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Cost-Effectiveness of Pre-Exposure Prophylaxis Among Adolescent Sexual Minority Males

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Abstract

Purpose: Pre-exposure prophylaxis (PrEP) has been proven safe and effective in preventing HIV among adolescent sexual minority males (ASMM), but the cost-effectiveness of PrEP in ASMM remains unknown. Building on a recent epidemiological network modeling study of PrEP among ASMM, we estimated the cost-effectiveness of PrEP use in a high prevalence U.S. setting with significant disparities in HIV between black and white ASMM.

Methods: Based on the estimated number of infections averted and the number of ASMM on PrEP from the previous model and published estimates of PrEP costs, HIV treatment costs, and quality-adjusted life years (QALYs) gained per infection prevented, we estimated the cost-effectiveness of PrEP use in black and white ASMM over 10 years using a societal perspective and lifetime horizon. Effectiveness was measured as lifetime QALYs gained. Cost estimates included 10-year PrEP costs and lifetime HIV treatment costs saved. Cost-effectiveness was measured as

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cost/QALY gained. Multiple sensitivity analyses were performed on key model input parameters and assumptions used.

Results: Under base-case assumptions, PrEP use yielded an incremental cost-effectiveness ratio of $33,064 per QALY in black ASMM and $427,788 per QALY in white ASMM. In all sensitivity analyses, the cost-effectiveness ratio of PrEP use remained <$100,000 per QALY in black ASMM and >$100,000 per QALY in white ASMM.

Conclusions: We found favorable cost-effectiveness ratios for PrEP use among black ASMM or other ASMM in communities with high HIV burden at current PrEP costs. Clinicians providing services in high-prevalence communities, and particularly those serving high-prevalence communities of color, should consider including PrEP services.

Keywords

PrEP use; Adolescent sexual minority males; Cost-effectiveness

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Adolescent sexual minority males (ASMM)—those who identify as gay or bisexual or are sexually active with other males—have a high prevalence of sexual risk behaviors that place them at high risk for HIV infection. Results from the 2017 National Youth Risk Behavior Survey of high school students aged 13–18 years showed that among those who were sexually active, the percentage of male students not using a condom during the last sexual intercourse was higher in ASMM than in non-ASMM (48.0% vs. 38.4%) [1]. In 2016, there were 1,688 HIV diagnoses in the U.S. among adolescents aged 13–19 years, of which 81% were among sexual minority males [2]. A recent Centers for Disease Control and Prevention trend analysis of national HIV surveillance data showed that the annual number of HIV diagnoses among young men who have sex with men (MSM) aged 13–29 years increased 3% per year from 2008 to 2016 [3].

Pre-exposure prophylaxis (PrEP) has been proven safe and effective in preventing HIV among adult MSM [4] and has been shown to be feasible and acceptable among young adult and ASMM [4,5]. In 2012, the U.S. Food and Drug Administration approved the use of daily tenofovir/emtricitabine (Truvada) as PrEP for adults [6] and recently approved PrEP use for adolescents [7]. Two recent modeling studies have assessed the potential epidemiologic impact of PrEP interventions on the HIV epidemic among ASMM [8,9]. Goodreau et al. [8] showed that despite relatively low adherence, PrEP use among sexually active 13- to 18-year-old ASMM in high-risk U.S settings can have a large impact on HIV incidence in this population with reasonable efficiency in terms of the number of individuals that need to be treated to avert a single infection. Drawing largely on data from Atlanta [10], Hamilton et al. [9] extended the previous model to include significant racial disparities, as often found in heavily impacted U.S. cities [11] and demonstrated that PrEP can reduce HIV incidence among both black and white ASMM but is far more efficient for black ASMM because of higher incidence [9].

In 2019, the U.S. government set a new goal to end the HIV epidemic in the U.S. within 10 years [12]. Part of the driving force behind this new initiative is that for the first time, we have safe and effective biomedical interventions for both treatment and prevention in

ART and PrEP. Although PrEP is effective in preventing HIV infections, its costs are considerably high. Prior studies on the cost-effectiveness of PrEP in MSM in the U.S. have produced mixed results [13–17]. All studies [15,16] that assessed PrEP use for the general MSM population found it not cost-effective (>$100,000 per quality-adjusted life years [QALY]). By contrast, among studies [13–16] that focused on MSM at high risk, the cost/QALY gained by PrEP was <$100,000 in three of four studies [13,15,16] but >$100,000 in one study [14]. Those studies were different in many ways, including model types, PrEP efficacy, baseline prevalence and incidence, HIV treatments costs and QALY estimates, analytical horizon, and method for calculating present values. Furthermore, none of those studies focused on PrEP use among ASMM. Although HIV incidence may be low in the general population of ASMM, it is high in certain subgroups, including black ASMM. Thus, the cost-effectiveness of PrEP use among ASMM remains unknown. Using the network modeling study by Hamilton et al. [9], we sought to assess the potential cost-effectiveness of PrEP use in black and white ASMM in high-prevalence U.S. settings with significant racial disparities.

Methods

Study design

Based on the estimated number of infections averted (NIA) and the number of ASMM on PrEP (NAP) obtained from Hamilton's model [9] and published estimates of PrEP costs, HIV treatment costs, and QALY gained per infection prevented, we estimated the cost-effectiveness of PrEP use in black and white ASMM compared with "No PrEP" over 10 years using a societal perspective and lifetime horizon. We measured effectiveness as lifetime QALYs gained associated with cases of HIV infections averted because of PrEP use. Cost estimates included 10-year PrEP costs for all ASMM on PrEP and lifetime HIV treatment costs saved associated with cases averted because of PrEP use. Cost-effectiveness was measured as cost per QALY gained. Future costs averted, and QALYs gained were discounted to present value at a 3% annual rate, and all costs were adjusted to 2017 dollars using the Medical Care component of the Consumer Price Index for Medical Care [18].

NIA and NAP

The estimates of NIA and NAP were generated from Hamilton's [9] stochastic, dynamic, network model that simulated HIV transmission of PrEP interventions over 10 years among 13- to 18-year-old black and white ASMM in high prevalence U.S. settings. Sexual relationships comprising the network were modeled using separable-temporal exponential-family random graph models [19]. Within each relationship, anal intercourse (AI), condom use, and role selection were determined stochastically. Individuals could test for HIV, initiate or terminate treatment, and initiate or terminate PrEP. Intrahost viral and vital dynamics were also modeled. The modeled population of 10,000 ASMM included 50% black and 50% white, with 7% HIV prevalence among sexually active 18-year-old ASMM. Blacks and whites represented populations with high and low HIV prevalence (12.4% and 1.4%), respectively, which was consistent with overall racial disparities in U.S. cities with the highest overall HIV burden.

Base-case PrEP scenario

The base-case PrEP scenario considered PrEP for 16- to 18-year-old ASMM, initiating PrEP 6 months after first AI, 40% coverage (40% of those meeting relevant criteria were enrolled in PrEP), and adherence profiles from the ATN113 trial [9]. The cohort adherence included 20.9%, 24.4%, 13.1%, and 41.6% of PrEP users with no measurable adherence, low (<2 pills/week), medium (2–3 pills/week), and high adherence (≥4 pills/week), respectively [5]. Per-act transmission was reduced at each adherence level by 0%, 31%, 81%, and 95%, respectively (weighted average reduction of 58%) [8]. There was no difference by race in PrEP coverage, discontinuation, or adherence. Table 1 presents the mean, the 25th, and the 75th percentile values of NIA and NAP of 100 simulation runs in each of the 10 years.

PrEP costs, HIV treatment costs, and QALYs gained

We used literature estimates [15,16,20–22] to calculate PrEP costs, medical costs saved, and QALYs gained in each PrEP scenario. For our base-case analysis, we used an annual PrEP cost of $12,376 from Juusola et al. [15], who estimated the costs of daily tenofovir-emtricitabine, five physician visits with HIV tests per year, sexually transmitted disease testing every 6 months, and renal function test annually. We used a lifetime HIV treatment cost of $478,142 and 4.45 QALYs gained from Farnham et al. [20], who estimated mean lifetime HIV treatment costs and mean lifetime QALYs lost per HIV infection assuming that all patients were infected at the age of 35 years and were diagnosed and entered care at a CD4 count of 500 cells/mL or above. In sensitivity analysis, for PrEP cost, we used the range of $5,452–$17,137 from Chen et al. [16]. For lifetime HIV treatment cost, we used an estimate of $382,170 from Hutchinson et al. [21] as the lower bound and used the estimate of $478,059 from Farnham et al. [20] as the upper bound. All costs estimates were adjusted to 2017 dollars. For QALYs gained per infection averted, we used the 4.45 QALYs from Farnham et al. [20] as the lower bound and used 6.43 QALY from Hutchinson et al. [22] as the higher bound. Key parameters used in the cost-effectiveness analysis (CEA) are summarized in Table 2. Lifetime treatment cost and QALY estimates were discounted.

Our source model [9] only measured outcomes through age 18 years, so some infections that appear to be averted in the model may actually be infections delayed until adulthood. Thus, before calculating lifetime HIV treatment costs and QALYs gained, we converted the NIA at age 18 years to the NIA over a lifetime. Hess et al. [23] assessed lifetime risk of receiving an HIV diagnosis in the U.S. if existing infection rates continue, which includes 10-year age-conditional risk of HIV diagnosis among HIV-free males and females aged 20–50 years. Based on the age- conditional risk of HIV diagnosis among black and white MSM, we estimated the lifetime probability of an 18-year-old ASMM not getting infected (Table 2) and used this probability estimate and the NIA at age 18 years to calculate the lifetime NIA.

Base-case CEA

Our base-case CEA assessed the cost-effectiveness of the base-case PrEP scenario described previously. We started from the NIA and NAP generated from the network model and calculated PrEP costs, lifetime treatment costs saved, and lifetime QALYs gained in each of the 10 years based on the lifetime NIA, the NAP, annual PrEP cost per person, lifetime HIV treatment costs per patient, and lifetime QALYs gained per infection averted. Next, we calculated the present value of all costs and QALYs in each year as well as the cumulative costs and QALYs over 10 years. Finally, we used the 10-year cumulative costs and QALYs to calculate the incremental cost-effectiveness ratio (ICER = [PrEP costs – HIV treatment costs saved]/number of QALYs gained).

Sensitivity analyses

Because of uncertainties in the key model parameter estimates used in the base-case CEA and the assumptions used in the base-case PrEP scenario, we conducted three sets of sensitivity analyses. First, a multivariate sensitivity analysis was performed to assess robustness of the base-case results to uncertainty in the four key parameter values—annual PrEP cost, lifetime HIV treatment cost, lifetime QALYs gained, and the probability of an 18-year-old ASMM not getting infected over the lifetime. Monte Carlo simulation of 10,000 trials was performed using @RISK (Palisade Corp). All key model parameter estimates were varied simultaneously and were drawn from distributions listed in Table 2. Second, the values of the NIA and NAP used in our base-case CEA were model generated and were the means of 100 simulation runs. To assess the robustness of the base-case results to the random variation in the values of these two parameters, we assessed the cost-effectiveness of the base-case PrEP scenario with the 25th percentile and the 75th percentile values of the NIA and NAP across 100 simulation runs. Third, we conducted sensitivity analyses on coverage, adherence, and eligibility criteria by assessing the cost-effectiveness of 13 additional PrEP scenarios drawn from Hamilton et al. [9]. These additional scenarios reflected variations in overall coverage level (30%, 40%, and 50%) in combination with coverage disparity by race (a 2.1-fold coverage ratio between white and black ASMM), adding adherence disparity by race (white/black ratios of 1.62 and .35 for the highest and lowest adherence levels, respectively), and changing eligibility criteria to a group at much higher risk (16- to 18-year-old ASMM with ≥ 10 acts of condomless AI (CAI) in the previous 6 months). In this analysis, besides black and white groups, we included the overall ASMM group to assess the cost-effectiveness for the entire PrEP program under each PrEP scenario.

Results

Table 3 shows the base-case CEA results. Under base-case assumptions and parameter values, PrEP use among black ASMM would save an estimated $62.2 million in HIV treatment costs and 579 QALYs at a total PrEP cost of $81.4 million over 10 years, resulting in an ICER of $33,064 per QALY gained. In contrast, PrEP use among white ASMM would save an estimated $16.8 million in HIV treatment costs and 156 QALYs at a total PrEP cost of $83.7 million over 10 years, resulting in an ICER of $427,788 per QALY gained.

In 95% of 10,000 simulation trials of the multivariate sensitivity analysis on key model parameters, the ICER of PrEP use remained <$100,000 per QALY among black ASMM (–$31,614 per QALY to $75,360 per QALY), and >$100,000 per QALY among white ASMM ($127,314 per QALY to $563,174 per QALY; result not shown). Of all four parameters examined, annual PrEP cost had the highest impact on the ICER, contributing to 94% and 89% of ICER variance in black and white ASMM, respectively (result not shown).

Table 4 shows the results of the sensitivity analysis on NIA and NAP estimates. PrEP use among black ASMM would result in an ICER of $98,785 per QALY when the 25th percentile values of NIA and NAP were used and $301 per QALY when the 75th percentile values of both parameters were used. PrEP use among white ASMM would result in an ICER of $1,190,247 per QALY when the 25th percentile values were used and $227,357 per QALY when 75th percentile values were used.

Table 5 shows the cost-effectiveness results of all 14 PrEP usage scenarios. At all combinations of coverage, adherence, and eligibility, the ICERs of PrEP use remained <$100,000 per QALY ($10,461–$45,274 per QALY) among black ASMM and >$100,000 per QALY ($372,306–$576,783 per QALY) among white ASMM. The ICER of the entire PrEP program was >$100,000 per QALY in all 14 scenarios except one—when PrEP was used among ASMM with the greatest risk (≥10 acts of CAI in the previous 6 months) and both race groups had 40% coverage. The impact of coverage and adherence disparities on the cost-effectiveness of PrEP use was much smaller in black ASMM than in white ASMM. When switching PrEP eligibility from initiating PrEP 6 months after first AI to having 10 or more acts of CAI in the previous 6 months, ICERs were reduced substantially in both groups and in all coverage and adherence scenarios.

Discussion

Our study fills a void in the literature by assessing the potential cost-effectiveness of PrEP use in ASMM. Our analysis demonstrated that in higher prevalence U.S. settings, compared with “No PrEP,” PrEP use in 40% of ASMM aged 16–18 years who had initiated AI would cost $33,064 per QALY gained in black ASMM and $427,788 per QALY gained in white ASMM. Although there is no official, single cost per QALY threshold for cost-effectiveness in the U.S., a cost-effectiveness standard of $100,000 per QALY has been frequently cited in cost-effectiveness studies [24]. From our base-case analysis, the ICER of PrEP use was <$100,000 per QALY in black ASMM and >$100,000 per QALY in white ASMM. Our base-case findings were essentially unchanged in the face of wide-ranging sensitivity analyses. The ICER of PrEP use in black ASMM remained <$100,000 per QALY in all scenarios considered, including those with coverage and adherence disparities by race. In contrast, the ICER of PrEP use in white ASMM remained >$100,000 per QALY in all scenario considered. Although prioritizing PrEP for ASMM with the greatest risk (with 10 or more acts of CAI in the previous 6 months) would improve cost-effectiveness in both racial groups, the ICER remained >$100,000 per QALY in white ASMM. The ICER of the entire PrEP program was >$100,000 per QALY in all 14 PrEP scenarios except one—when PrEP was used among ASMM with the greatest risk (with 10 or more acts of CAI in the previous 6 months) and both race groups had 40% coverage. The findings of this study suggested that PrEP use in ASMM at high risk can be a cost-effective HIV prevention intervention at current PrEP costs.

Our sensitivity analysis on key model parameters showed that of all four parameters examined, annual PrEP cost had the highest impact on the ICER, contributing to 94% and 89% of ICER variance in black and white ASMM, respectively. Because of such findings, we furthered our base-case analysis to analyze at what PrEP cost (holding all other parameters at the base-case value) the ICER of PrEP use in white ASMM and overall ASMM will be <$100,000 per QALY. We found that if PrEP cost decreases by 60% (<$4,978), then the ICER in white ASMM would be <$100,000 per QALY. At the same time, if PrEP cost declines by only 8% (<$11,440), then ICER in overall ASMM would be <$100,000 per QALY. If generic forms of PrEP are available in the U.S., it is highly likely that the entire PrEP program be <$100,000 per QALY.

Compared with earlier studies that focused on MSM at high risk [13–15], our findings are generally consistent with the analyses that considered secondary HIV transmission averted. For instance, Desai et al. [13] found that PrEP use would cost $32,000 per QALY gained in a population of MSM at high risk in New York City with an initial prevalence of 14.6% and incidence of 1.35%. Juusola et al. [15] found that PrEP use would cost $172,091 per QALY gained in 20% of the general MSM population, and it would cost approximately $50,000 per QALY gained in a population of MSM at high risk with an initial prevalence of 20% and incidence of 2.3%. By contrast, our findings differ from earlier analyses of PrEP use among MSM at high risk that ignored secondary HIV transmission averted. For instance, the study by Paltiel et al. [14] found that PrEP use would cost $298,000 per QALY gained in a population of MSM at high risk with an annual incidence of 1.6%. Our study did not aim to examine whether considering secondary HIV transmission averted in mathematical models impacts cost-effectiveness of PrEP use. Yet, our results call for a rigorous analysis of this phenomenon in the future.

Similar to any model-based CEA, our study has some limitations. First, the original study simulated the population of 10,000 ASMM, which resulted in small changes in the number of incident cases. Furthermore, the combination of very high HIV treatment costs, very low incidence, and significant model stochasticity could have generated large increases in ICER under slight increases in coverage in white ASMM (e.g., from 40% to 41%). Despite the impact of model stochasticity, the ICER of PrEP remained >$100,000 per QALY among whites in all the tested scenario, whereas it remained <$100,000 per QALY among blacks in all. Second, there were uncertainties in the key parameter estimates used for the cost-effectiveness analyses as well as in the PrEP program parameters (coverage, adherence, and disparities in coverage and adherence by race). Third, because of lack of empirical data, we assumed that lifetime HIV treatment costs and QALYs lost per infection are the same regardless of age of acquiring HIV. Consequently, we did not consider the benefit of delayed infections, which may bias the results against PrEP for young ASMM. Fourth, because of lack of available data, we assumed independence between adolescent PrEP use and later adult lifetime HIV risk. Fifth, we did not consider risk compensation in this study, which would decrease the cost-effectiveness of PrEP in this or any population. However, a previous study by Chen et al. [16] showed that including risk compensation has a very small effect on the cost-effectiveness of PrEP use.

Because of these limitations, we have carefully conducted three sets of sensitivity analyses, aimed to assess robustness of our base-case results, and concluded that PrEP use was consistently <$100,000 per QALY in black ASMM and consistently >$100,000 per QALY in white ASMM regardless of changes in key model parameter values and PrEP program parameter values. There have been considerable concerns about the uptake and adherence of PrEP among ASMM because of multiple factors, including developmental, psychosocial, socioeconomic, and structural variables [25]. Our study demonstrated that even at relatively lower coverage (19.4%) and lower adherence (30.9% had no measurable adherence and 31.7% had high adherence), PrEP use in black ASMM could be <100,000 per QALY because of the high incidence in this population.

Although we parameterized the model with race-specific differences in uptake and adherence using data from clinical trials, the race-specific differences in outcomes of the model can largely be explained by disparities in HIV incidence. Thus, race in this model is a social construct that serves as a proxy for both individual- and community-level factors that place someone at increased risk for HIV. It is possible that PrEP is >$100,000 per QALY for certain black ASMM but <$100,000 per QALY for certain white ASMM because of individual differences in circumstances. Clinicians, in deciding whether a patient is a good candidate for PrEP, should not simply consider the patient's race but rather look holistically at the patient's risk behavior, partner characteristics, and community HIV profile.

In summary, our study demonstrated that PrEP use among ASMM at high risk can be cost-effective in high-prevalence U.S. settings. These results can help health care providers, insurance providers, and public health authorities understand the potential cost-effectiveness of PrEP scale-up in ASMM and make more informed clinical decisions and decisions regarding coverage and resource allocation. Our study suggests that clinical providers and institutions that primarily serve black youth in settings with high overall HIV prevalence and large racial disparities—as is common in many counties targeted for the Ending the HIV Epidemic efforts—should consider PrEP as a key component of HIV prevention services for ASMM they serve. Broader PrEP campaigns may include informational and marketing materials targeting black ASMM. Providing access and improving adherence to PrEP for ASMM in high-prevalence communities, especially in high-prevalence communities of color, have the potential to greatly reduce HIV incidence in this population and do so in a cost-effective manner. Given that the new initiative of Ending the HIV Epidemic aims to reduce new infections by 90% in 10 years and emphasizes PrEP use as the key prevention strategy for high-risk groups [12], improving access and adherence for ASMM at high risk should be considered a public health priority. Further innovation in PrEP adherence strategies is needed, including strategies specifically designed for adolescents. In addition, with the growth in the number of ASMM using PrEP, PrEP could become a useful tool for addressing racial disparities in HIV, given the higher HIV incidence among black ASMM.

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IMPLICATIONS AND CONTRIBUTION

The recent Ending the HIV Epidemic initiative aims to reduce new infections by 90% in 10 years. The findings of this cost-effectiveness study support pre-exposure prophylaxis use among adolescent sexual minority males in communities with high HIV burden. Clinicians providing services in high-prevalence communities should consider including pre-exposure prophylaxis services.

Table 1

Number of infections averted and number of ASMM on PrEP over 10 years[a]

Year	Black						White					
	NIA			NAP			NIA			NAP		
	Mean	25th percentile	75th percentile	Mean	25th percentile	75th percentile	Mean	25th percentile	75th percentile	Mean	25th percentile	75th percentile
1	21	12	28	720	709	730	4	2	7	767	756	776
2	24	14	33	741	732	752	4	1	7	768	759	777
3	24	15	31	752	741	762	3	0	6	769	758	780
4	26	19	34	754	743	763	5	4	8	769	756	780
5	25	16	33	753	742	764	5	2	7	769	761	779
6	26	18	32	752	739	765	4	2	7	771	760	782
7	26	19	36	753	741	763	4	1	7	770	762	780
8	28	23	34	754	744	763	4	1	6	771	761	784
9	27	18	35	754	742	763	6	3	9	770	758	784
10	25	15	36	754	739	766	4	2	7	770	758	782
10-y cumulative	251	169	332	7,488	7,372	7,591	44	18	71	7,695	7,591	7,803

ASMM = adolescent sexual minority males; NAP = number of ASMM on PrEP; NIA = number of infections averted; PrEP = pre-exposure prophylaxis.

[a]The mean, 25th percentile, and 75th percentile values of NIA and NAP were the results of 100 simulation runs.

Table 2

Key parameter estimates used in cost-effectiveness analyses

Parameter	Base-case value	Sensitivity range	Source	Distributions
Annual PrEP cost ($)	12,376	5,452–17,137	Juusola 2012 [15], Chen 2014 [16]	Gamma (α = 4, β = 2,853)
Lifetime treatment cost saved per case of HIV averted ($)[a]	478,142	382,170–478,142	Farnham 2013 [20], Hutchinson 2006 [21]	Gamma (α = 50, β = 9,632)
QALYs gained per case of HIV averted[a]	4.45	4.45–6.43	Farnham 2013 [20], Hutchinson 2010 [22]	Gamma (α = 10, β = .4)
Lifetime probability of an 18-year-old not getting infected				
Black ASMM	.592	.591–.644	Calculated based on estimates from Hess 2017 [23]	Beta (α = 7, β = 5)
White ASMM	.916	.914–.917	Calculated based on estimates from Hess 2017 [23]	Beta (α = 55, β = 5)

ASMM = adolescent sexual minority males; PrEP = pre-exposure prophylaxis; QALY = quality-adjusted life years.

[a] Lifetime HIV treatment costs saved and QALYs gained per case of infection averted were discounted. All costs were in 2017 dollars.

Table 3

Base case cost-effectiveness analysis results

Year	Black ASMM				White ASMM			
	PrEP costs ($)	Lifetime treatment costs averted ($)[a]	Lifetime QALYs gained[a]	ICER ($/ QALY gained)	PrEP costs ($)	Lifetime treatment costs averted ($)[a]	Lifetime QALYs gained[a]	ICER ($/ QALY gained)
1	8,916,437	5,822,546	54.19		9,490,205	1,769,431	16.47	
2	8,906,283	6,617,560	61.59		9,231,334	1,700,886	15.83	
3	8,776,044	6,283,405	58.48		8,966,204	1,403,644	13.06	
4	8,539,999	6,623,654	61.65		8,707,172	2,068,190	19.25	
5	8,283,667	6,330,134	58.91		8,458,090	1,945,689	18.11	
6	8,031,371	6,387,490	59.45		8,231,114	1,564,107	14.56	
7	7,801,862	6,163,517	57.36		7,984,423	1,536,891	14.30	
8	7,589,310	6,460,415	60.13		7,759,780	1,371,048	12.76	
9	7,363,724	6,131,474	57.06		7,526,922	1,991,485	18.53	
10	7,149,336	5,393,177	50.19		7,305,548	1,443,397	13.43	
10-y cumulative	81,358,034	62,213,372	579.01	33,064	83,660,791	16,794,768	156.31	427,788

ASMM = adolescent sexual minority males; ICER = incremental cost-effectiveness ratio; PrEP = pre-exposure prophylaxis; QALY = quality-adjusted life years.

[a]Costs averted and QALYs gained were discounted to present value at a 3% rate.

Table 4

Results of sensitivity analysis on NIA and NAP[a]

	Black ASMM		White ASMM	
	25th percentile value	**75th percentile value**	**25th percentile value**	**75th percentile value**
PrEP costs ($)	80,097,883	82,476,372	82,530,747	84,828,878
Lifetime treatment cost averted ($)	41,731,126	82,246,082	6,833,454	27,223,859
Lifetime QALYs gained	388	765	64	253
ICER ($/QALY gained)	98,785	301	1,190,247	227,357

ASMM = adolescent sexual minority males; ICER = incremental cost-effectiveness ratio; NAP = number of ASMM on PrEP; NIA = number of infections averted; PrEP = pre-exposure prophylaxis; QALY quality-adjusted life years.

[a]The cost-effectiveness was assessed using the 25th and 75th percentile values of NIA and NAP of 100 simulation runs.

Table 5

Cost-effectiveness results of multiple PrEP scenarios

PrEP scenario	Coverage (%)			Adherence			Eligibility	ICER ($/ QALY)	ICER ($/ QALY)	ICER ($/ QALY)
	All	Black	White	All	Black	White		Black	White	All
1 (base-case)	40	40	40	20.9%, 24.4%, 13.1%, 41.6%[a]			Aged 16–18 and AI experienced	33,064	427,788	116,971
2	30	19	41					29,275	539,573	188,016
3	40	26	54					33,469	558,259	196,249
4	50	32	68					31,525	576,626	194,419
5	30	19	41	20.9%, 24.4%, 13.1%, 41.6%	30.9%, 18.7%, 18.7%, 31.7%	10.9%, 18.8%, 18.8%, 51.5%		33,616	473,581	184,166
6	40	26	54					41,637	466,783	192,680
7	50	32	68					45,274	512,706	204,084
8	40	40	40	20.9%, 24.4%, 13.1%, 41.6%			Aged 16–18 and 10+ CAI in last 6 mo	17,008	372,306	91,782
9	30	19	41					10,461	456,654	148,477
10	40	26	54					15,411	485,126	159,256
11	50	32	68					14,488	513,673	160,067
12	30	19	41	20.9%, 24.4%, 13.1%, 41.6%	30.9%, 18.7%, 18.7%, 31.7%	10.9%, 18.8%, 18.8%, 51.5%		31,550	403,256	168,700
13	40	26	54					22,640	427,013	160,793
14	50	32	68		31,871	452,017	176,344			

AI = anal intercourse; CAI = condomless anal intercourse; ICER = incremental cost-effectiveness ratio; PrEP = pre-exposure prophylaxis; QALY = quality-adjusted life years.

[a]The cohort adherence included 20.9%, 24.4%, 13.1%, and 41.6% of PrEP users with no measurable adherence, low (<2 pills/wk), medium (2–3 pills/wk), and high adherence (>4 pills/wk), respectively.