Title

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Distribution of behavioral patterns prior to infection among San Francisco men who have sex with men newly infected with HIV in 2014

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Abstract

Background—Despite continued reductions in the number of HIV cases reported among San Francisco men who have sex with men (MSM) and the HIV-prevention potential offered by pharmaceutical tools such as pre-exposure prophylaxis (PrEP), there are uncertainties, particularly given reported decreases in consistent condom use. A key uncertainty is what groups of MSM should be targeted. The present study estimates the distribution of behavioral patterns prior to infection among San Francisco MSM newly infected with HIV in 2014.

Methods—We used a novel modeling approach. The approach uses estimates from the National HIV Behavioral Surveillance System for MSM, the Medical Monitoring Project, two trials of PrEP, and a meta-analysis of per-act risks of HIV infection.

Results—The modeling study suggests that 76% of newly HIV-infected MSM in 2014 were individuals with no discernible strategy in the 6 months prior to infection: that is, they had condomless receptive anal intercourse with one or more partner not perceived to be HIV-uninfected. An estimated 7% of newly infected MSM were serosorters prior to infection.

Conclusions—Prevention efforts in San Francisco must reach HIV-uninfected MSM with no discernible behavioral strategy, a group that constitutes 8% of HIV-uninfected MSM in the city. Our study suggests that if all HIV-uninfected, San Francisco MSM with no discernible strategy

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had been on PrEP in 2014, there would have been 70% fewer HIV infections among San Francisco MSM. Uncertainty analysis suggests that PrEP's impact may be maximized by encouraging PrEP persistence and concomitant reductions in sexual risk behaviors.

Keywords

HIV prevention; men who have sex with men (MSM); condom use; serosorting; seroadaptive behaviors; pre-exposure prophylaxis (PrEP)

INTRODUCTION

In San Francisco, a majority of HIV infections occur among men who have sex with men (MSM). Non-injecting MSM made up 69% of the 255 HIV cases newly reported in the health jurisdiction in 2015, while MSM who inject drugs made up an additional 10% of reported cases.[1] The 177 cases reported among non-injecting MSM in 2015 represent a 51% decrease since 2006.[1]

Despite continued reductions in the number of HIV cases reported among San Francisco MSM[1] and the HIV-prevention potential offered by pharmaceutical tools such as pre-exposure prophylaxis (PrEP), there are uncertainties and areas of concern, particularly given reported decreases in consistent condom use among HIV-uninfected San Francisco MSM.[2] A key uncertainty is what groups of MSM, if any, should be targeted by prevention efforts, whether for PrEP or for other behavioral changes. Indeed, the Centers for Disease Control and Prevention (CDC)'s recommended indications for PrEP use among MSM include various overlapping behaviors, such as condomless anal intercourse or having an HIV-infected partner.[3,4]

The focus of the present study is estimating the distribution of behavioral patterns prior to infection among San Francisco MSM newly infected with HIV in 2014. In other words, our quantities of interest are the prevalences of prior-to-infection behavioral patterns, as shown in Figure 1 and further explained in the Methods section, among San Francisco MSM newly infected with HIV in 2014. Such quantities have been elusive. Though numerous prior studies have estimated risks,[5,6] relative risks,[7] or odds ratios[8,9] of HIV infection associated with behaviors, we are not aware of any study that has estimated our quantities of interest, and certainly not for the same population and time period. One study estimated population-attributable fractions,[10] but this measure is the proportion of additional infections attributable to the exposure, not the percent of newly infected individuals who had the exposure. Additionally, this study did not examine serosorting, an increasingly popular behavioral pattern among San Francisco MSM[2] involving only having intercourse with partners perceived to be HIV-concordant.

The scarcity of information on the quantities of interest is not due to lack of interest. Officials and researchers have hypothesized, and sometimes assumed, that HIV infection primarily occurs among high-risk MSM. However, it is in fact alternatively possible that infection mostly occurs among relatively low-risk MSM, since there are more low-risk MSM in San Francisco than high-risk MSM[2] (we elaborate on risk behaviors in the next

section). Clarification of this uncertainty could help lead to targeted prevention efforts among San Francisco MSM.

We present here a novel modeling approach to estimate the distribution of behavioral patterns prior to infection among San Francisco MSM newly infected with HIV in 2014, a year in which roughly 10% of HIV-uninfected San Francisco MSM accessed PrEP.[2] A key feature of our study is that it uses a mutually exclusive classification of behavioral patterns that includes increasingly popular behaviors[2] such as serosorting and PrEP use. As a secondary aim, we estimated the probabilities of infection associated with these groups.

METHODS

Though the research question is fairly simple, it can not be directly answered via data. Surveys of newly HIV-infected individuals are challenging and a longitudinal study would require a large population since the incidence rate in the population is low.[11] Thus, to address the research question, we used a data-informed modeling approach.

Data

Table 1 summarizes the model's data sources.

We primarily relied on data from San Francisco's third (MSM3) and fourth (MSM4) implementations of the CDC's National HIV Behavioral Surveillance for MSM. Recruitment occurred via time-location sampling, and captured diverse samples of MSM believed to be generalizable to adult MSM who visit venues included in the sampling frame; these include bars or dance clubs, parks and street locations, cafes and restaurants, and social organizations.[12] Sampling for MSM3 and MSM4 took place in 2011 and 2014, respectively. The University of California, San Francisco's Committee on Human Research reviewed and approved both studies. Participants verbally provided informed consent to an interviewer-administered behavioral survey and HIV testing. We only used data from MSM who reported being HIV-uninfected, under the rationale that perceived status, not true infection status, is what informs behavior; this left 353 individuals from MSM3 and 279 individuals from MSM4.

The surveys collected detailed information from each respondent on up to five recent sexual partnerships. Questions regarding the HIV statuses of the sexual partners allowed respondents to indicate that a partner was HIV-infected, HIV-uninfected, or had an unknown status (whether because the status was unknown to the partner or because it was unknown to the respondent). We defined potentially HIV-infected partners as HIV-infected or unknown-status partners.

The information collected in the partnership assessment allowed for measurement of the 7 hierarchically defined behavioral patterns considered in the study (Figure 1): accessing PrEP at least once, no anal intercourse, 100% condom use (not having condomless anal intercourse), serosorting (not having anal intercourse with potentially HIV-infected partners), condom serosorting (not having condomless anal intercourse with potentially HIV-infected partners), seropositioning (not having receptive anal intercourse with potentially

HIV-infected partners), and no discernible strategy (having condomless receptive anal intercourse with potentially HIV-infected partners). We placed PrEP at the top of the hierarchical definition because we thought it would be useful to refer to sexual behaviors among individuals who did not access PrEP. The survey did not assess for frequency or persistence of PrEP use. Serosorting and seropositioning are often termed seroadaptive behaviors.[13,14] The names of these categorizations are consistent with prior literature[2,13,14]; our use does not imply that the patterns always result from intent. Similarly, by design, the behavioral classifications reflect the HIV-infected individuals' perspectives; these are not necessarily consistent with reality or risk reduction. For example, serosorting can involve error (as explained in the following section, we do allow for such error to occur). Likewise, seropositioning may coincidentally involve selection of a relatively large proportion of non-virally-suppressed HIV-infected partners (as explained below, we assigned viral suppression using stratified estimates from the Medical Monitoring Project).

Additional questions in the survey—involving demographics, sexual behaviors, and sexual infection—permitted measurement of indication for PrEP use (ie, possible eligibility for PrEP use), as defined via two methods proposed by the CDC: an assessment tool and a risk index.[3,4]

Several additional estimates supplemented the primary data. We used estimates of prevalences of durable viral suppression (viral load less than 200 copies/ml, consistently across time) from the MSM subset of the CDC's 2014 implementation of the Medical Monitoring Project.[15] We used 3 prevalence estimates (Alison Hughes, PhD, email communication, 2016): one for all main partnerships (68.4%), one for casual partnerships involving condomless receptive anal intercourse (63.2%), and one for casual partnerships not involving condomless receptive anal intercourse (84.4%).

To capture the effect of accessing PrEP at least once, we used estimates of PrEP efficacy obtained from two large clinical trials among MSM: 43.9% and 86.7%.[16,17] For the main component of our analysis, we used the midpoint between the two efficacy estimates, 65.3%. We believe this value to be consistent with what might be expected with moderate-to-high levels of PrEP persistence. For comparison, the iPrEx trial estimates that if the medication is used on at least 90% of days, efficacy is 73%, slightly higher than our midpoint of 65.3%. Moreover, 7% of individuals in our sample who accessed PrEP did not report receiving it from a provider, implying low persistence for at least 7% of the group.

We used estimated per-act risks of HIV infection reported in a recent meta-analysis.[18] Our model allows for transmission via 4 types of sexual contact with HIV-infected, virally nonsuppressed partners: condomless receptive anal intercourse (per-act risk of 1.38%), condom-protected receptive anal intercourse (0.28%), condomless insertive anal intercourse (0.11%), and condom-protected insertive anal intercourse (0.02%). Finally, we used an estimated population size, 44,161, from a recent modeling study.[19]

Model

In short, we simulated a population of HIV-uninfected MSM and randomly assigned behavioral groups (Figure 1) using individual-level data from MSM4. Using partnership-

level data from MSM3 and MSM4, we then randomly assigned sexual partnerships, including partnership characteristics and 6 months of sexual behaviors. Using prevalence estimates from MSM4, we allowed for unrecognized infection among partners reported as being HIV-uninfected and imputed infection for unknown-status partners. We imputed viral suppression of HIV-infected partners using stratified estimates from the Medical Monitoring Project.[15] Finally, using the behavioral data and estimates for per-act risks of HIV infection[18] and PrEP efficacy,[16,17] we mathematically computed probabilities of HIV infection. A lengthier description of the model follows.

We simulated a population of 44,161 HIV-uninfected MSM, randomly jointly assigning a behavioral pattern (Figure 1) and indications for PrEP use to each individual, using estimates from MSM4. Essentially, we simply resampled individuals from MSM4 with replacement.

We then randomly assigned a categorized number of sexual partners to each individual conditionally on behavioral group, using multinomial distributions and group-specific probability estimates from MSM3 and MSM4. If an individual had 6 or more sexual partners, we randomly assigned the number of partners by randomly generating from a standard uniform distribution and applying the random value to a linear-spline fit of the MSM3- and MSM4-based cumulative distribution function for the individual's behavioral group (each fit is simply a series of straight lines through the observed distribution points).

We randomly assigned partnership data from MSM3 and MSM4, by partnership, to each simulated individual, conditionally on behavioral group and number of partners. In other words, for each simulated partnership for each simulated individual, we randomly sampled a partnership from the pool of partnerships reported by survey respondents with the same behavioral group and categorized number of partners as the simulated individual.

If a simulated individual had more than 5 sexual partners, we randomly sampled additional partnerships from the set of casual partners reported by respondents of the same behavioral group as the individual of interest. The sampling process takes advantage of the pool of reported partnerships, rather than assuming mixing patterns for partnership formation.

Because MSM3 and MSM4 assessed HIV statuses of sexual partners via respondent report, misclassification and missingness were possible. We assumed that partners reported as being infected were in fact infected. However, for each partner reported as being uninfected, we randomly imputed HIV infection using a Bernoulli distribution and a probability equal to the MSM4-estimated prevalence of unrecognized infection among self-reported HIV-uninfected MSM. Similarly, for each partner reported as having an unknown HIV status, we randomly imputed HIV infection using a Bernoulli distribution and a probability equal to the MSM4-estimated prevalence of HIV.

As MSM3 and MSM4 did not elicit information regarding antiretroviral use among HIV-infected sexual partners, we randomly assigned durable viral suppression using Bernoulli distributions with probability estimates from the Medical Monitoring Project. As explained in the Data subsection, we used 3 prevalence estimates (for each of 3 probability distributions), defined by partnership type (main or casual) and the occurrence of condomless receptive anal intercourse. We did not allow partners with unrecognized

infection—ie, partners reported as being uninfected who were in fact infected—to be virally suppressed.

We allowed for error in the reporting of numbers of sexual acts. Specifically, if the number of reported acts exceeded 10, we randomly assigned the number of acts using a normal distribution with a mean equal to the self-reported count and a standard deviation equal to 10% of the mean.

We computed each simulated individual's probability of infection using per-act risks of infection and the number of sexual acts with HIV-infected partners who were not durably virally suppressed. As explained in the Data subsection, we allowed for HIV infection via 4 types of sexual contact with virally nonsuppressed HIV-infected partners: condomless receptive anal intercourse, condom-protected receptive anal intercourse, condomless insertive anal intercourse, and condom-protected insertive anal intercourse. We assumed that per-act risks of infection are equal to 0 via sex with HIV-uninfected partners or virally suppressed HIV-infected partners. We accounted for PrEP efficacy among individuals who accessed PrEP by multiplying the probability of infection by 1 minus the efficacy. Finally, we randomly assigned each individual's infection status using a Bernoulli distribution and the individual's calculated probability of infection.

A mathematical description of the model is provided in the Supplemental Digital Content.

In our primary set of analysis, we used constant values for the probability distributions' parameters, using estimates from the aforementioned data sources. We repeated the modeling exercise 1,000 times, and report the means of output values across replications. We conducted all analysis in R.

In our uncertainty analysis, described in the following subsection, we allowed the probability distributions' parameters to vary across simulation runs.

Uncertainty analysis

For our uncertainty analysis, we used Latin hypercube sampling[20] to allow values of some of the probability distributions' parameters to vary across simulation runs. Computational demands limited the number of parameters we were able to include in the analysis. In reducing the possible list, we prioritized parameters that were likely to impact HIV transmission, based on current scientific understanding. Additionally, we favored parameters that have estimates that originate from relatively small samples or are not within 0.01 of 0 or 1 on a probability scale.

Ultimately, we selected 6 distributional parameters (Table 2): (1) the prevalence of no discernible strategy among MSM who accessed PrEP at least once, (2) the prevalence of HIV among unknown-status partners, (3) the prevalence of recognized infection among HIV-infected MSM, (4) the prevalence of viral suppression among HIV-infected partners with whom condomless receptive anal intercourse (C-RAI) occurred, (5) the per-act risk of HIV infection via C-RAI with an HIV-infected person who is not virally suppressed, and (6) PrEP efficacy.

We used a triangular distribution for each of the 6 parameters (Table 2). In most cases, we allowed the mode to be the point estimate for the parameter and the distributional limits to be the 95% confidence intervals. In the case of PrEP efficacy, we allowed the mode to be the midpoint between two published estimates[16,17] and the limits to be the two point estimates.

We used 75 parameter combinations, with 50 replications per parameter combination. We computed the 2.5th and 97.5th percentiles of the means of the replications, which we report as the 95% uncertainty intervals accompanying the point estimates from the primary analysis. Additionally, we computed partial rank correlation coefficients between the parameters and output values. We conducted all analysis in R.

RESULTS

The modeling exercise suggests that the incidence rate of HIV infection among San Francisco MSM in 2014 was 0.6 (95% interval from uncertainty analysis: 0.5–0.7) per 100 person-years. With rounding, this matches a previously published estimate for the same population and year.[11] Assuming a population size of 44,161 HIV-uninfected MSM, our study suggests 255 non-injecting MSM were infected in 2014. In comparison, the number of cases reported in 2014 among non-injecting San Francisco MSM was 225.[1]

Table 3 summarizes the distribution of behavioral patterns prior to infection among San Francisco MSM newly infected with HIV in 2014. It also shows the distribution of the groups among all HIV-uninfected San Francisco MSM in 2014, estimated from MSM4. On average, the modeling exercise suggests that 76.4% (95% interval: 72.6–80.0%) of newly infected San Francisco MSM in 2014 were individuals with no discernible strategy prior to infection. An estimated 7.4% (95% interval: 6.3–8.0%) of newly infected MSM in 2014 were serosorters prior to infection while an estimated 8.0% (95% interval: 3.8–12.7%) were individuals who accessed PrEP at least once prior to infection.

Table 4 presents the probability of infection for various behavioral groups. The modeling exercise suggests that MSM with no discernible strategy had a 2.9% (95% interval: 2.5–3.5%) probability of becoming infected HIV over a 6-month period in 2014. Serosorters had a 0.1% (95% interval: 0.0–0.1%) probability of infection while individuals who accessed PrEP at least once had a 0.2% (95% interval: 0.1–0.4%) probability of infection.

DISCUSSION

Our study suggests that newly infected San Francisco MSM are overwhelmingly individuals who had no discernible HIV-risk-reduction strategy prior to infection. This finding suggests that HIV prevention in San Francisco must reach HIV-uninfected MSM with this behavioral pattern. Possible interventions for this risk group, which made up an estimated 8% of HIV-uninfected San Francisco MSM in 2014, include PrEP or seroadaptive behaviors such as serosorting. Indeed, our study suggests that if all HIV-uninfected MSM with no discernible strategy had been on PrEP in 2014 we would have seen a 70% lower number of infections among MSM in San Francisco. Similarly, if all HIV-uninfected MSM with no discernible strategy had been serosorters, we would have seen a 75% lower number of infections.

Our research not only finds that most newly infected MSM are individuals who had no discernible strategy prior to infection, but also that the risk associated with the behavioral pattern is quite high: 3% over 6 months or 6% over 1 year. This is fairly consistent with the probability implied in a study of Seattle MSM,[21] and provides further support for the notion that HIV prevention in San Francisco should reach no-discernible-strategy MSM: such a strategy would have relatively high positive predictive value. No other pattern in our analysis, including either of the CDC's suggested indications for PrEP use, appears as predictive of infection. Indeed, we suggest that no discernible strategy might be used as a possible primary indication for PrEP use, particularly if positive predictive value is valued.

Our results also provide insight on seroadaptive behaviors such as sersorting. Though more than one third of HIV-uninfected San Francisco MSM in 2014 were serosorters, only 7% of San Francisco MSM newly infected with HIV in 2014 were serosorters prior to infection. In congruence with some prior studies,[22] our study suggests that though serosorting is indeed risky, the risk of infection associated with the pattern is relatively low: a probability of 0.1% over one year.

Meanwhile, we estimate that 8% of San Francisco MSM newly infected with HIV in 2014 used PrEP at least once in the year preceding infection. This estimate is consistent with a recent study that found that 9% of newly infected MSM at a clinic in Rhode Island had accessed PrEP.[23] Additionally, our study suggests that individuals who accessed PrEP had a 0.5% probability for HIV infection over a one-year period in 2014. This estimate is congruent with findings from randomized controlled trials of PrEP in MSM populations: the PROUD trial suggests a 1.2% risk over one year[17] while the cumulative probability of infection in the first year of follow-up of the iPrEx trial appears to be roughly 2%.[16] Encouragingly, a study of PrEP-initiating MSM at Kaiser Permanente Medical Center in San Francisco found no new infections, but the upper bound of the study's one-year risk estimate was 1%,[24] above our estimate of 0.5%.

Assuming a population size of 44,161 HIV-uninfected MSM, our study suggests that 38 HIV infections were prevented among San Francisco MSM in 2014 due to PrEP efficacy, corresponding to a hypothetical reduction of 13 percentage points. In comparison, San Francisco saw 21.9% fewer infections among non-injecting MSM between 2013 and 2014 (a drop from 288 reported cases to 225).[1] Two findings from our uncertainty analysis suggest that further work could increase PrEP's impact, as measured by the proportion of newly infected individuals who had accessed PrEP and the risk of infection associated with the PrEP group. First, partial rank correlation coefficients (PRCC) in the uncertainty analysis suggest that increases in efficacy result in increases in PrEP's impact (the absolute values of the PRCC are 0.94 and 0.93). As we view changes in efficacy as reflecting changes in average levels of medication persistence, this finding highlights the importance of PrEP persistence. Second, partial rank correlation coefficients suggest that reducing the prevalence of no discernible strategy in the PrEP group also increases PrEP's impact (absolute values of the PRCC: 0.95 and 0.94). Together, the two findings underscore the importance of two key components of the CDC guidelines for PrEP use: persisting with PrEP and accompanying PrEP use with reductions in risk behaviors[3]; no other factor considered in the uncertainty analysis has as large of an impact on the PrEP findings. Data show that there is room for

improvement in San Francisco on at least one of the two components: a San Francisco clinic reported fairly high levels of medication persistence among PrEP-initiating MSM and transgender men, but increases in condomless anal intercourse.[25]

Models require simplification of complex real-world processes. One possible target of scrutiny is our assumption of constant per-act risks. Indeed, several studies have suggested that per-act risks of infection vary across individuals.[6,26,27] In an additional sensitivity analysis (results not shown), we allowed the per-act risks to vary from individual to individual by adding normally distributed random errors, with standard deviations equal to the standard errors reported in the recent meta-analysis.[18] This sensitivity analysis suggests no meaningful impact of the assumption of constant per-act risks on any of the study's findings. Another possible focus of curiosity is our assumption of no risk of infection via sex with virally suppressed partners. This assumption is not technically supported: the meta-analysis suggests, for example, that the risk of infection via one act of C-RAI with a virally suppressed partner is 0.06%.[18] This represents relatively low risk: it is one 23rd of the review's estimated risk via C-RAI with a nonsuppressed partner. Nevertheless, we did perform sensitivity analysis allowing for risk via sex with virally suppressed partners. This analysis resulted in no meaningful change in any of the findings (results not shown).

Our uncertainty analysis, presented throughout the Results via the 95% uncertainty intervals, addressed limitations of the MSM3 and MSM4 surveys as data sources for this study: error or missingness in the reporting of HIV statuses of sexual partners and the absence of assessment of viral suppression among sexual partners or PrEP persistence among respondents. We included other areas of possible scrutiny in or uncertainty analysis as well, including per-act risks of infection and the MSM4-derived sexual behaviors among individuals who accessed PrEP. The analysis consistently shows that our results are fairly robust to the inputs.

Our findings have important implications for HIV prevention among MSM, clearly suggesting that prevention efforts in San Francisco must reach HIV-uninfected MSM with no discernible strategy. These individuals, who may be identified in provider settings via brief behavioral assessments (perhaps even using diagrams such as Figure 1), should be encouraged to adopt harm-reduction behaviors such as PrEP use, condom use, or serosorting —all of which carry lower risks of infection than no discernible strategy. Indeed, the relatively high risk associated with no discernible strategy makes the behavioral pattern a possible indication for PrEP use. Finally, our uncertainty analysis is congruent with CDC recommendations[3,4] in finding that the impact of PrEP uptake can be maximized by increasing PrEP persistence and decreasing sexual risk behaviors among PrEP users. We recommend further research in other settings and time periods (given differences in sexual behaviors, HIV treatment, and PrEP use across communities and time), as well as studies regarding possible barriers to PrEP persistence or risk reduction among HIV-uninfected MSM with no discernible strategy.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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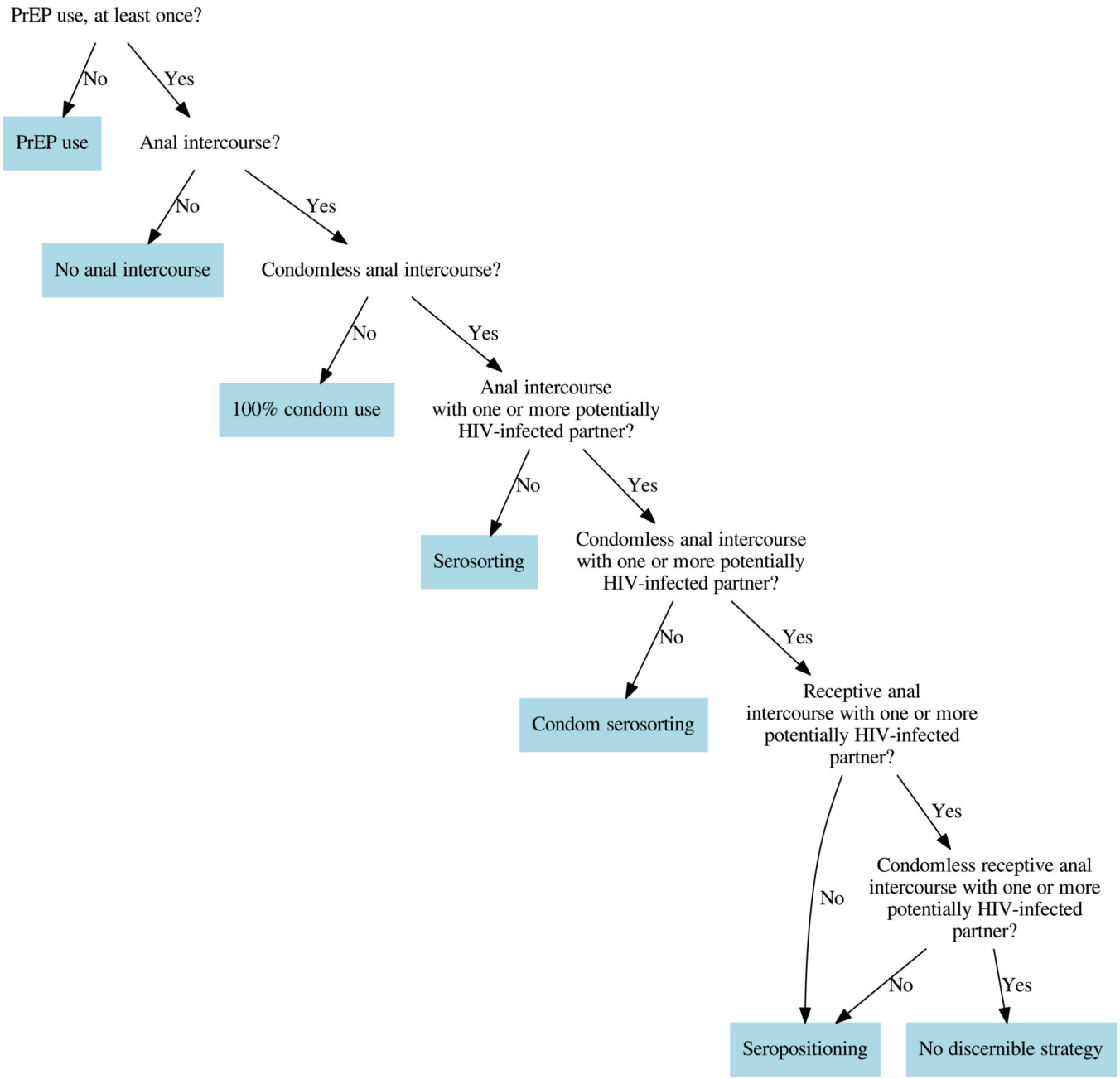

Figure 1.

Classification scheme for behavioral patterns among HIV-uninfected men who have sex with men. The scheme is an adaptation of previously defined grouping systems.[13;14]

Table 1

Model variables and parameters, and corresponding data sources.

Variable or parameter	Source
Behaviors	MSM4[12]
Number of partners	MSM4 and MSM3[12]
Partnership characteristics	
Number of acts	MSM4 and MSM3
Reported HIV discordance *	MSM4 and MSM3
True HIV discordance †	MSM4
Viral suppression	Medical Monitoring Project[15]
Number of transmissible acts ‡	By definition, from above
Per-act risks	Meta-analysis[18]
PrEP efficacy	iPrEx[16] and PROUD[17]

* HIV status of sexual partner, reported by the survey respondent.

† True HIV status of sexual partner, assigned according to estimates.

‡ Number of acts with HIV-infected partners who are not virally suppressed.

Table 2

Parameters for the triangular distributions used in the uncertainty analysis.

Distributional parameter	Lower	Upper	Mode
No discernible strategy, given PrEP*	0.062	0.366	0.214
HIV prevalence of unknown partners†	0.221	0.311	0.266
Recognized infection‡	0.937	1.000	0.970
Viral suppression of C-RAI partners§	0.415	0.848	0.632
Per-act risk via C-RAI¶	0.010	0.019	0.014
PrEP efficacy	0.439	0.867	0.653

*The prevalence of no discernible strategy among MSM who accessed PrEP.

†The prevalence of HIV among unknown-status partners.

‡The prevalence of recognized infection among HIV-infected MSM.

§The prevalence of viral suppression among HIV-infected partners with whom condomless receptive anal intercourse (C-RAI) occurred.

¶The probability of HIV infection via C-RAI with an HIV-infected partner who is not virally suppressed.

Table 3

Distribution of behavioral patterns among HIV-uninfected MSM and distribution of prior behavioral patterns among newly HIV-infected MSM. San Francisco, 2014.

	Distribution among HIV-uninfected MSM, percent scale*	Distribution among newly HIV-infected MSM, percent scale (95% interval)†
PrEP, at least once	9.7	8.0 (3.8, 12.7)
No anal intercourse	21.5	0.0‡
100% condom use	16.5	2.2 (1.7, 2.6)
Serosorting	34.8	7.4 (6.3, 8.0)
Condom serosorting	4.7	3.8 (3.1, 4.4)
Seropositioning	5.4	2.3 (1.7, 2.7)
No discernible strategy	7.5	76.4 (72.6, 80.0)
PrEP indication, assessment	65.9	97.1 (96.7, 97.5)
PrEP indication, risk index	50.9	98.3 (98.1, 98.8)

*The point estimates are from a 2014 sample of San Francisco MSM.

†The point estimates are the means of replications of the simulation exercise. The intervals are the 2.5th and 97.th percentiles of means of replications in the uncertainty analysis.

‡Assumed to be 0.

Table 4

Probability of HIV infection among San Francisco MSM, over a 6-month period in 2014.

	Probability of infection, percent scale (95% interval)*
PrEP, at least once	0.2 (0.1, 0.4)
No anal intercourse	0.0†
100% condom use	0.0 (0.0, 0.0)
Serosorting	0.1 (0.0, 0.1)
Condom serosorting	0.2 (0.2, 0.3)
Seropositioning	0.1 (0.1, 0.1)
No discernible strategy	2.9 (2.5, 3.5)
PrEP indication, assessment	0.5 (0.4, 0.5)
PrEP indication, risk index	0.6 (0.5, 0.7)

*The point estimates are the means of replications of the simulation exercise. The intervals are the 2.5th and 97.th percentiles of means of replications in the uncertainty analysis.

†Assumed to be 0.