HHS Public Access

Author manuscript

AIDS. Author manuscript; available in PMC 2021 November 01.

Published in final edited form as:

AIDS. 2020 November 01; 34(13): 1951–1957. doi:10.1097/QAD.0000000000002618.

A Taxonomy of Pragmatic Measures of HIV Pre-Exposure Prophylaxis (PrEP) Use: Application in a PrEP-Using Cohort in Chicago, IL

Maria PYRA[1,2], **Laura RUSIE**[1], **Michael CASTRO**[1], **Kristin KEGLOVITZ BAKER**[1], **Moira MCNULTY**[2], **Nick BOHM**[1], **Andrei PROKURAT**[1], **John SCHNEIDER**[1,2]

[1]Howard Brown Health, 4025 Sheridan Rd, Chicago IL 60640

[2]Chicago Center for HIV Elimination, University of Chicago, 5837 S Maryland Ave, Chicago IL 60637

Abstract

Objectives: As delivery of PrEP becomes an HIV prevention priority in the U.S., standard, pragmatic measures of PrEP use are needed to compare and evaluate prevention implementation programs. By using readily available electronic health record data (EHR), we describe and compare measures of persistence and retention.

Design: Retrospective cohort

Methods: Using EHR prescription data for patients at a large urban Federally Qualified Health Center from 2015 to 2019, we calculated measures of persistence and retention and compared them to pharmacy claims data, PrEP biomarkers, and HIV outcomes.

Results: Total PrEP time was 19.8 months on average. During this period, average adherence by medication prescription ratio (MRxR) was 89%; 77% of patients had an MRxR ≥85% and 90% have an MRxR ≥57%. Over the first six months, average proportion of day covered (PDC) ≥85% was 53% and PDC ≥57% was 57%. Prescription fill rates, based on claims data from a pharmacy partner, ranged from 45% to 60%. Using tenofovir-diphosphate as the gold standard, PDC had high sensitivity (97%) but low specificity (≤13%). As a measure of retention, over the first six months, 59% of patients had quarterly HIV tests.

Conclusion: Total PrEP time is useful measure of overall persistence, while PDC can assess persistence and adherence at a specific time point. Adherence by PDC is more conservative compared to MRxR; both will overestimate true adherence. Retention in care can be measured by quarterly HIV tests. Using consistent terminology and reporting timepoints and adherence thresholds will help reporting and comparing PrEP delivery programs.

Corresponding Author: Maria Pyra, Howard Brown Health, 4025 Sheridan Rd, Chicago IL 60640, 773 388 1600, Mariap@howardbrown.org.

Conflicts of Interest:
We declare no other conflicts of interest.

Introduction

PrEP implementation is undergoing intensive scale-up as part of efforts to end the HIV epidemic (EHE). However, measures of PrEP use have largely been developed in clinical trial settings and are not accessible or comparable for real-world healthcare settings. Indeed, definitions of persistence and retention have varied widely thus far in the literature, making comparisons difficult. For instance, persistence has been assessed by medication possession ratio (MPR), proportion of days covered (PDC), and time to discontinuation [1–5]; retention has been described as quarterly visits, semi-annual visits, and quarterly HIV tests [6–10]. Adherence to long-term medications has been studied for other medical conditions and may serve as a useful guide [11–13], with some special considerations.

For the purposes of this analysis, we consider adherence broadly to be a process with specific, measurable elements[14]. First is PrEP uptake or initiation, which is not a focus of this paper. While understanding the denominator, or number of individuals who would benefit from PrEP, remains a challenge, the PrEP-to-Need ratio is a useful measure of uptake [15]. Next, adherence (sometimes referred to as execution or compliance) is how well patients actually take PrEP. There are a range of options to assess adherence, from self-report as the most subjective to biomarkers as the most objective. There are key considerations in determining how to measure PrEP adherence, including how many doses per week are needed to be effective and how to account for 2–1-1 (or event-driven) dosing strategies. Another aspect of adherence, persistence, is the length of time on PrEP [16]; discontinuation is a related concept. Questions regarding seasonal or cyclic use of PrEP can make assessing persistence and discontinuation difficult; the concept of prevention-effective adherence, or using PrEP during periods of risk, is foundational in PrEP delivery[17]. Finally, a related concept is retention, which we define as maintaining HIV prevention care, with or without PrEP use.

Our goal was to determine population-level measures of persistence and retention in order to evaluate and compare PrEP implementation programs. These measures are not intended to evaluate how an individual patient is using PrEP, which depends on their specific context and choices. An ideal measure will be accessible to various healthcare settings and can be extended to future modalities of PrEP.

Methods

EHR data was collected for all HIV-uninfected patients who received their first PrEP prescription between January 2015 and August 2018. PrEP prescriptions were defined as tenofovir and emtricitabine with no third antiretroviral (thereby excluding PEP prescriptions); for patients with a concurrent Hepatitis B diagnosis, charts were reviewed to clarify the indication. This algorithm has previously been validated [9]. All subsequent PrEP prescriptions through September 2019 were included; we also collected data on all HIV tests starting from PrEP initiation. Any patient who was ever prescribed more than 180 pills in one prescription (including refills) was excluded as an outlier.

A summary of PrEP use measures can be found in Table 1. For all the measures, we relied on prescription date, number of pills prescribed, and the number of refills; PrEP supply was the total number of pills available from each prescription (the number of pills times the number of fills). All measures were censored at HIV acquisition. Total PrEP time was calculated as the number of months from the date of the first PrEP prescription until the end of the last supply; on PrEP at six months (or 12 months) was determined as whether total PrEP time was greater or equal to the respective number of months. The medication prescription ratio (MRxR) was the total number of pills prescribed divided by total PrEP time on days; this value can exceed 100% and was therefore capped at 100% [12]; a binary measure was created to determine if MRxR was ≥85% (equivalent to six doses per week) or ≥57% (equivalent to four doses per week).

Next we calculated the proportion of days covered (PDC) for each month (see Supplemental Figure 1 for examples); this method involves moving an overlapping prescription to the end of the previous prescription, thereby extending the total length of time covered [13,18]. PDC traditionally uses >80% as a threshold [18], but given the data on effective PrEP use, we chose a cut-off of PDC for each month ≥85% (six doses per week) or alternatively ≥57% (four doses per week); we defined these as early (first six months) or late (first 12 months). These values can also be summed over the first six (or 12) months to provide a continuous value.

We also created two measures specifically of retention; for all measures, there was one-week window before or after for HIV test dates. Using total PrEP time (in quarters) as the denominator, retention over total PrEP time is the proportion of quarters with an HIV test. Consistent with PDC, we measured whether each quarter has an HIV test over the first six months (early retention) or 12 months (late retention). To note, retention over total PrEP time only includes visits during the period when a patient is on PrEP (though it includes gaps in PrEP use), while early and late retention include patients who may have completely stopped using PrEP but are still engaging in HIV prevention services. All of these measures were then compared by race/ethnic group among MSM, using Chi square tests for binary measures and Wilcoxon rank sum tests for continuous measures.

In addition, claims data from approximately 100 Walgreens pharmacies were matched to the EHR prescriptions by the date the prescription was written, with a two-week window before or after. From this, we determined how many PrEP prescriptions were actually filled, with fill rates capped at 100%. Finally, as a measure of validation, we used dried blood spots (DBS) a subset of 169 patients who had been enrolled in the first CDC PrEP implementation study (SHIPP) to compare the objective biomarker TFV-DP to PDC over the prior month. In addition, we report PrEP measures comparing patients who seroconverted while on PrEP to those who remained HIV negative, as well as the AUC for each measure; this analysis was limited to those who seroconverted after 6 months to avoid immortality bias. This study was approved by the Howard Brown Health Institutional Review Board.

Role of the Funding Source

Study sponsors were not involved in the design, analysis, interpretation of results, or writing of this report.

Results

Data were collected from 6,068 patients who ever had a PrEP prescription (Table 2). While the majority of patients were white, the proportion identifying as Latinx (21.7%) and Black/African-American (18.2%) were similar." Most patients were privately insured (including private Medicaid expansion insurance) and 26.9% were uninsured or self-pay. The majority, 89.1%, were cismen and 75.7% identified as gay. At PrEP initiation, 8% were diagnosed with chlamydia and 6% with gonorrhea. The subset of patients with DBS data were similar overall, except that they had been on PrEP longer on average. We present the examples of each PrEP measure, as well as by race/ethnicity among men who have sex with men (MSM) solely as an example and not to specifically compare across race/ethnicity.

PrEP Measures Over All Time

Total PrEP time and the related measures in Table 3 describe PrEP use over the entire duration. Overall persistence, measured by average Total PrEP Time was 19.8 months, with 79% of patients on PrEP at six months and 64% on PrEP at 12 months. During the full period of PrEP use, adherence as measured by MRxR was 89% on average; 77% of patients had an MRxR ≥85% and 90% have an MRxR ≥57%, as measures of effective adherence. Finally for retention over all PrEP use, patients had quarterly HIV tests 71% of follow-up time, on average, with little variation across groups. All measures differed significantly by race/ethnicity.

PrEP Measures at Specific Time Points

Also presented in Table 3 are PDC and related measures. Early PDC ≥85% was 53% on average, slightly less than early PDC ≥57% at 57% on average. Early PDC ≥85% was higher than late PDC ≥85%, at 32% on average. In order to compare with MRxR, we also reported average PDC, which as 81% over the first six months and 70% over the first 12 months. For all PrEP use measures, there were large racial/ethnic differences, significant at $p<0.05$. Retention was also higher over the first six months vs the first 12 months, at 59% vs 30%; there were racial/ethnic differences in retention at both time points, also at $p<0.05$.

Comparisons of Measures

Direct comparisons for some measures (for instance TPT and PDC) would not be appropriate as they capture different constructs; however Table 4 presents meaningful contrasts, although timeframes may differ across measures.". The on PrEP measure overestimates persistence relative to the PDC measures. For instance, 79% of patients are on PrEP at six months, while 57% have PDC ≥57% and 53% have PDC ≥85%. Similarly, the average MRxR (over all PrEP use) was 89%, compared to an average PDC of 81% over the first six months. The relative differences between White and Black MSM were greater for PDC measures compared to measures over all time. For instance, the odds ratio between Black and White MSM would be 0.50 (95% CI 0.42, 0.58) for PDC ≥85% and 0.68 (95% CI 0.57, 0.82) for on PrEP at 6 months. In comparing the continuous measures, the risk difference between Black and White MSM would be 9.3% (95% CI 7.3%, 11.3%) for PDC and 4.9% (95% CI 3.3%, 6.4%) for MRxR.

Claims & TFV-DP Comparisons

On average, patients filled 45% of all PrEP prescriptions, compared to Walgreens claims data. Among patients (n=3901) who filled their first PrEP prescription at a Walgreens, the average fill rate was 60% and among those whose prescription was electronically sent to a Walgreens (n=5639), the average fill rate was 51%.

There were 224 DBS samples from the first six months of PrEP use (Supplemental Table 1) from which tenofovir-diphosphate (TFV-DP) was quantified. Using a cut-off of 1050 fmol/punch [19,20], the sensitivity of PDC ≥85% in the prior month was 97% and the specificity was 7%. Similarly, using a cut-off of 700 fmol/punch, the sensitivity of PDC ≥57% in the prior month was 97% and the specificity was 13%.

Finally, we looked at HIV acquisition to understand the discriminatory values of these measures, though importantly, these are not meant to be predictive. We limited these measures to values that were calculated over the first six months only, and excluded cases that occurred during the first six months, to avoid immortality bias (i.e., HIV uninfected patients would potentially have more time on PrEP than patients censored at HIV infection) (Table 5). The proportion of patients meeting each measure was higher among those who did not acquire HIV compared to those who did seroconvert. All the metrics we compared had similar, poor area under the curves (AUC), ranging from 0.62 to 0.68 and overlapping 95% confidence intervals..

Discussion

In the analysis, we present a taxonomy of measures that can make reporting and comparing PrEP use adherence across programs more meaningful. For implementation researchers, community stakeholders, and public health departments interested in the full duration of PrEP use, total PrEP time is our recommended measure of persistence, with the understanding that it includes gaps in PrEP use. Total PrEP time is also the simplest calculation, while MRxR can easily measure adherence over the same time period. This may be appropriate when considering a prevention-effective adherence framework, in which patients are expected to start and stop PrEP in conjunction with their HIV risk [17]. However, MRxR overestimates PrEP use compared to PDC. In addition, using Total PrEP Time to calculate on PrEP at six months can results in different values depending on when the calculation is made (see Supplemental Figure 1).

We chose to report retention over the full duration of PrEP as a proportion of quarters with an HIV test rather than a binary measure of successfully having a test every quarter, given that the length of time on PrEP can vary widely and might confound retention. Furthermore, we defined retention as an HIV test rather than a follow-up visit, as HIV testing is part of the CDC recommendations [21] and follow-up visits may be defined differently at different clinics.

For programs that are further along with a focus on specific PrEP use time points, we favor PDC. Inherent in PDC, these measures include specific unit of time, with early measures defined as the first six months and late measures as the first 12 months, and include specific

level of adherence as well. While we think six months in particular is an important value to assess early drop off, we recognize that other timepoints are also valid choices and should be clearly stated in reporting results. Likewise, we set two thresholds of effective adherence - ≥85% and ≥57% - corresponding to six and four weekly doses respectively. The former is an appropriate choice for broad engagement with most populations; if a program is more specialized to focus on predominantly MSM the latter might be more appropriate. Furthermore, 2–1-1 dosing with at least one sexual encounter per week would also be captured by the ≥57% threshold; only if a large portion of the patient population was using 2–1-1 for rare sexual encounters would a lower adherence threshold be needed [22]. As non-daily regimens become more popular, specifying and reporting the adherence threshold used as well as the proportion of patients using non-daily PrEP will improve the comparability of adherence literature. More work to validate these measures and establish ideal thresholds of "success" would be valuable, especially as new formulations of PrEP become available.

It is important to consider the future of PrEP and the ability of metrics to incorporate other PrEP modalities, such as injections or implants. For instance, total PrEP time could be from first prescription of any PrEP modality to end of any PrEP supply. For PDC-based measures, we would recommend that new PrEP modalities truncate rather than extend any overlapping PrEP prescriptions, assuming patients are more likely to switch to the new prescription immediately. Finally, the smaller the unit used to assess adherence the less likely that it will hide gaps in use; for instance, there are situations where a patient would have PDC ≥85% if measured over 6 months but have PDC<85% for each individual month (Supplemental Figure 1).

We do not expect that these measures to be predictive of HIV acquisition at an individual level, which would require a much higher AUC; however we did expect that a good measure of PrEP use should relate to the primary outcome, HIV acquisition. All of these measures demonstrated evidence of this relationship with AUCs ≥0.62 and Cis excluding 0.50 (with 0.50 being non-discriminatory). Likewise, we do not expect any population to reach 100% on any of these measures; they are meant mostly for comparison.

While self-report, claims data, and biomarker data would all provide useful adherence data, we used EHR prescriptions as a common resource that many clinical settings will have access to, though non-electronic prescription data would also be sufficient for these metrics. Using one of the largest real-world PrEP cohorts, we were able to evaluate EHR data using claims and biomarker data. As expected, EHR data overestimate actual adherence; not all prescriptions are filled and not all filled prescriptions are taken. We found that at least 60% of prescriptions were picked up, though importantly prescriptions may have been filled at outside pharmacies where claims data was not available for the analyses described. When possible, reporting fill rates may help contextualize EHR-based adherence measures. Certainly, use of pharmacy claims data will require organizations without prescribers to work closely with clinics and pharmacies if these EHR-based measures are to be used. However, TFV-DP results showed that PDC over the prior month had a high sensitivity but low specificity; individuals who do not meet the PDC threshold are likely not taking the drug, while most but not all individuals who meet the PDC threshold are taking the drug.

In summary, total PrEP time most closely captures a strict definition of persistence, while PDC can assess persistence and adherence at a specific time point. PDC is a more conservative measure of adherence compared to MRxR, though it will likely still overestimate true adherence. While we did find larger differences by OR or RD across race/ethnic groups using PDC-based measures relative to Total Time/MRxR measures, these may be a function of our data rather than inherent properties of the measures and should be examined further. Retention in care can be measured by quarterly HIV tests, either over all time or at specific time points, and may be relevant for agencies that partner with clinics and have visit history data. If other choices in time point or adherence level are appropriate for a specific study, these should be clearly stated so that comparisons can still be made. Consistent PrEP use terminology and definitions will help compare PrEP outcomes as this important HIV prevention strategy is increasingly implemented within ending the epidemic contexts.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements:

MP designed the research question and conducted the analysis. LR, NB, and AP contributed to data collection. All authors contributed to writing and editing. JS was supported in part by R01 AI120700. This work was supported in part by the Third Coast Center for AIDS Research, an NIH funded center (P30 AI117943). MM was supported by K23 MH118969. The CDC foundation funded the DBS measurement of tenofovir-diphosphate, which was performed by the University of Colorado. The conclusions, findings, and opinions expressed by authors contributing to this article do not necessarily reflect the official position of the Centers for Disease Control and Prevention, Gilead Sciences, the University of Colorado or the authors' affiliated institutions.

Funding: JS was supported in part by R01 AI120700. This work was supported in part by the Third Coast Center for AIDS Research, an NIH funded center (P30 AI117943). MM was supported by K23 MH118969. The CDC foundation funded the DBS measurement of tenofovir-diphosphate, which was performed by the University of Colorado. The conclusions, findings, and opinions expressed by authors contributing to this article do not necessarily reflect the official position of the Centers for Disease Control and Prevention, Gilead Sciences, the University of Colorado or the authors' affiliated institutions.

References

1. Marcus JL, Hurley LB, Hare CB, Nguyen DP, Phengrasamy T, Silverberg MJ, et al. Preexposure Prophylaxis for HIV Prevention in a Large Integrated Health Care System: Adherence, Renal Safety, and Discontinuation. J Acquir Immune Defic Syndr 2016; 73:540–546. [PubMed: 27851714]
2. van Epps P, Maier M, Lund B, Howren MB, Beck B, Beste L, et al. Medication Adherence in a Nationwide Cohort of Veterans Initiating Pre-exposure Prophylaxis (PrEP) to Prevent HIV Infection. J Acquir Immune Defic Syndr 2018; 77:272–278. [PubMed: 29210835]
3. Krakower D, Maloney KM, Powell VE, Levine K, Grasso C, Melbourne K, et al. Patterns and clinical consequences of discontinuing HIV preexposure prophylaxis during primary care. J Int AIDS Soc 2019; 22. doi:10.1002/jia2.25250
4. Dombrowski JC, Golden MR, Barbee LA, Khosropour CM. Patient Disengagement from an HIV Pre-Exposure Prophylaxis Program in a Sexually Transmitted Disease Clinic. Sex Transm Dis 2018; 45:e62–e64. [PubMed: 29485544]
5. Spinelli MA, Scott HM, Vittinghoff E, Liu AY, Morehead-Gee A, Gonzalez R, et al. Provider Adherence to Pre-exposure Prophylaxis Monitoring Guidelines in a Large Primary Care Network. Open Forum Infect Dis 2018; 5. doi:10.1093/ofid/ofy099

6. Chan PA, Mena L, Patel R, Oldenburg CE, Beauchamps L, Perez-Brumer AG, et al. Retention in care outcomes for HIV pre-exposure prophylaxis implementation programmes among men who have sex with men in three US cities. J Int AIDS Soc 2016; 19. doi:10.7448/IAS.19.1.20903
7. Montgomery MC, Oldenburg CE, Nunn AS, Mena L, Anderson P, Liegler T, et al. Adherence to Pre-Exposure Prophylaxis for HIV Prevention in a Clinical Setting. PLoS One 2016; 11. doi:10.1371/journal.pone.0157742
8. Hevey MA, Walsh JL, Petroll AE. PrEP Continuation, HIV and STI Testing Rates, and Delivery of Preventive Care in a Clinic-Based Cohort. AIDS Educ Prev 2018; 30:393–405. [PubMed: 30332309]
9. Rusie LK, Orengo C, Burrell D, Ramachandran A, Houlberg M, Keglovitz K, et al. Preexposure Prophylaxis Initiation and Retention in Care Over 5 Years, 2012–2017: Are Quarterly Visits Too Much? Clin Infect Dis doi:10.1093/cid/ciy160
10. Zucker J, Carnevale C, Richards P, Slowikowski J, Borsa A, Gottlieb F, et al. Predictors of Disengagement in Care for Individuals Receiving Pre-exposure Prophylaxis (PrEP). Jaids Journal of Acquired Immune Deficiency Syndromes 2019; 81. doi:10.1097/QAI.0000000000002054
11. Stolpe S, Kroes MA, Webb N, Wisniewski T. A Systematic Review of Insulin Adherence Measures in Patients with Diabetes. JMCP 2016; 22:1224–1246. [PubMed: 27783551]
12. Hofmeyer BA, Look KA, Hager DR. Refill-Based Medication Use Quality Measures in Kidney Transplant Recipients: Examination of Proportion of Days Covered and Medication Possession Ratio. JMCP 2018; 24:367–372. [PubMed: 29578851]
13. CDC. Calculating Proportion of Days Covered (PDC) for Antihypertensice and Antidiabetic Medications: An Evaluation Guide for Grantees. 2015https://www.cdc.gov/dhdsp/docs/med-adherence-evaluation-tool.pdf (accessed 19 Nov2019).
14. Raebel MA, Schmittdiel J, Karter AJ, Konieczny JL, Steiner JF. Standardizing Terminology and Definitions of Medication Adherence and Persistence in Research Employing Electronic Databases: Medical Care 2013; 51:S11–S21. [PubMed: 23774515]
15. Siegler AJ, Mouhanna F, Giler RM, Weiss K, Pembleton E, Guest J, et al. The prevalence of PrEP use and the PrEP-to-need ratio in the fourth quarter of 2017, United States. Annals of Epidemiology 2018; 0. doi:10.1016/j.annepidem.2018.06.005
16. Cramer JA, Roy A, Burrell A, Fairchild CJ, Fuldeore MJ, Ollendorf DA, et al. Medication compliance and persistence: terminology and definitions. Value Health 2008; 11:44–47. [PubMed: 18237359]
17. Haberer JE, Bangsberg DR, Baeten JM, Curran K, Koechlin F, Amico KR, et al. Defining success with HIV pre-exposure prophylaxis: a prevention-effective adherence paradigm. AIDS 2015; 29:1277–1285. [PubMed: 26103095]
18. Nau DP. Proportion of Days Covered (PDC) as a Preferred Method of Measuring Medication Adherence. Pharmacy Quality Alliance
19. Castillo-Mancilla JR, Zheng J-H, Rower JE, Meditz A, Gardner EM, Predhomme J, et al. Tenofovir, Emtricitabine, and Tenofovir Diphosphate in Dried Blood Spots for Determining Recent and Cumulative Drug Exposure. AIDS Research and Human Retroviruses 2012; 29:121010062750004.
20. Anderson PL, Liu AY, Castillo-Mancilla JR, Gardner EM, Seifert SM, McHugh C, et al. Intracellular Tenofovir-Diphosphate and Emtricitabine-Triphosphate in Dried Blood Spots following Directly Observed Therapy: the DOT-DBS Study. Antimicrob Agents Chemother Published Online First: 16 October 2017. doi:10.1128/AAC.01710-17
21. Preexposure prophylaxis for the prevention of HIV infection in the United State- 2017 Update: a clinical practice guideline. Centers for Disease Control and Prevention, US Public Health Service; 2017 https://www.cdc.gov/hiv/pdf/risk/prep/cdc-hiv-prep-guidelines-2017.pdf (accessed 13 Jun2018).
22. Antoni G, Tremblay C, Delaugerre C, Charreau I, Cua E, Castro DR, et al. On-demand pre-exposure prophylaxis with tenofovir disoproxil fumarate plus emtricitabine among men who have sex with men with less frequent sexual intercourse: a post-hoc analysis of the ANRS IPERGAY trial. The Lancet HIV 2019; 0. doi:10.1016/S2352-3018(19)30341-8

Table 1.

A Taxonomy of Pragmatic PrEP Measures based on EHR data

Total Time & Related Measures				
Measure	**Definition**	**Captures**	**Best For**	**Limitations**
Total PrEP Time (TPT)	Months from 1st prescription till end of last supply *	Persistence	Describing duration of PrEP use; good for prevention-effective adherence	Includes gaps in PrEP use
On PrEP at 6 months	If TPT is ≥6 months **	Persistence	Comparing PrEP use at a particular time point	May change depending on when it is measured
Medication Rx Ratio (MRxR)	Total # pills/TPT in days; capped at 100% *	Adherence	Describing adherence for duration	Includes gaps in PrEP use & overlapping prescriptions
MRxR ≥85%	If MRR on PrEP ≥85% (equivalent to 6/7 doses) ** • *Alternative ≥57% (equivalent to 4/7 doses)*	Adherence	Comparing effective PrEP use for duration	
Quarterly Retention over Total PrEP Time	Total #quarters with an HIV test/TPT in quarters *	Retention	Describing retention for duration of PrEP use	Does not include retention after PrEP use
Proportion of Days Covered (PDC) & Related Measures				
Measure	**Definition**	**Captures**	**Best For**	**Limitations**
Early Proportion of Days Covered ≥85%	For each of the 1st 6 months, ≥85% days are covered by PrEP prescriptions ** • *Alternative ≥57% days are covered*	Persistence; Adherence	Comparing effective PrEP use at a particular time point	More complicated to calculate
Proportion of Days Covered	Number of days covered by PrEP prescriptions over the 1st 6 months, divided by 180 days *	Adherence	Describing PrEP use at a particular time point	
Early Retention	If each of the first two quarters had an HIV test **	Retention	Comparing retention at a particular time point	

* Continuous Measure

** Binary Measure

Table 2.

PrEP Patient Characteristics, Chicago 2011–2018

	Full sample (n=6068)	MSM Only (n=5247)	DBS Data (n=169)
Age			
<18	0.3% (13)	0.2% (10)	0% (0)
18–24	22.9% (1392)	21.0% (1103)	20.1% (34)
25–29	30.3% (1839)	31.0% (1625)	26.6% (45)
30–34	18.3% (1109)	19.2% (1006)	17.2% (29)
35–39	11.1% (672)	11.2% (585)	17.2% (29)
40–44	6.5% (393)	6.6% (346)	7.7% (13)
≥45	10.7% (650)	10.9% (572)	11.2% (19)
Race/Ethnicity			
White	51.7% (3138)	54.9% (2878)	53.3% (90)
Black	18.2% (1107)	15.5% (812)	16.0% (227)
Latinx	21.7% (1316)	21.6% (1131)	24.9% (42)
Asian	5.9% (355)	5.9% (310)	5.3% (9)
Unknown	2.5% (152)	2.2% (116)	0.6% (1)
Gender			
Cismen	89.1% (5408)	100% (5247)	89.4% (156)
Ciswomen	3.1% (190)	--	3.0% (5)
Transwomen	6.1% (370)	--	5.5% (14)
Transmen	1.7% (100)	--	2.8% (7)
Orientation			
Gay	75.7% (4593)	85.4% (4481)	78.7% (133)
Bisexual	8.6% (521)	7.9% (416)	8.9% (15)
Straight	5.1% (311)	0.9% (46)	3.6% (6)
Other	10.6% (643)	5.8% (304)	8.9% (15)
Insurance			
Private	57.7% (3499)	61.5% (3228)	61.5% (104)
Public	15.4% (935)	12.1% (635)	18.9% (32)
Self-pay/Uninsured	26.9% (1631)	26.4% (1383)	19.5% (33)
Baseline positive CT test	8.0% (488)	8.1% (427)	3.0% (5)
Baseline positive GC test	6.1% (365)	6.3% (332)	3.6% (6)
Baseline positive syphilis test	0% (0)	0% (0)	0% (0)
HIV acquired during observation	1.2% (75)	1.1% (59)	0.6% (1)

Table 3.

Examples of PrEP Use Measures, by Race/Ethnicity among MSM, Chicago 2011–2019

Measures Over Total Duration				
	Black (n=812)	**Latinx (n=1131)**	**White (n=2878)**	**Total (n=5247)**
Mean Total PrEP Time (SD)*	18.0 (13.7)	19.3 (14.1)	20.6 (14.3)	19.8 (14.2)
On PrEP at 6m*	75% (605)	77% (871)	81% (2333)	79% (4131)
Mean MRxR (SD)*	86% (23)	89% (21)	90% (19)	89% (20)
MRxR ≥85% on PrEP*	68% (553)	77% (866)	79% (2265)	77% (4016)
MRxR ≥57% on PrEP*	86% (702)	89% (1001)	91% (2633)	90% (4721)
Mean Quarterly Retention (SD)*	70% (23)	72% (23)	70% (22)	71% (23)
Measures at Specific Time Points				
	Black (n=812)	**Latinx (n=1131)**	**White (n=2878)**	**Total (n=5247)**
Early PDC ≥85%*	40% (325)	50% (568)	57% (1651)	53% (2758)
Late PDC ≥85%*	23% (183)	31% (345)	36% (1039)	32% (1681)
Early PDC ≥57%*	45% (362)	55% (626)	62% (1783)	57% (3008)
Late PDC ≥57%*	26% (210)	35% (401)	41% (1185)	37% (1939)
Mean Early PDC (SD)*	75% (28)	79% (27)	84% (25)	81% (26)
Mean Late PDC (SD)*	62% (32)	68% (32)	74% (30)	70% (31)
Early Quarterly Retention*	51% (418)	60% (678)	62% (1793)	59% (3114)
Late Quarterly Retention*	24% (195)	31% (352)	32% (923)	30% (1585)

* Differences between Black, Latinx & White MSM were significant ($p<0.05$) by chi square tests (for binary measures) and Wilcoxon rank sum tests (for continuous measures).

Table 4.

Comparison of PrEP Measures, by Race/Ethnicity Among MSM in the cohort, Chicago 2011–2019

	Black (n=812)	Latinx (n=1131)	White (n=2878)	Total (n=5247)
On PrEP at 6m	75% (605)	77% (871)	81% (2333)	79% (4131)
Early PDC ≥85%	40% (325)	50% (568)	57% (1651)	53% (2758)
Early PDC ≥57%	45% (362)	55% (626)	62% (1783)	57% (3008)
Mean MRxR (SD)	86% (23)	89% (21)	90% (19)	89% (20)
Mean Early PDC (SD)	75% (28)	79% (27)	84% (25)	81% (26)

Table 5.

Binary PrEP Measures & HIV Acquisition, Among All Patients

	Acquires HIV* (n=51)	No HIV (n=5994)	AUC (95% CI)
On PrEP at 6m	41.2% (21)	77.0% (4616)	0.68 (0.61, 0.75)
Early PDC ≥85%	21.6% (11)	50.1% (3002)	0.64 (0.59, 0.70)
Early PDC ≥57%	25.5% (13)	54.5% (3265)	0.64 (0.58, 0.71)
Early Quarterly Retention	33.3% (17)	57.7% (3460)	0.62 (0.56, 0.69)

*HIV acquired between 6 & 24 months after PrEP initiation.