence at ≥4 doses/week were generally high among MSM who used PrEP but relatively low among all MSM likely indicated for PrEP. Young MSM remain a critical group to focus both PrEP persistence and adherence messaging.

MSM with less than college education may benefit from programs addressing ongoing PrEP use and interventions to support adherence may be important to tailor for Black MSM and for local contexts. Improvements to patient-provider communication about sexual health and PrEP may also support increases in PrEP uptake and downstream measures of the PrEP continuum including persistence and adherence, which will remain key to achieving national EHE objectives.

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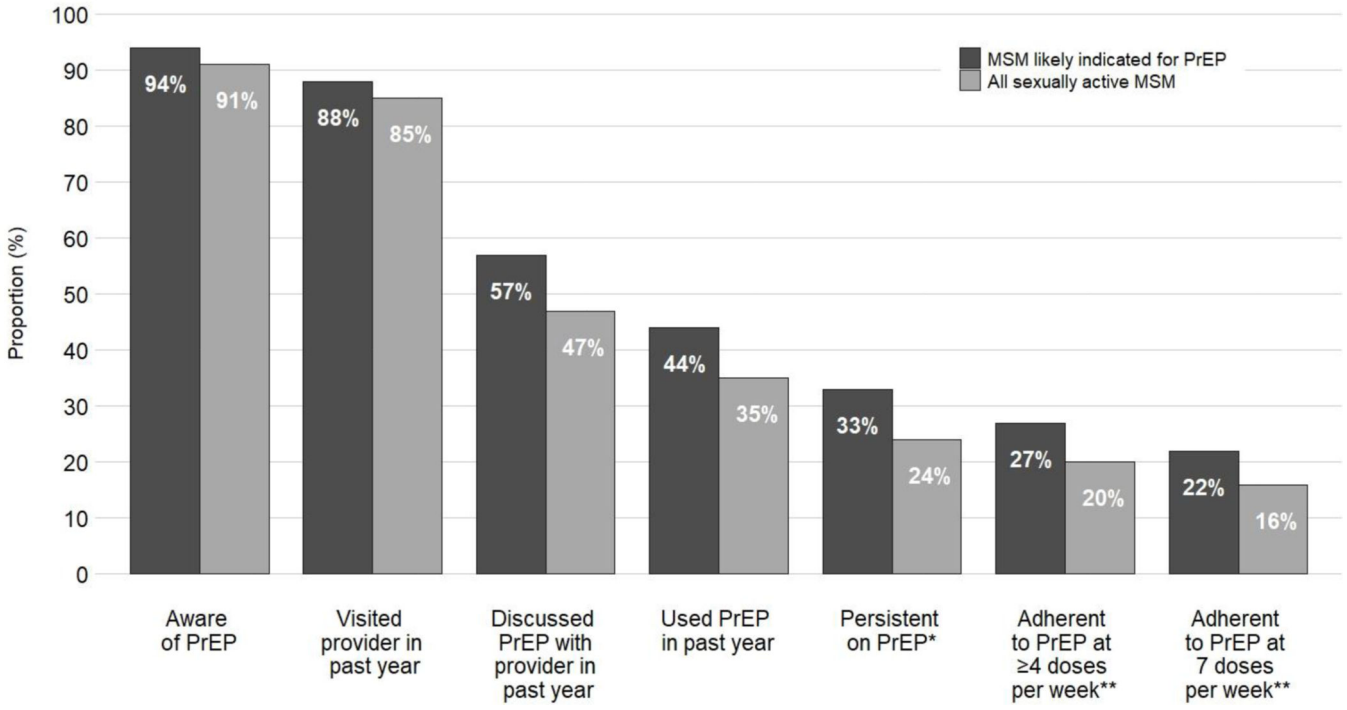

Figure 1. PrEP continuum among men who have sex with men by PrEP indication status—National HIV Behavioral Surveillance, 4 U.S. cities, 2017

Notes: MSM likely indicated for PrEP self-reported 1) having an HIV-positive male sex partner at last sex or ≥2 male sex partners in the past 12 months AND 2) having condomless anal sex in the past 12 months or a bacterial STI in the past 12 months.

*Persistence was defined as self-reporting PrEP use in the past 12 months and having any tenofovir (TFV), emtricitabine (FTC), or tenofovir diphosphate (TFV-DP) detected by liquid chromatography mass spectrometry in DBS.

**Adherent at ≥4 doses per week was defined as self-reporting PrEP use in past month and having TFV-DP detected at ≥700 fmol/punch by liquid chromatography mass spectrometry in DBS. Adherent at 7 doses per week was defined as self-reporting PrEP use in past month and having TFV-DP detected at ≥1250 fmol/punch by liquid chromatography mass spectrometry in DBS.

Table 1.

PrEP persistence and associated characteristics among HIV-negative men who have sex with men likely indicated for PrEP and who reported PrEP use in the past 12 months[1]—National HIV Behavioral Surveillance, 4 U.S. cities, 2017

	PrEP Persistence[2] (N=391)		
	n (%)	City-adjusted PR (95% CI)[3]	P-value
Age (years)			
18–29	116 (70)	0.8 (0.7, 0.9)	<0.01
30–39	132 (87)	1.0 (0.9, 1.1)	0.83
≥40	63 (86)	Referent	
Race/ethnicity			
Black/African American	53 (72)	0.9 (0.8, 1.1)	0.23
Hispanic/Latino[4]	79 (77)	0.9 (0.8, 1.0)	0.16
White	136 (85)	Referent	
Other/multiple	42 (78)	0.9 (0.8, 1.1)	0.33
Education			
High school or less	40 (67)	0.8 (0.6, 0.9)	0.01
Some college or technical degree	59 (67)	0.8 (0.7, 0.9)	<0.01
College degree or higher	212 (87)	Referent	
Household Income			
<$49,999	114 (73)	0.9 (0.8, 1.0)	0.07
$50,000 - $74,999	66 (85)	1.0 (0.9, 1.2)	0.63
≥$75,000	131 (83)	Referent	
Health insurance			
No health insurance	21 (68)	0.8 (0.7, 1.0)	0.08
Public	61 (69)	0.8 (0.7, 1.0[6])	0.02
Private[5]	227 (84)	Referent	
Sexual identity			
Homosexual	292 (81)	Referent	
Bisexual/heterosexual	18 (60)	0.8 (0.6, 1.0)	0.09
Number of male sex partners, past 12 months			
1–4	41 (58)	0.7 (0.5, 0.8)	<0.01
5–9	53 (73)	0.8 (0.7, 1.0[6])	0.02
≥10	217 (88)	Referent	
Condomless anal sex with last male sex partner			
No	113 (75)	0.9 (0.8, 1.0)	0.09
Yes	197 (82)	Referent	
HIV status of last male sex partner [7]			
HIV-negative (concordant negative)	183 (78)	Referent	

	PrEP Persistence[2] (N=391)		
	n (%)	City-adjusted PR (95% CI)[3]	P-value
HIV-positive (discordant)	30 (79)	1.0 (0.8, 1.2)	0.91
Unknown	97 (83)	1.0 (0.9, 1.2)	0.39
City			
Los Angeles	74 (81)	1.0 (0.8, 1.1)	0.72
Philadelphia	34 (68)	0.8 (0.7, 1.0)	0.10
San Francisco	122 (82)	Referent	
Washington DC	81 (79)	1.0 (0.8, 1.1)	0.55
Total[8]	311 (80)		

Abbreviations: PR=prevalence ratio, CI=confidence interval, mo=months

[1]Among participants who reported using PrEP in the past 12 months, consented to dried blood spot (DBS) storage, provided DBS, and had valid test results.

[2]Persistence was defined as self-reporting PrEP use in the past 12 months and having any tenofovir (TFV), emtricitabine (FTC), or tenofovir diphosphate (TFV-DP), and no other antiretroviral drug, detected by liquid chromatography mass spectrometry in DBS.

[3]Obtained from log-linked Poisson regression models with generalized estimating equations accounting for clustering by venue recruitment event and adjusting for city.

[4]Hispanic/Latino persons can be of any race.

[5]Those with multiple insurance coverages that included at least 1 private were classified as private.

[6]Upper confidence limit rounded up to 1.0 or p-value rounded up to 0.05.

[7]"Concordant negative" is a last male sex partner who was HIV-negative based on report by the participant who tested HIV-negative in NHBS. "Discordant" is a last male sex partner who was HIV-positive based on report by the participant who tested HIV-negative in NHBS.

[8]Numbers may not sum to total due to missing values.

Table 2.

PrEP adherence and associated characteristics among HIV-negative men who have sex with men likely indicated for PrEP and who reported PrEP use in the past month[1]—National HIV Behavioral Surveillance, 4 U.S. cities, 2017

	PrEP Adherence (N=302)					
	≥4 doses per week (TFV-DP ≥700 fmol/punch)[2]			7 doses per week (TFV-DP ≥1250 fmol/punch)[3]		
	n (%)	City-adjusted PR (95% CI)[4]	P-value	n (%)	City-adjusted PR (95% CI)[4]	P-value
Age (years)						
18–29	88 (73)	0.8 (0.7, 0.9)	<0.01	72 (60)	0.7 (0.6, 0.9)	<0.01
30–39	100 (80)	0.8 (0.8, 0.9)	<0.01	78 (62)	0.7 (0.6, 0.9)	<0.01
≥40	55 (96)	Referent		50 (88)	Referent	
Race/ethnicity						
Black/African American	33 (58)	0.8 (0.6, 1.0[6])	0.04	24 (42)	0.7 (0.5, 1.0[6])	0.04
Hispanic/Latino[5]	61 (79)	0.9 (0.8, 1.1)	0.24	47 (61)	0.8 (0.6, 1.0[6])	0.04
White	109 (87)	Referent		95 (76)	Referent	
Other/multiple	39 (93)	1.0 (0.9, 1.2)	0.37	33 (79)	1.0 (0.8, 1.2)	0.85
Education						
High school or less	26 (62)	0.8 (0.6, 1.0[6])	0.04	19 (45)	0.7 (0.5, 0.9)	0.02
Some college or technical degree	47 (76)	0.9 (0.8, 1.1)	0.23	37 (60)	0.9 (0.7, 1.1)	0.16
College degree or higher	170 (86)	Referent		144 (73)	Referent	
Household Income						
<$49,999	85 (73)	0.9 (0.8, 1.0)	0.16	67 (57)	0.8 (0.7, 1.0)	0.07
$50,000 – $74,999	53 (85)	1.0 (0.9, 1.1)	0.77	43 (69)	0.9 (0.8, 1.1)	0.54
≥$75,000	105 (85)	Referent		90 (73)	Referent	
Health insurance						
No health insurance	17 (85)	1.0 (0.9, 1.2)	0.68	12 (60)	0.9 (0.6, 1.3)	0.61
Public	45 (70)	1.0 (0.8, 1.1)	0.66	37 (58)	1.0 (0.8, 1.2)	0.79
Private[7]	179 (83)	Referent		149 (69)	Referent	
Sexual identity						
Homosexual	231 (82)	Referent		188 (66)	Referent	
Bisexual/heterosexual	12 (67)	0.9 (0.7, 1.2)	0.57	12 (67)	1.2 (0.8, 1.6)	0.39
Number of male sex partners, past 12 mo						
1–4	29 (66)	0.8 (0.7, 1.0)	0.05	20 (45)	0.7 (0.5, 1.0[6])	0.03
5–9	38 (73)	0.9 (0.8, 1.1)	0.38	33 (63)	1.0 (0.8, 1.3)	0.98
≥10	176 (85)	Referent		147 (71)	Referent	
Condomless anal sex with last male sex partner						
No	89 (81)	1.0 (0.9, 1.2)	0.53	75 (68)	1.1 (0.9, 1.3)	0.25
Yes	153 (80)	Referent		124 (65)	Referent	

	PrEP Adherence (N=302)					
	≥4 doses per week (TFV-DP ≥700 fmol/punch)[2]			7 doses per week (TFV-DP ≥1250 fmol/punch)[3]		
	n (%)	City-adjusted PR (95% CI)[4]	P-value	n (%)	City-adjusted PR (95% CI)[4]	P-value
HIV status of last male sex partner						
HIV-negative (concordant)	140 (80)	Referent		120 (69)	Referent	
HIV-positive (discordant)	22 (67)	0.9 (0.7, 1.1)	0.22	16 (48)	0.7 (0.5, 1.0)	0.07
Unknown	80 (85)	1.1 (0.9, 1.2)	0.35	63 (67)	1.0 (0.8, 1.1)	0.59
City						
Los Angeles	62 (83)	1.0 (0.8, 1.1)	0.58	54 (72)	1.0 (0.9, 1.2)	0.91
Philadelphia	21 (55)	0.6 (0.5, 0.9)	0.01	13 (34)	0.5 (0.3, 0.8)	<0.01
San Francisco	106 (87)	Referent		87 (71)	Referent	
Washington DC	54 (81)	0.9 (0.8, 1.1)	0.41	46 (69)	1.0 (0.8, 1.2)	0.71
Total[8]	243 (80)			200 (66)		

Abbreviations: PR=prevalence ratio, CI=confidence interval, mo=months

[1] Among participants who reported PrEP use in past 1 month, 5 weeks, or 31 days and who consented to dried blood spot (DBS) storage, provided DBS, and had valid tenofovir diphosphate (TFV-DP) results.

[2] Detected TFV-DP at ≥700 fmol/punch by liquid chromatography mass spectrometry in DBS.

[3] Detected TFV-DP at ≥1250 fmol/punch by liquid chromatography mass spectrometry in DBS.

[4] Obtained from log-linked Poisson regression models with generalized estimating equations accounting for clustering by venue recruitment event and adjusting for city.

[5] Hispanic/Latino persons can be of any race.

[6] Upper confidence limit rounded up to 1.0 or p-value rounded up to 0.05.

[7] Those with multiple insurance coverages that included at least 1 private were classified as private.

[8] Numbers may not sum to total due to missing values.

Table 3.

Multivariable models[1] of PrEP persistence and adherence among men who have sex with men likely indicated for PrEP—National HIV Behavioral Surveillance, 4 U.S. cities, 2017

	PrEP Persistence[2]		PrEP Adherence[3]			
			≥4 doses per week (TFV-DP ≥700 fmol/punch)[4]		7 doses per week (TFV-DP ≥1250 fmol/punch)[5]	
	aPR (95% CI)	P-value	aPR (95% CI)	P-value	aPR (95% CI)	P-value
Age (years)						
18–29	0.9 (0.8, 1.0[6])	0.04	0.8 (0.7, 0.9)	<0.01	0.8 (0.6, 0.9)	0.01
30–39	1.0 (0.9, 1.1)	0.91	0.8 (0.7, 0.9)	<0.01	0.7 (0.6, 0.9)	<0.01
≥40	Referent		Referent		Referent	
Race/ethnicity						
Black/African American	—	—	0.8 (0.6, 1.0)	0.05[7]	0.7 (0.5, 1.0[6])	0.05[6]
Hispanic/Latino[8]	—	—	1.0 (0.8, 1.1)	0.56	0.9 (0.7, 1.1)	0.21
White	—	—	Referent		Referent	
Other/multiple	—	—	1.1 (1.0, 1.2)	0.23	1.1 (0.9, 1.3)	0.40
Education						
High school or less	0.8 (0.7, 1.0)	0.08	—	—	—	—
Some college or technical degree	0.8 (0.7, 0.9)	<0.01	—	—	—	—
College degree or higher	Referent		—	—	—	—
Number of male sex partners, past 12 mo						
1–4	0.7 (0.6, 0.8)	<0.01	—	—	0.7 (0.5, 1.0[6])	0.03
5–9	0.8 (0.7, 1.0[6])	0.02	—	—	1.0 (0.8, 1.2)	0.76
≥10	Referent		—	—	Referent	
City						
Los Angeles	1.1 (0.9, 1.2)	0.27	1.0 (0.9, 1.2)	0.66	1.1 (0.9, 1.4)	0.21
Philadelphia	1.0 (0.9, 1.3)	0.68	0.8 (0.6, 1.1)	0.21	0.6 (0.4, 1.1)	0.10
San Francisco	Referent		Referent		Referent	
Washington DC	1.0 (0.9, 1.1)	0.56	1.0 (0.9, 1.2)	0.90	1.0 (0.9, 1.3)	0.66

J Acquir Immune Defic Syndr. Author manuscript; available in PMC 2024 August 26.

Abbreviations: aPR= adjusted prevalence ratio, CI=confidence interval, mo=months

[1]Poisson regression models with generalized estimating equations accounting for clustering by venue recruitment event were used to obtain aPRs, 95% CIs, and p-values. All models adjusted for city. Other variables retained in the final multivariable models were determined using a manual backwards elimination approach, starting with variables that had significant or borderline significant associations with the respective outcome ($p<0.10$) in models adjusted only for city.

[2]Among participants who reported using PrEP in the past 12 months, consented to dried blood spot (DBS) storage, and had valid test results. Persistence was defined as self-reporting PrEP use in the past 12 months and having any detected tenofovir (TFV), emtricitabine (FTC), or tenofovir diphosphate (TFV-DP) by liquid chromatography mass spectrometry in DBS.

[3]Among those who reported PrEP use in past month, consented to DBS storage, and had valid TFV-DP results.

[4]Detected TFV-DP at ≥700 fmol/punch by liquid chromatography mass spectrometry in DBS.

[5]Detected TFV-DP at ≥1250 fmol/punch by liquid chromatography mass spectrometry in DBS.

[6]Upper confidence limit rounded up to 1.0 or p-value rounded up to 0.05.

[7]Race/ethnicity was retained in the final model because it was borderline significant at 0.05 and removing it resulted in more than a 10% change in the city aPRs.

[8]Hispanic/Latino persons can be of any race.