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ORIGINAL PAPER

Changes in Sexual Behavior and STI Diagnoses Among MSM Initiating PrEP in a Clinic Setting

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Abstract

We examined changes in sexual behavior and sexually transmitted infection (STI) prevalence among 183 men who have sex with men (MSM) initiating pre-exposure prophylaxis (PrEP) at an STD Clinic in Seattle, WA. We used generalized estimating equations to measure changes in sexual behavior during PrEP use, and linked PrEP patient data with STI surveillance data to compare the prevalence of chlamydia, gonorrhea, and early syphilis in the periods prior to and during PrEP use. Reporting never using condoms in the prior 30 days increased (adjusted relative risk = 1.46; 95% confidence interval 1.13, 1.88) at 12 months after PrEP initiation compared to the initial PrEP visit. Reporting unknown status partners in the prior 30 days decreased at 12 months compared to the initial PrEP visit, but there was no change in number of sexual partners or reporting HIV-positive or HIV-negative partners. The percentage of patients diagnosed with any STI while using PrEP (49.2%) was higher than the percentage diagnosed in the 12 months prior to PrEP use (35.0%), likely driven in part by increased STI screening during PrEP use. Among MSM on PrEP, we observed decreases in condom use, and a higher prevalence of STIs during PrEP use compared to prior to PrEP initiation.

Keywords Men who have sex with men · HIV · Pre-exposure prophylaxis · Sexually transmitted infections · Sexual behavior

Introduction

Men who have sex with men (MSM) are disproportionately impacted by HIV in the United States (US), accounting for 86% of new infections among men in 2016 [1]. Pre-exposure prophylaxis (PrEP) reduces the risk of HIV acquisition in MSM by over 85% among highly adherent participants [2–4] and is now being offered routinely in many clinical settings in the US [5]. The possibility of risk compensation—an increase in risk behavior following the application of a method for risk reduction—raises concerns that there will be increases in condomless sex or number of sexual partners in populations using PrEP [6–8], which could facilitate the transmission of sexually transmitted infections (STI). Most evidence describing PrEP risk compensation comes from clinical trials of PrEP efficacy and open-label studies, which have found no evidence of increases in high-risk behavior [2, 3, 9]. However, new data from clinic-based studies shows decreased condom use and increases in some STIs among MSM using PrEP, suggesting that risk compensation may occur outside of the context of research settings [10–12]. Further, increasing bacterial STI rates in the US have reinforced concerns regarding risk compensation among MSM on PrEP. The rate of primary and secondary syphilis among men has increased 70% during the past 5 years, with an estimated 58% of cases occurring among MSM [13]. While much of this increase predated widespread adoption of PrEP, it may be that PrEP is an important factor driving changes in

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sexual behavior and associated increases in STI rates among MSM.

The Public Health – Seattle & King County (PHSKC) STD Clinic provides PrEP to patients at high risk for HIV, and collects robust sexual behavior data from PrEP patients at each clinical visit. This setting provides an opportunity to examine changes in sexual behavior and STI risk before and after the implementation of PrEP among a clinic-based population of MSM. The primary objectives of this study were to determine whether and how MSM change their sexual behavior after initiating PrEP and to examine STI diagnoses among MSM on PrEP. We hypothesized that there would be no change in number of male sexual partners or sexual position, but that MSM would be more likely to report HIV-positive and unknown status partners, and less likely to use condoms while taking PrEP. We further hypothesized that the prevalence of all STIs would be higher during PrEP use compared to the period prior to PrEP use.

Methods

Study Design, Setting and Population

This study was a secondary analysis of longitudinal data from a cohort of MSM who initiated PrEP through the PHSKC STD Clinic between October 2014 and April 2017. Per PHSKC and Washington State (WA) PrEP guidelines [14] the PHSKC STD Clinic has provided PrEP to patients at high risk for acquiring HIV since October 2014. This group includes transgender persons who have sex with men and MSM who report any of the following risk factors in the past 12 months: diagnosis of rectal gonorrhea or early syphilis; use of methamphetamine or amyl nitrites (poppers); or exchanging sex for money or drugs. PrEP is also recommended for patients who are in ongoing sexual relationships with HIV-positive partners who are not virally suppressed. STD Clinic clinicians evaluate patients for PrEP eligibility, and those who meet the recommended criteria are offered PrEP through the clinic.

At the PrEP initiation visit, patients complete a behavioral questionnaire by computer-assisted self-interview (CASI), are tested for HIV and STIs, and are given a PrEP prescription. Clinic staff verify the initial prescription fill. Patients return 1 month after PrEP initiation, then quarterly for clinical follow up and monitoring. At quarterly visits patients are tested for HIV and STIs, complete behavioral questionnaires, and receive new 3-month prescriptions for PrEP. If patients are unable to attend a follow-up appointment in person, STD Clinic clinicians can call in one 30-day prescription refill. Clinic staff attempt to determine reason for PrEP discontinuation for all patients who stop attending follow-up appointments or stop using PrEP. Patients are categorized as lost to follow-up if clinic staff are unable to reach them after three attempts.

PrEP patients were included in this analysis if they initiated PrEP during the study period, and completed a questionnaire during their initial visit and at least one follow-up visit. If patients stopped and re-started PrEP during the study period, the longest series of completed questionnaires was used. This study was approved by the University of Washington Institutional Review Board.

Data Sources and Measures

Patients complete a CASI at PrEP initiation and at quarterly follow-up visits. The CASI queries patients on aggregate sexual behavior with male partners during the prior 30 days. Data collected in the CASI include number of male sexual partners, partner HIV status (HIV-positive, HIV-negative, unknown status), sexual role (insertive, receptive) by partner HIV status, and condom use by partner HIV status and sexual role. Data on sexual role and partner HIV status are collected as yes/no, while data on condom use are collected as always/usually/sometimes/never. Condom use variables were recoded into binary categories of "ever" versus "never" for this analysis.

Data on age, race, and insurance status were obtained from electronic medical records. Data on bacterial STI diagnoses were obtained from the Public Health Issue Management System (PHIMS), the electronic STI surveillance system used in WA. WA laws require laboratories and medical providers to report all cases of chlamydia (CT), gonorrhea (GC), and syphilis to local health authorities who subsequently provide data to the WA Department of Health via PHIMS. Through PHIMS, we obtained data on all positive STI laboratory tests reported in King County. STI diagnosis (CT, GC, early syphilis (primary, secondary, or early latent)), anatomic site of infection, and diagnosis date were obtained from PHIMS, and linked to PrEP patients via deterministic matching by last name and date of birth.

HIV and STI Testing

Quarterly HIV and STI tests are recommended for all patients obtaining PrEP through the clinic, and are performed as part of routine clinical care. Patients are screened for CT and GC at each anatomic site (urethra, pharynx, rectum) based on reported exposure. Urine samples, and urethral, pharyngeal, and rectal swabs were tested for GC and CT using nucleic acid amplification testing (APTIMA Combo 2, Hologic, Inc, Marlborough, MA). Blood samples were tested for syphilis using a qualitative rapid plasma reagin test, with confirmatory tests performed using *Treponema pallidum* particle agglutination assay and, as needed, enzyme-linked immunosorbent assay (EIA). All

cases of syphilis in King County are assigned stages by a disease intervention specialist based on laboratory and clinical findings. Blood samples were tested for HIV using a fourth-generation antigen/antibody test (BioRad GS HIV Combo Ag/Ab EIA, Hercules, CA). At the initial visit, patients are also tested using an INSTI rapid antibody test (BioLytical Laboratories, Richmond, BC).

Statistical Analysis

To examine behavioral trends, we used generalized estimating equations (GEE) to model changes in self-reported sexual behavior over time. Separate models were developed for each behavior. We identified age, race, and insurance status a priori as confounders, and included them in all models. Time was included as a continuous variable, measured in days since initial questionnaire. Quadratic and cubic time variables were initially included in all models to test for nonlinear changes in behavior, but were left out of final models if they were not statistically significant. Number of male sexual partners was modeled using a Poisson distribution with exchangeable correlation structure, to obtain adjusted incidence rate ratios (aIRR) comparing each time point to the time point immediately prior. All other behaviors were modeled using log binomial distribution with exchangeable correlation structure, to obtain the adjusted relative risk (aRR) and corresponding 95% confidence interval (CI) of reporting each behavior at each time point compared with the time point immediately prior. Patients were included in the analysis even if they did not complete the CASI at all visits, but were dropped from individual models if they did not report a behavior at any of their visits. Adjusted IRR (for number of male sexual partners) and aRR (all other behaviors) were calculated for 3-, 6-, 9-, and 12-month time points compared to the initiation visit.

To explore possible increases in STI diagnosis among PrEP patients before and after PrEP initiation, we examined the burden of bacterial STIs in three distinct time periods: (1) during the 12 months prior to PrEP initiation not including the 30 days just prior to PrEP initiation (i.e., prevalent STIs); (2) during PrEP use, beginning 30 days after initiation visit through 90 days after the last in-person visit (i.e., incident STIs); and at the time of PrEP initiation, defined as 30 days prior through 30 days after the PrEP initiation visit (to capture prevalent infections that occurred around the time of PrEP initiation). STIs diagnosed within 30 days of PrEP initiation were separated to ensure that STIs acquired prior to PrEP use (that were diagnosed during PrEP initiation) did not contribute to the proportion of STIs diagnosed during PrEP use. For each time period, we calculated the proportion of patients with at least one STI diagnosis. This calculation was repeated for each STI. We used paired t-tests to compare mean number of STIs diagnosed per patient before and after PrEP initiation.

We used Stata version 13.1 (College Station, TX, USA) for all analyses. Two-sided statistical tests were performed at a significance level of 0.05.

Results

Between October 2014 and April 2017, 376 MSM were evaluated for PrEP through the PHSKC STD Clinic. Forty-two patients were excluded because they did not complete CASIs at their initial visit; an additional 138 were excluded because they had initial CASIs but no follow-up data. Of the remaining 196 patients, 93% (183 patients) had complete behavioral data available at their initial visit and at least one follow-up visit and are included in this analysis. The mean number of PrEP clinic visits for these 183 patients was 4.1 (standard deviation (SD): 2.2 visits). The mean length of time between the initial CASI and last CASI was 335 days (SD 210 days). Of the 183 patients, 134 had a visit at 3 months, 110 had a visit at 6 months, 87 had a visit at 9 months, and 63 had a visit at 12 months. The mean age of these 183 men was 31.2 years (SD 8.9). Half the patients were white, non-Hispanic, and almost 60% were on private insurance (Table 1).

Sexual Behavior

The proportion of participants reporting each sexual behavior during the 30 days prior to initial PrEP visit are included in Table 1. The majority of participants reported anal sex with HIV-negative partners, and the proportion reporting anal sex with HIV-positive or unknown status partners was 22.5% and 39.0%, respectively. At the initial visit, 13.8% of patients reported never using condoms, regardless of sexual role or partner HIV status. The mean number of male sexual partners reported at the initial visit was 4 (SD 3.7).

The absolute proportion of patients reporting anal sex with HIV-negative and HIV-positive partners remained unchanged during 12 months of follow-up, while the proportion reporting sex with unknown status partners decreased to 11% at 12 months. There were no changes in the absolute proportion of patients reporting receptive anal sex during the 12-month follow-up period, or in the proportion reporting insertive anal sex. The absolute proportion of patients reporting never using condoms overall increased to a high of 22% at 9 months and declined to 16% at 12 months. Absolute proportions in other categories of condom use followed a similar pattern of increasing through 9 months, after which the proportion appeared to level off or decrease slightly for never using condoms during receptive anal sex, and during anal sex with HIV-positive and HIV-negative partners.

Table 1 Characteristics of MSM Initiating PrEP at the PHSKC STD clinic at the time of the initial PrEP visit (N = 183)

Characteristic	N	%
Age (mean, SD)	31.2	8.9
Race/ethnicity		
White, non-Hispanic	102	55.7
Black, non-Hispanic	12	6.6
Hispanic	35	19.1
Other, non-Hispanic	34	18.6
Insurance status		
Public/patient assistance[a]	76	41.5
Private	107	58.5
Sexual behavior in past 30 days		
Number of male sex partners (mean, SD)	4.0	3.7
Receptive anal sex[b]	139	79.4
Insertive anal sex[b]	120	68.6
Any HIV+ partners[c]	37	22.5
Any HIV− partners[c]	149	90.1
Any unknown status partners[c]	64	39.0
Never used condoms, overall[c]	22	13.8
Never used condoms during receptive anal sex[c]	20	15.0
Never used condoms during insertive anal sex[c]	20	17.5
Never used condoms with HIV+ partners[c]	7	18.9
Never used condoms with HIV− partners[c]	23	15.4
Never used condoms with unknown status partners[c]	7	11.0

[a]e.g. Medicaid or drug company patient assistance

[b]The denominator (n = 175) is the number of patients who reported at least one sexual partner in the last 30 days

[c]The denominator is the number of patients who responded to the question about that sexual behavior in the past 30 days. e.g. The denominator for "Never Used Condoms during Receptive Anal Sex" (n = 133) is the number of patients who reported having receptive anal sex in the past 30 days

There was no statistically significant change in the mean number of male sexual partners reported in the past 30 days over the follow up period (Table 2). MSM were no more likely to report either HIV-positive or HIV-negative partners during PrEP use, though the adjusted relative risk of reporting partners of unknown HIV status was 0.41 (95% CI 0.29, 0.57) at the 12-month visit compared to the initial visit. MSM were no more likely to report insertive or receptive anal sex at 12 months compared to PrEP initiation. The adjusted relative risk of reporting never using condoms overall at 12 months after PrEP initiation compared to the initial visit was 1.46 (95% CI 1.13, 1.88), with similar trends in those with HIV-positive and HIV-negative partners. We also observed increases in never using condoms for receptive anal sex (aRR = 1.56; 95% CI 1.23, 1.98) and insertive anal sex (aRR = 1.32; 95% CI 1.01, 1.72) at 12 months compared to the initial visit. This finding was similar when we stratified by partner HIV status and sexual role (data not shown).

Bacterial STIs

Half the patients were diagnosed with an STI around the time of PrEP initiation (Table 3). A higher percentage of patients were diagnosed with any STI in the period during PrEP use (49.2%) than the period prior to PrEP use (35.0%). Over half of patients were diagnosed with an STI within 30 days of PrEP initiation visit. There were only slight differences in the proportion of patients with urethral GC comparing these periods. The proportion diagnosed with primary and secondary syphilis was lower in the period during PrEP use compared to before. A higher proportion of patients were diagnosed with CT during PrEP use compared to before PrEP use, which is driven primarily by a high proportion of incident rectal CT diagnoses during PrEP use. There were no MSM in our clinic diagnosed with HIV while on PrEP.

Of 183 patients, 33 (18%) had at least one STI diagnosis both during the year prior to PrEP initiation and during PrEP use. Among all 183 patients there was a significant difference in mean number of STI cases diagnosed per person prior to PrEP use compared to during PrEP use (0.5 vs. 1.1; $p < 0.001$). Among the 33 patients who were diagnosed with STIs both prior to and during PrEP use, the mean number of STI cases per person diagnosed prior to PrEP initiation was also significantly lower than the mean number of STI cases per person diagnosed during PrEP use (1.5 vs. 2.6; $p = 0.002$).

Discussion

In this clinic-based population of MSM using PrEP in Seattle, we found decreases in condom use and in reporting of unknown status partners, but no change in sexual positioning, number of sexual partners, or reporting of HIV-positive or -negative partners. Half of the PrEP patients were diagnosed with a bacterial STI while on PrEP, and the proportion of patients with STIs during PrEP use was higher than prior to PrEP use. It is unclear whether this observed difference is a result of declining condom use or other factors such as an increase in the frequency of screening for STIs. There was an overall trend toward a greater number of STIs in the period during PrEP use, and the mean number of STIs was significantly higher for the sub-set of MSM diagnosed with STIs before and during PrEP use.

Our findings are consistent with both predicted and measured behavior change reported in recent studies of PrEP in clinics or clinic systems. Among MSM using PrEP at Kaiser Permanente San Francisco, 41% of PrEP users had decreased their condom use after 6 months of PrEP use [10] and among MSM using PrEP at an STD clinic in Providence, Rhode Island, the mean number of condomless anal sex partners

Table 2 Risk of reporting sexual behaviors at each follow-up period among MSM on PrEP at PHSKC STD clinic, comparing each time point to the initial prep visit

Sexual behavior	N	3 months		6 months		9 months		12 months	
		aIRR	95% CI	aIRR	95% CI	aIRR	95% CI	aIRR	95% CI
Number of male sexual partners	183	1.01	(0.96, 1.05)	1.01	(0.93, 1.11)	1.02	(0.89, 1.17)	1.03	(0.86, 1.23)
		aRR	95% CI	aRR	95% CI	aRR	95% CI	aRR	95% CI
Partner HIV status									
Any HIV-positive partners	181	1.01	(0.96, 1.06)	1.01	(0.91, 1.12)	1.02	(0.87, 1.19)	1.02	(0.83, 1.26)
Any HIV-negative partners	181	1.00	(0.98, 1.01)	0.99	(0.97, 1.02)	0.99	(0.95, 1.02)	0.98	(0.93, 1.03)
Any unknown status partners	181	0.80	(0.74, 0.87)	0.64	(0.54, 0.76)	0.51	(0.40, 0.66)	0.41	(0.29, 0.57)
Sexual position									
Receptive	182	1.00	(0.99, 1.02)	1.00	(0.97, 1.04)	1.01	(0.96, 1.06)	1.01	(0.95, 1.08)
Insertive	182	1.00	(0.98, 1.02)	1.00	(0.96, 1.04)	1.00	(0.94, 1.06)	1.00	(0.93, 1.08)
Never uses condoms[a]									
Overall	180	1.10	(1.03, 1.17)	1.21	(1.06, 1.37)	1.33	(1.10, 1.60)	1.46	(1.13, 1.88)
During receptive anal sex	167	1.12	(1.05, 1.19)	1.25	(1.11, 1.41)	1.40	(1.17, 1.67)	1.56	(1.23, 1.98)
During insertive anal sex	152	1.07	(1.00, 1.15)	1.15	(1.00, 1.31)	1.23	(1.01, 1.50)	1.32	(1.01, 1.72)
With HIV-positive partners	76	1.08	(1.00, 1.16)	1.16	(1.00, 1.36)	1.25	(1.00, 1.58)	1.35	(0.99, 1.84)
With HIV-negative partners	176	1.08	(1.02, 1.14)	1.16	(1.03, 1.30)	1.25	(1.05, 1.49)	1.34	(1.06, 1.70)
With unknown status partners[b]	90	1.61	(1.13, 2.28)	2.07	(1.18, 3.65)	2.15	(1.10, 4.20)	1.80	(0.90, 3.58)

All estimates from GEE models, adjusted for age, race, and insurance status

aIRR adjusted incidence rate ratio, *aRR* adjusted relative risk

[a]The subcategories refer to the risk of reporting never using condoms with partners specific to each behavior category. e.g. for "During Receptive Anal Sex," this is the risk of reporting never using condoms with partners with whom the patient has engaged in receptive anal sex

[b]Quadratic time included in this model

Table 3 The proportion of MSM initiating PrEP diagnosed with STIs before and after PrEP initiation, PHSKC STD clinic (N = 183)

	12 months prior to PrEP initiation		At PrEP initiation (± 30 days)		During PrEP use[a]	
	Mean	SD	Mean	SD	Mean	SD
Number of STIs per patient	0.52	0.84	0.72	0.82	1.11	1.62
	N	%	N	%	N	%
Any STI	64	35.0	95	51.9	90	49.2
Chlamydia	28	15.3	36	19.7	62	33.9
Gonorrhea	41	22.4	67	36.6	58	31.7
Syphilis (1°, 2°, early latent)	16	8.7	21	11.5	17	9.3
Syphilis (1°, 2°)	13	7.1	15	8.2	8	4.4
Anatomic site						
Pharyngeal gonorrhea	13	7.1	33	18.0	34	18.6
Rectal gonorrhea	27	14.8	51	27.9	32	17.5
Urethral gonorrhea	15	8.2	12	6.6	17	9.3
Pharyngeal chlamydia	5	2.7	3	1.6	8	4.4
Rectal chlamydia	21	11.5	29	15.8	53	29.0
Urethral chlamydia	11	6.0	6	3.3	15	8.2

[a]Mean time on PrEP = 13 months

increased from 2.0 at initial visit to 3.3 at 6 months, though there was no change in total number of sex partners [11]. In our study, we similarly found a nearly 50% increase in condomless anal sex at 12 months compared to the initial visit and found similar increases in condomless anal sex for both receptive and insertive roles. Notably, our findings contradict several clinical trials and open-label studies that found no evidence of changes in sexual behavior among participants using PrEP [3, 9, 15, 16]. It is possible that the placebo-controlled nature of many of these trials, or uncertainty regarding the efficacy of PrEP at the time the trials were undertaken may have contributed to the absence of changes in sexual behavior observed in these studies.

We observed no change in the proportion of patients reporting HIV-positive or HIV-negative partners, but a steep decline in unknown status partners, which has not been reported in other studies. The latter finding could be either because PrEP-using MSM in our clinic are preferentially choosing sexual partners who know their own HIV status, or because they discuss HIV status with their partners more often after initiating PrEP. Additional research should be conducted to assess whether PrEP facilitates HIV serostatus discussions between sexual partners.

The proportion of patients with diagnosed STIs in our cohort differed somewhat from that reported by Marcus and colleagues' study of MSM on PrEP at Kaiser Permanente Northern California, which found that the percentage of participants with urethral GC and rectal CT doubled between initial visit and 12 months, from 0.9 to 2.5 and from 7.7 to 14.1%, respectively [12]. Our results showed a similar relative increase in the proportion of participants with rectal CT (11.5% prior to PrEP vs. 29.0% during PrEP), but not urethral GC (8.2% vs. 9.3%, respectively). Further, findings from a PrEP demonstration project in Melbourne, Australia report the proportion of patients diagnosed with at least one STI during PrEP use ranged from 25 to 35% during months 3–12 of follow-up. The proportion of patients in our cohort that were diagnosed with at least one incident STI during follow-up was somewhat higher, at 50%.

Our hypothesis that the proportion of patients with STIs would be higher during PrEP use than before PrEP use was not supported for either GC or syphilis. We observed slight increases in the proportion of participants diagnosed with rectal GC and early syphilis during PrEP compared to the year prior to PrEP use, and a high proportion of patients diagnosed with these STIs within 30 days of PrEP initiation. However, rectal GC and early syphilis are criteria for PrEP initiation at our clinic, and pre-PrEP and peri-PrEP prevalence of these infections may be inflated as a result, potentially limiting the comparability of the pre- and during-PrEP time periods. We observed a higher prevalence of CT during PrEP use, which was primarily driven by a higher prevalence of rectal CT. Because rectal CT is most often asymptomatic, it is likely that some proportion of this change is due to ascertainment bias resulting from increased testing frequency. Prevalence of urethral GC—which was essentially unchanged between the periods prior to and during PrEP use—is not among the eligibility criteria for receipt of PrEP in our clinic, and unlikely to be subject to ascertainment bias because it is usually symptomatic. Given the absence of change in proportion of patients with symptomatic STIs, it is likely that the overall higher prevalence of STIs during PrEP use is due in part to increased STI screening after PrEP initiation. Notably, we observed an increase in the mean number of STIs per patient during PrEP compared to the year prior to PrEP use, particularly among the subset of patients who experienced STI diagnoses both before and during PrEP use. However, in the absence of a control group for comparison, it is unclear whether this increase is due primarily to ascertainment bias resulting from increased testing, or a result of increases in condomless anal sex.

Our study had a number of strengths. First, our use of longitudinal data from a clinic population enabled us to study the effects of PrEP use on the sexual behavior of high-risk MSM in a non-research setting. Second, GEE models allowed for valid estimates of population-level regression coefficients despite variable length of time between clinic visits and varying length of follow-up. Third, our clinic's sexual behavior CASI is robust and includes information on condom use by partner HIV status and sexual role. Finally, access to data from our STI surveillance system enabled us to identify STI's diagnosed outside of the STD clinic for more complete ascertainment of incidence.

Our results should be interpreted in light of several limitations. First, per our clinic's eligibility criteria for initiating PrEP, MSM in this study are at higher risk for HIV and other STIs than the general MSM population. Therefore, these results may not be generalizable to the broader MSM population in Seattle or other locations. Second, the decrease in absolute proportion of patients reporting some sexual behaviors between 9 and 12 months may be an artifact of decreasing sample size. Third, while our results highlight the high rate of bacterial STIs among MSM using PrEP, our lack of a comparison group makes it difficult to determine whether or not rates would have been high in the absence of PrEP use. Fourth, the fact that diagnoses of rectal GC or syphilis in the preceding 12 months are among the eligibility criteria for PrEP initiation in our clinic may have resulted in selection bias in the comparison of GC and syphilis diagnosis rates prior to versus during PrEP use. Further, increases in the prevalence of chlamydia during PrEP use should be interpreted with caution due to ascertainment bias resulting from increased testing frequency during PrEP use.

In summary, we found that MSM decreased their use of condoms following PrEP initiation. Further, both the proportion of patients diagnosed with STIs and the mean

number of STIs per patient increased during PrEP use, although this was likely due in part to more frequent STI screening during PrEP use. In our clinic population, PrEP is functioning well as an HIV prevention tool; there were no new HIV diagnoses among MSM on PrEP during our observation period. However, even in the presence of decreasing HIV risk, behavioral changes that may increase risk of bacterial STIs are concerning. Incidence of bacterial STIs among MSM in the US have been increasing over the past decade, and STIs remain a substantial source of morbidity in this population [13, 17, 18]. King County has seen a sizeable increase in the rates of syphilis among MSM since 1997, and incidence of both GC and CT in this population have also been steadily increasing since 2008 [19]. Given our observed population-level decreases in condom use among MSM on PrEP, and the continued increases in bacterial STIs in the general population of MSM in King County, it is likely that PrEP use will be a factor contributing to rising rates of bacterial STIs among MSM in the future. Ongoing screening and treatment of STIs is both a necessary component of PrEP patient care, and a potential method for decreasing STI burden in this population in the face of decreasing condom use [20]. As we continue to roll out PrEP programs targeting MSM at high risk for HIV, it will be increasingly important to evaluate ways in which we can use PrEP programs to engage MSM in sexual health and comprehensive STI prevention programs that do not focus solely on condom use.

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Compliance with Ethical Standards

Conflict of interest CMK, MRG, LAB and LEM have received donations of specimen collection kits and reagents from Hologic, Inc. unrelated to this work. LEM has received speaker's fees from Hologic, Inc. unrelated to this work. JCD has conducted studies unrelated to this work funded by grants to the University of Washington from Hologic, Curatek, and Quidel, and has received a speaker's honorarium and travel support for a meeting on retention in HIV care from Gilead. MRG has received research support from GlaxoSmithKline. MAM, SD, and AD declare that they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent For this type of study formal consent is not required.

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