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Behavior, Intention or Chance? A Longitudinal Study of HIV Seroadaptive Behaviors, Abstinence and Condom Use

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Abstract Seroadaptive behaviors have been widely described as preventive strategies among men who have sex with men (MSM) and other populations worldwide. However, causal links between intentions to adopt seroadaptive behaviors and subsequent behavior have not been established. We conducted a longitudinal study of 732 MSM in San Francisco to assess consistency and adherence to multiple seroadaptive behaviors, abstinence and condom use, whether prior intentions predict future seroadaptive behaviors and the likelihood that observed behavioral patterns are the result of chance. Pure serosorting (i.e., having only HIV-negative partners) among HIV-negative MSM and seropositioning (i.e., assuming the receptive position during unprotected anal sex) among HIV-positive MSM were more common, more successfully adhered to and more strongly associated with prior intentions than consistent condom use. Seroconcordant partnerships occurred significantly more often than expected by chance, reducing the prevalence of serodiscordant partnerships. Having no sex was intended by the fewest MSM, yet half of HIV-positive MSM who abstained from sex at baseline also did so at 12 month follow-up. Nonetheless, no preventive strategy was consistently used by more than one-third of MSM overall and none was adhered to by more than half from baseline to follow-up. The effectiveness of seroadaptive strategies should be improved and used as efficacy endpoints in trials of behavioral prevention interventions.

Keywords Men who have sex with men · Serosorting · HIV

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Introduction

The US Centers for Disease Control and Prevention (CDC) defines serosorting as "a person choosing a sexual partner known to be of the same HIV serostatus, often to engage in unprotected sex, in order to reduce the risk of acquiring or transmitting HIV" [1]. Le Talc and Jablonski offered the broader term of seroadaptation that includes not only choosing seroconcordant partners, but also choosing different sexual practices based on serostatus [2]. An example of a seroadaptive strategy is strategic positioning or seropositioning, the preventive effect of which is presumed in the lower probability of acquiring infection from the insertive rather than receptive anal-sex position [3]. Serosorting and other forms of seroadaptation have been described worldwide, especially among men who have sex with men (MSM) [4–11] and to a limited extent among women and persons in countries with generalized epidemics [12, 13].

In our previous research, we defined and measured the prevalence of several strategies of seroadaptation among MSM in San Francisco [14]. In addition to serosorting as defined by the CDC (called pure serosorting in our lexicon)

and seropositioning, we characterized oral sex serosorting [i.e., having unprotected anal intercourse (UAI) with seroconcordant partners, otherwise having oral sex], condom serosorting (i.e., having UAI when seroconcordant, otherwise using a condom) and condom seropositioning (i.e., having UAI in the less risky position, otherwise using a condom). Collectively, the prevalence of seroadaptive behaviors was higher than consistent condom use. Further, the prevalence of seroadaptive behaviors measured four years apart (2004 and 2008) in the same target population using the same methods appeared remarkably stable [14, 15].

Despite high and stable prevalence of seroadaptive behaviors, the notion that these behaviors are consciously chosen risk-reduction strategies that have a high level of adherence in a large proportion of MSM may be wrong. The two surveys mentioned above were cross-sectional [14, 15], and the proportions are simply two snapshots of a dynamic equilibrium (i.e., it is possible that individuals within the population frequently change their behavior, but the overall proportions remain stable over time). The high levels of apparent seroadaptive strategies may actually result probabilistically from the prevailing HIV prevalence and sexual practices of MSM without any intentions towards risk reduction. For example, because HIV-negative MSM are more numerous than HIV-positive MSM, they are likely to find other HIV-negative partners by chance alone. Moreover, a causal link between intention and behavior is difficult to demonstrate, particularly if the intentions to use seroadaptive strategies are not measured among individuals prior to their behavior. We therefore conducted a longitudinal study of seroadaptation among MSM with the aims of measuring the individual level of stability of seroadaptive behaviors, to gauge the role of chance in the prevalence of these strategies and to explicitly link prior intentions for seroadaptation to individuals' future behavior.

Methods

Study Subjects, Sampling Design and Recruitment

We used time-location sampling (TLS) methods as standardized by the US CDC for the National HIV Behavioral Surveillance (NHBS) surveys to recruit MSM for this study of HIV seroadaptive behaviors [16]. TLS is used around the world to obtain quasi probability-based, cross-sectional samples of hidden and hard-to-reach populations from the diversity of venues where they congregate [17]. We previously described the details of our recruitment methods in a presentation of the baseline data [18]. The present study includes the longitudinal data collected 12 months following initial recruitment.

In brief, our study started with a formative mapping phase that identified the venues where MSM congregate, the time periods of attendance and when different social groups were present. Venues included bars, cruising areas, gyms, dance clubs, social organizations, street locations and other places where MSM were found in sufficient numbers to enable recruitment of a minimum of eight in a 4-hour period. From the mapping, a sampling frame was constructed that included all possible 4-hour venue-day-time (VDT) periods from which a random selection of VDT was drawn. At the selected VDT, potentially eligible men were counted to construct sampling fractions and cluster sizes to adjust point estimates and standard errors in analysis. Staff intercepted men crossing a predetermined line or zone and performed a brief interview to determine eligibility (over 18 years old and residing in one of ten San Francisco Bay Area counties). Although some non-MSM are present in the various venues, the few enrolled are not included in the present analysis. If eligible and willing to participate, written informed consent was obtained. Intercepts were done consecutively without choice on the part of the field team until all staff were occupied and resumed when a staff was available.

Baseline Measures

A computer-based, self-administered questionnaire was used in a private area at or near the venues to collect demographic and behavioral data. The measures of primary interest for the present analysis are a set of mutually exclusive, hierarchical sexual behavior patterns constructed from the information provided by the respondent concerning their own HIV status, each of their partners' HIV status and all sexual episodes with all of up to five partners in the preceding 6 months. We previously presented the rationale for the risk hierarchy, the methods to elicit the information and the computer-based mode of data collection in detail [14, 18] and summarize here. To improve recall and to collect highly detailed information, we used the following process. Respondents gave initials or nicknames of their five most recent partners. For each partner, they gave their relationship status and HIV serostatus. They then indicated how long they were having sex with the partner working backwards from the present up to the previous 6 months, providing a count of the number of episodes of oral sex and insertive and receptive anal sex. Further, respondents indicated for how many episodes they used a condom. We did not conduct HIV testing on participants' partners. To classify the partners' HIV serostatus, we recorded the respondent's report, how they knew the serostatus, how certain they were about the serostatus and if they knew when the partner last tested and any risk since their last test. As reported previously, we found no overall

correlations between the type of partner (e.g., main vs. casual), how they came to know their serostatus and how certain they were about their serostatus and therefore used the self-report as answered to the direct question on the partners serostatus [14, 15, 18]. Also as previously reported, greater than 82% of men had fewer than five partners therefore the schema captures the vast majority of sexual behavior [14].

Based on the responses for all sexual episodes across all partnerships, we created mutually exclusive hierarchical categories of behavioral patterns defined by other researchers, our previous studies and relative transmission probabilities [1–15, 18–20]. We defined three broad behavioral patterns: safer sex practices, HIV seroadapative behaviors and high acquisition and transmission risk. Safer sex practices were no sex with any partners, only having oral sex with all partners and 100% condom use for all anal sex with all partners. HIV seroadaptive behaviors were "pure serosorting" (UAI with seroconcordant partners), "oral sex serosorting" (UAI with seroconcordant partners, oral sex with serodiscordant or unknown status), "condom serosorting" (UAI with seroconcordant partners, condoms with serodiscordant or unknown status), "seropositioning" (UAI with seroconcordant partners, receptive UAI by HIV-positive MSM with serodiscordant or unknown status, insertive UAI by HIV-negative MSM with serodiscordant or unknown status) and "condom seropositioning" (UAI with seroconcordant partners, condom use by HIV-negative MSM in the receptive position with serodiscordant or unknown, condom use by HIV-positive MSM in the insertive position with serodiscordant or unknown). Highest acquisition risk was receptive UAI by HIV-negative MSM with serodiscordant or unknown status partners. Highest transmission risk was insertive UAI by HIV-positive MSM with serodiscordant or unknown status partners. Using this schema, men were classified into one behavioral category at baseline and one category at 12 months follow-up and entered as such into our models that associated the behavioral patterns to their intentions.

After completing the baseline information on sexual behaviors with partners, we asked men to gauge their future intentions to engage in the above-described patterns using a Likert-like scale. For example, we asked whether they agreed or disagreed with the following statements: "In the next 6 months, I will always use a condom with all my partners when having anal sex" (100% condom use) or "I will only have sex with guys who have the same serostatus as me" (pure serosorting) as "disagree, somewhat disagree, somewhat agree, or agree". In our analysis comparing behavioral patterns and intentions, we entered the collapsed "somewhat agree/agree" into the models as having the intention.

HIV Testing and Knowledge of Serostatus

Upon completion of the baseline survey, on-site pre-test counseling was done and oral fluid specimens were collected for HIV testing. Results were disclosed to participants at an appointed time at the San Francisco Department of Public Health or by telephone as per participant preference. All participants were tested by us at baseline and 12 months, regardless of whether they self-reported as HIV negative, unknown or positive. For analysis of behaviors, participants were classified according to our HIV test results and therefore also knew their serostatus after completing the baseline survey. We also re-tested participants at 12 months if they were HIV negative at baseline. We include in our analysis those who were negative at baseline and at follow-up as well as those who were HIV-positive at baseline and at follow-up. Of note, four HIV seroconversions occurred during the follow-up period; however, these were too few for statistical inference and they are not included in the analysis.

Follow-up

At enrollment, we obtained multiple types of contact information, including email addresses, home addresses and telephone numbers to conduct follow-up. We provided participants with a website and unique log-in code to conduct the 6 and 12 month follow-up surveys over the internet via a secured server. Individual reminder emails with log-in instructions were sent to participants 2 weeks before the 6 and 12 month follow-up dates. Participants who did not complete their survey after the first email were sent another the week following the due date. Subsequent weekly phone calls and e-mail reminders were sent for up to three more times, for a maximum of five emails and three phone calls over a five-week period. People who did not have access to the internet were offered the option of completing the follow-up surveys using one of our office computers in private. The patterns of sexual behavior at 12 months were measured identically as at baseline. The present analysis includes all MSM who provided complete information on their sexual behaviors at baseline and 12 months. The 6 month data are not included in the present analysis for several reasons. First, the main purpose of the 6 month follow-up was to maintain contact with participants to reinforce retention in the cohort. As such, the 6 month survey was truncated and did not include all of the measures at baseline and 12 month follow-up. Finally, the 6 month survey was entirely online whereas the baseline and 12 month surveys included in person HIV counseling and testing.

Analysis

Our analysis centered on testing the hypothesis that seroadaptive behaviors may or may not be consciously adopted and adhered to strategies by MSM to reduce their risk of acquiring or transmitting HIV. We approached this hypothesis in several ways.

First, seroadaptive behaviors are predicated on engaging in different sexual practices according to whether partners are HIV seroconcordant or serodiscordant. We therefore tested the hypothesis that there were greater numbers of seroconcordant partnerships than would be expected by chance alone. If men are consciously adopting pure serosorting through choosing partners of the same serostatus, then there should be more positive-positive and negative-negative partnerships than would occur by chance according to the marginal probabilities dictated by HIV prevalence and the number of partnerships described in our sample. We tested this hypothesis using a χ^2 test comparing the weighted number of seroconcordant partnerships to the expected number.

Second, we further hypothesized that if seroadaptive behaviors result from conscious decisions to adopt specific risk reduction strategies, there should be consistency in the behavioral patterns of individuals over time. We therefore compared individuals' sexual behavior classifications at baseline to those at 12 month follow-up, describing how many individuals adhered to their baseline behavioral pattern, how many changed and to which practices they changed. To assess if men tended to become more or less risky over time, we used weighted paired *t*-tests assessing the individual change scores across the hierarchy from baseline to 12 months.

Third, to examine the temporal sequence of the hypothesized cause and effect relationship, we assessed the association between the respondents' stated intentions at baseline and their actual behavior 12 months later using weighted χ^2 tests. We also examined the association between baseline intentions and their past behavior reported at baseline. Our hypothesis was that baseline intention would be associated with baseline behavior as well as follow-up behavior. If baseline intentions are associated with future behavior, then evidence supports (but does not prove) the conscious adoption of seroadaptation for risk reduction. If baseline intentions are associated with past behavior but not future behavior, then evidence may support an effect-cause or *post-hoc* rationalization (e.g., men's recent pattern of sexual behavior could lead them to attribute their past actions to a risk reduction strategy rather than their intentions leading to future risk reduction).

All analysis was weighted using the sampling event weights, and clustering was specified on venues. The internal review boards of the University of California San Francisco and the University of Pittsburg reviewed and approved the protocol for this study.

Results

Of 1,207 MSM enrolled at baseline, 732 (61%) completed follow-up and provided sufficient information to classify their pattern of sexual behavior for the 6-month period preceding the baseline interview and for the six-month period preceding the 12 month interview. Table 1 compares the characteristics of the initially enrolled participants to those completing follow-up. There was slightly but significantly higher retention of men who were older, white and more educated. Subjects at 12-month follow-up were similar to subjects at baseline with respect to employment, income, San Francisco county residence, birth in the US, sexual identity and HIV serostatus. HIV prevalence at baseline was 21%.

The 732 men in the present cohort analysis reported their sexual behaviors and partners' characteristics within 1,713 partnerships in the 6 months preceding the baseline interview. Of the partnerships, 72% were HIV-negative seroconcordant, 13% were HIV-positive seroconcordant and the remaining 15% were serodiscordant. The corresponding expected proportions under an assumption of random selection of sexual partners are 60, 5 and 35%, respectively. The χ^2 test for the difference between the observed and expected seroconcordancy suggests the finding is not likely due to chance (χ^2 471.8, $p < 0.001$). We found similar results for the distribution of seroconcordant and serodiscordant partnerships among the 1,404 reported at 12-month follow-up (71, 12 and 17%, respectively, χ^2 291.2, $p < 0.001$).

Tables 2 and 3 show the prevalence, consistency and changes between nine sexual behavior patterns for HIV-negative and HIV-positive men at baseline and 12-months. Among HIV-negative men (Table 2), 12% engaged in no sex, 12% in only oral sex, 28% used condoms consistently, 28% were pure serosorters, 2% were oral sex serosorters, 6% were condom serosorters, 6% were seropositioners, 1% were condom seropositioners and 5% engaged in risky sex in the 6 months preceding the baseline survey. Overall, HIV-negative respondents did not increase or decrease their level of risk by 12-month follow-up; i.e., there was no evidence of significant change among individuals with respect to becoming more or less risky over time (paired *t*-test, $t = 0.42$, $p = 0.67$). Nonetheless, substantial numbers of HIV-negative men changed their behavioral pattern from baseline to 12 months. The sexual behavior patterns most consistently adhered to by HIV-negative men (depicted by the bold cells along the diagonal in Table 2) were pure serosorting (47% of those engaging in pure

Table 1 Study population characteristics at baseline and 12-month follow-up among men who have sex with men (MSM), San Francisco, total denominator of 1207 at baseline, including 732 with 12-month follow-up

Variable	Baseline %	12-month follow-up %	χ^2 (df), *p*-value
Age group in years			4.7 (2.3,148.0), 0.01
18–24	16	14	
25–34	36	34	
35–44	25	27	
45–54	15	15	
55+	8	10	
Race/ethnicity			3.1 (2.8,182.3), 0.03
African American	7	6	
Asian	11	11	
Latino	19	17	
White	50	53	
Other	13	12	
Highest level of education completed			5.0 (2.0,192.2), 0.01
Post graduate	20	23	
College graduate	35	38	
Some college	31	30	
High school graduate	10	6	
Some high school or less	3	2	
Other	1	1	
Employment			1.5 (2.7,174.3), 0.23
Full-time	62	62	
Part-time	14	15	
Sporadic	10	10	
Unemployed	6	4	
Other	9	9	
Annual income in US $			1.3 (2.9,186.3), 0.29
0–10,000	15	13	
10,001–30,000	26	26	
30,001–50,000	22	22	
50,001–70,000	15	16	
70,001–90,000	9	9	
90,000+	13	14	
Unknown	<1	0	
Residency			0.02 (1,65), 0.88
City and county of San Francisco	77	77	
Other Bay Area county	23	23	
Born in the United States	79	79	0.06 (1,65), 0.81
Sexual orientation (all had male–male sex)			1.4 (2.4,153.2), 0.24
Gay	90	91	
Bisexual	8	7	
Straight	1	1	
Other	1	1	
HIV serostatus (by test result)			1.8 (2.0,128.4), 0.17
HIV-positive	21	21	
HIV-negative	79	79	
Unknown	<1	0	

serosorting at baseline also engaged in the behavior at follow-up), 100% condom use (44%) and only oral sex (38%). Behaviors least adhered to were condom serosorting (1%), condom seropositioning (7%) and oral sex serosorting (14%).

Among HIV-positive men (Table 3), 11% engaged in no sex, 14% in only oral sex, 15% used condoms consistently, 13% were pure serosorters, 4% were oral sex serosorters, 6% were condom serosorters, 20% were seropositioners, 3% were condom seropositioners and 13% engaged in risky sex in the 6 months preceding the baseline survey. As with HIV-negative men, the aggregate frequencies of the behavioral patterns appeared largely the same at 12 months yet individual changes in patterns were common. There was no evidence that HIV-positive individuals became more or less risky as a whole from baseline to follow-up (paired t-test, $t = -0.13$, $p = 0.90$). The behavioral patterns most adhered to for HIV-positive men were having no sex (50% of those reporting no sex at baseline also reported no sex at 12 month follow), having only oral sex (46%) and seropositioning (39%). Only 18% of HIV-positive men who used condoms 100% of the time at baseline continued to do so at 12 months.

Figure 1 arrays the intentions of men towards risk reduction strategies measured at baseline. Condom serosorting (i.e., agree or strongly agree with "I will always use a condom unless I know for a fact that my partner has the same serostatus as me") was the most commonly expressed intention, intended by 75% of HIV-negative and 56% of HIV-positive men. Consistent condom use ranked second among the intentions of HIV-negative men (71%); however, the resolve to withdraw before ejaculation was the second most common intention among HIV-positive men (46%). The intention for pure serosorting was expressed by 64% of HIV-negative men and by 37% of HIV-positive men. For seropositioning, 41% of HIV-positive men and 33% of HIV-negative men expressed the intention to use this strategy. The least often intended strategy was to have no sex, expressed by 7% of HIV-positive men and 8% of HIV-negative men. Having UAI only when one's partner is on anti-retroviral therapy (ART) or when one's partners' viral load is low were both intended by 22% of HIV-positive men, and by 14% and 9%, respectively, of HIV-negative men. The strategy of only topping when one's own viral load is undetectable, relevant only to HIV-positive men, was intended by 25%.

Tables 4 and 5 link men's intentions at baseline to their future behavior at 12 months. The third column represents adherence to the strategy at 12 months among those who expressed the intention to do so at baseline. The fourth column represents those who practiced the strategy at 12 months among those who did not express the intention to do so at baseline. The latter can be thought of as the proportion of the men engaging in the behavioral pattern by chance, by circumstances or due to partners' intentions rather than the respondents' own intentions. The difference

Table 2 Safer sex, seroadaptation and risky sex behaviors at baseline and 12-month follow-up among HIV-negative men who have sex with men, San Francisco

Follow-up	Baseline									
	Safer sex			Seroadaptation					Risk	Follow-up marginal percent
	No sex	Only oral sex	100% condom use	Pure serosorting	Oral sex serosorting	Condom serosorting	Seropositioning	Condom seropositioning	Risky sex	
No sex	**35**	*11*	*15*	*8*	*9*	*2*	*4*	*0*	*10*	***13***
Only oral sex	***16***	**38**	*9*	*4*	*16*	*0*	*6*	*0*	*2*	***11***
100% condom use	***14***	***28***	**44**	*18*	*14*	*33*	*26*	*0*	*4*	***26***
Pure serosorting	***28***	***10***	***20***	**47**	*32*	*35*	*18*	*38*	*42*	***30***
Oral sex serosorting	***2***	***3***	***<1***	***6***	**14**	*6*	*3*	*0*	*2*	***3***
Condom serosorting	***<1***	***3***	***3***	***3***	***7***	**1**	*5*	*0*	*1*	***3***
Seropositioning	***3***	***1***	***3***	***3***	***4***	***9***	**19**	*46*	*3*	***5***
Condom seropostioning	***1***	***5***	***<1***	***0***	***0***	***6***	***0***	**7**	*8*	***2***
Risky sex	***1***	***1***	***6***	***11***	***3***	***8***	***19***	***9***	**28**	***8***
Baseline marginal percent	**12**	**12**	**28**	**28**	**2**	**6**	**6**	**1**	**5**	**100**

Percent of men engaging in behavior at baseline who remain (*bold*) in the category at follow-up, change to riskier behavior (*bold italic*) or change to less risky behavior (*italic*). For example, 47% of men engaging in pure serosorting at baseline also did so at follow-up; whereas, 11% went on to have serodiscordant unprotected receptive anal sex with a potentially serodiscordant partner and 18% went on to consistently use condoms at 12 months follow-up

Table 3 Safer sex, seroadaptation and risky sex behaviors at baseline and 12-month follow-up among HIV-positive men who have sex with men, San Francisco

Follow-up	Baseline									
	Safer sex			Seroadaptation					Risk	Follow-up marginal percent
	No sex	Only oral sex	100% condom use	Pure serosorting	Oral sex serosorting	Condom serosorting	Seropositioning	Condom seropositioning	Risky sex	
No sex	**50**	*11*	*11*	*24*	*0*	*21*	*33*	*0*	*5*	***20***
Only oral sex	***5***	**46**	*17*	*14*	*0*	*0*	*0*	*0*	*0*	***11***
100% condom use	***17***	***7***	**18**	*1*	*0*	*13*	*5*	*2*	*16*	***9***
Pure serosorting	***0***	***0***	***26***	**16**	*79*	*0*	*1*	*0*	*18*	***12***
Oral sex serosorting	***2***	***0***	***1***	***0***	**3**	*0*	*1*	*0*	*0*	***1***
Condom serosorting	***0***	***0***	***2***	***13***	***6***	**15**	*0*	*21*	*10*	***5***
Seropositioning	***0***	***36***	***8***	***14***	***8***	***22***	**39**	*9*	*21*	***21***
Condom seropositioning	***26***	***0***	***0***	***5***	***0***	***0***	***15***	**23**	*7*	***8***
Risky sex	***0***	***0***	***17***	***13***	***4***	***29***	***6***	***46***	**23**	***12***
Baseline marginal percent	**11**	**14**	**15**	**13**	**4**	**6**	**20**	**3**	**13**	**100**

Percentage of men engaging in behavior at baseline who remain (*bold*) in the category at follow-up, change to riskier behavior (*bold italic*) or change to less risky behavior (*italic*)

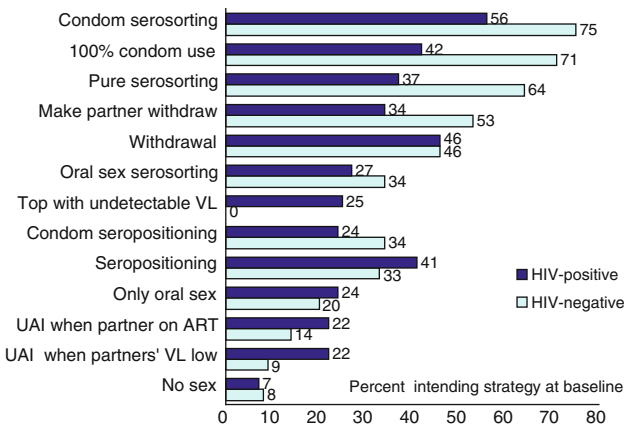

Fig. 1 Intentions for HIV prevention strategies, men who have sex with men (MSM), San Francisco. *VL* viral load, *UAI* unprotected anal intercourse, *ART* antiretroviral treatment

between the two proportions can be thought of as the ability of individuals who intend to use the strategy to do so, above what is likely to occur by chance or circumstance. For example, adherence to condom serosorting ("I will always use a condom unless I know for a fact that my partner has the same serostatus as me") was weak. Despite being the most commonly endorsed strategy (by 75% of HIV-negative MSM and 56% of HIV-positive MSM) very few men adhered to it (3% of HIV-negative men and 5% of HIV-positive men). Moreover, there was no evidence that those who intended to condom serosort did so more often than those who did not intend to (2% of HIV-negative MSM, 6% of HIV-positive MSM, χ^2 0.4, $p = 0.53$ for HIV-negative and $\chi^2 < 0.1$, $p = 0.95$ for HIV-positive men).

By these measures, the prevention strategy most often intended and most successfully adhered to for HIV-negative men was pure serosorting: 64% intended to adhere to it at baseline, of whom 38% did so at 12 months compared to 15% being behaviorally classified as pure serosorters at 12 months without stating the intention to do at baseline (χ^2 11.7, $p = 0.01$). By comparison, 100% condom use was intended by 71% of HIV-negative men at baseline, adhered to by 30% of these men at 12 months, but this level was not significantly higher than among men who did not have the intention of always using condoms (18%, χ^2 1.6, p = 0.21). In addition to pure serosorting, three other strategies showed significant associations between baseline intentions and adherence at 12 months among HIV-negative men: only having oral sex, oral sex serosorting, and condom seropositioning. Of note, levels of adherence to any intended strategy was low for HIV-negative men overall. In addition to 100% condom use, we found no evidence that adherence among those stating their intention was any higher than would occur in the absence of the intention for condom serosorting (as noted above), seropositioning and not having sex.

Unlike HIV-negative men, the intention to not have sex was successfully adhered to by HIV-positive men, with 63% not having sex at 12 months among those with this

Table 4 Prior intentions and future behavior with regard to safer sex and seroadaptive strategies, HIV-negative men who have sex with men, San Francisco

Agree or somewhat agree at baseline with statement "In the next 6 months, …"	Behavioral pattern	Percent of those stating the intention at baseline who had the behavior at 12 months	Percent of those not stating the intention at baseline who had the behavior at 12 months	χ^2 (df), *p*-value
"I will not have sex"	No sex	21	12	1.1 (1,59), 0.29
"I will only have oral sex"	Only oral sex	26	7	13.6 (1,59), <0.001
"I will always use a condom with all my partners when having anal sex"	100% condom use	30	18	1.6 (1,59), 0.21
"I will only have sex with guys who have the same HIV status as me"	Pure serosorting	38	15	11.7 (1,59), 0.01
"I will only have oral sex when the HIV status of my partner is different or not known to me"	Oral sex serosorting	6	2	6.2 (1,59), 0.02
"I will always use a condom unless I know for a fact that my partner has the same serostatus as me"	Condom serosorting	3	2	0.4 (1,59), 0.53
"I will always be a top"	Seropositioning	8	3	2.5 (1,59), 0.12
"I will always use a condom unless I am topping"	Condom seropositioning	4	1	6.2 (1,59), 0.02

Table 5 Prior intentions and future behavior with regard to safer sex and seroadaptive strategies, HIV-positive men who have sex with men, San Francisco

Baseline agree or somewhat agree with statement "In the next 6 months, …"	Behavioral pattern	Percent of those stating the intention at baseline who had the behavior at 12 months	Percent of those not stating the intention at baseline who had the behavior at 12 months	χ^2, *p*-value
"I will not have sex"	No sex	63	17	10.0 (1,44), 0.01
"I will only have oral sex"	Only oral sex	23	8	7.0 (1,44), 0.01
"I will always use a condom with all my partners when having anal sex"	100% condom use	20	2	13.9 (1,44), <0.001
"I will only have sex with guys who have the same HIV status as me"	Pure serosorting	28	2	26.9 (1,44), <0.001
"I will only have oral sex when the HIV status of my partner is different or not known to me"	Oral sex serosorting	1	1	0.3 (1,44), 0.59
"I will always use a condom unless I know for a fact that my partner has the same serostatus as me"	Condom serosorting	5	6	<0.1 (1,44), 0.95
"I will always be a bottom"	Seropositioning	41	7	14.7 (1,44), <0.001
"I will always use a condom unless I am a bottom."	Condom seropositioning	6	9	0.3 (1,44), 0.57

intention at baseline compared to 17% of those without the intention (χ^2 10.0, $p = 0.01$). Seropositioning and 100% condom use were also significantly adhered to by HIV-positive men with the intention to do so, also in contrast to HIV-negative men. Whereas adhering to oral sex serosorting and condom seropositioning were significantly associated with baseline intentions among HIV-negative men, they were not among HIV-positive men. In agreement with HIV-negative men, pure serosorting and only having oral sex were successfully adhered to among HIV-positive men expressing the intention at baseline.

Associations between baseline intentions and past behavior in the 6 months up to baseline were similar to future behaviors as described above with three exceptions; intentions were associated with past behavior but not future behavior for HIV-negative men intending on having no sex, 100% condom use and seropositioning. No discrepancies were noted in associations between intentions and future vs. past behavior among HIV-positive men.

Discussion

Our longitudinal study suggests that several seroadaptive strategies, including pure serosorting, are the result of intentionally taken risk reduction strategies by MSM and not simply the result of prevailing behavioral patterns or chance. We show that prior intentions towards pure serosorting predict subsequent behavior among both HIV-positive and HIV-negative men. Seroconcordant partnerships happen more frequently than would be predicted by chance given the prevalence of infection in the population. Collectively, seroadaptive strategies are more common than consistent condom use and individually more common in the cases of pure serosorting among HIV-negative MSM and seropositioning among HIV-positive MSM. Moreover, pure serosorting among HIV-negative MSM and seropositioning among HIV-positive MSM are more consistently adhered to than 100% condom use. Further, seroadaptation as consciously adopted preventive behavior compares favorably to 100% condom use given that HIV-negative men who intended to use condoms consistently did not do so more often than men who expressed no such intention.

Not all of our defined seroadaptive strategies were successful. Contrary to our expectation, condom serosorting failed to hold up under scrutiny. We felt there would be strong appeal in the notion that one can choose condomless sex when of the same HIV serostatus and use condoms when serodiscordant because it does not discriminate against partnering with anyone and can result in more gratifying sex when there is no risk of HIV transmission. Indeed, the intention to use this strategy was the most commonly expressed by both HIV-positive and HIV-negative MSM. The reality is quite different. Despite solid majorities of MSM intending condom serosorting, very few actually carried it out—and adherence to condom serosorting among men who intended to do so was not greater than among men with no such intention. Adherence to intended seropositioning among HIV-negative men and to oral sex serosorting and condom seropositioning among HIV-positive men were also disappointing. Another disappointment is that no seroadaptive behavior had a majority of men adhering to it, even when they stated the intention to do so. The same, unfortunately, was also true for 100% condom use.

Having only oral sex with all partners, while not a strategy dependent on knowledge of HIV serostatus, was significantly adhered to by men intending to use it and fairly common in practice by both HIV- negative and positive MSM. Oral sex as a prevention strategy may be under-appreciated, both for its lower probability of transmission compared to anal sex [19, 20] and for how common it is [18]. Apart from men who only engage in oral sex with all partners as described here, we previously reported from the baseline data that oral sex was by far the most common sexual act within and across all partnerships [18].

We gauged the baseline intentions of several additional seroadaptive strategies, but unfortunately due to time constraints in a lengthy questionnaire we did not assess adherence at follow-up. These included strategies related to withdrawal before ejaculation and the perceived preventive effects of ART and low viral load on HIV transmission [4, 21, 22]. Our study suggests a moderate to low level of belief in ART and low viral load as being less risky for HIV transmission; the corresponding strategies were intended by 14 and 9% of HIV-negative MSM, respectively. If the paradigm of ART and viral load suppression as prevention (e.g., "test and treat") continues to gain ground [22], assessment of behavioral adherence, as opposed to treatment adherence, to these strategies will be needed. This will be challenging, as it will require respondents to know not only the serostatus of partners, but also their treatment status, ART adherence and most recent viral load. Of note, the finding that more than one in five HIV-positive men intended on only having UAI with other HIV-positive MSM when their partners were on ART or had a low viral load suggests a concern for re- or superinfection [23]. Also of note, the intention of having sex under a calculated risk of low transmission due to viral load suppression was more common than the intention not to have sex at all.

Not having sex at all was the least endorsed strategy. Among HIV-negative MSM, the few who intended not to have sex at baseline were not more likely to abstain than those who did not claim such an intention. Moreover, the

association of the intention not to have sex with past behavior but not future behavior suggests that the intention may describe the recent situation (perhaps fatalistically or sardonically) rather than true intentions for the future. Nonetheless, among HIV-positive MSM, not having sex was adhered to by the majority who expressed the intention at baseline—the only strategy to achieve this level of adherence among HIV-positive or HIV-negative men. A portion of HIV-infected MSM appears willing and able to not take even the slightest risk in infecting or re-infecting someone else.

We recognize potential biases in responses to the questions posed in our study. Social desirability is likely to favor over-estimation of safer sex behavior and intentions. Also, we relied on respondents' reports of their partners' HIV serostatus without being able to verify their accuracy. Although our data captured how the respondent knew the partners' serostatus (e.g., by asking or other means), the nature of the relationship (e.g., regular or casual partner) and how certain they were of the information, we saw no clear and consistent means of using these responses to confirm the accuracy of the reported partners' serostatus. We also did not have the statistical power to stratify the analyses by partner type, a factor that may have a profound influence on the levels and abilities to adhere to prevention strategies, particularly seroadaptation as noted in previous studies [3, 5, 8, 9, 11]. We also recognize the limitation in not including in this analysis other measures relevant to intentions such as perceived behavioral control and self-efficacy. The time frame of the questions (i.e., in the last 6 months asked with a 1 year intervening period) also adds uncertainty in recall as well as the possible impact of events that may change behavioral patterns (e.g., entering or ending relationships, exposure to prevention interventions, etc.).

We also stress that the level of loss to follow-up and missing information (together 39%) along with differential loss to follow-up of younger, African American, Latino and less educated MSM also allows for potential biases. Our design of recruiting by random intercept at venues using the TLS method followed by online follow-up was, to our knowledge, the first of its kind. Longitudinal studies are often faced with the trade-off between enrolling those most likely to complete follow-up against having a representative or diverse sample of the population at risk. The diversity of our sample and the reasonable follow-up achieved by our design suggest the approach may provide a fair balance of internal and external validity, particularly if the methods are perfected. Moreover, our cohort retention rate compares favorably against other internet-based studies which may have particular difficulties with loss to follow-up [24]. As representative as our sample might be of our own MSM population, however, it may not extrapolate to other areas. In particular, San Francisco, apart from Seattle, may have the highest level of HIV testing and knowledge of serostatus (prerequisites for seroadaptive strategies) among MSM in North America [25, 26].

We recognize that our study does not directly measure the effectiveness of the seroadaptive strategies in preventing HIV acquisition or transmission. Our study is also unable to assess the problem of potential acute infection transmission. Much HIV transmission may occur from persons in the early period of infection when viral loads and therefore contagiousness is high yet the HIV antibody test will be negative [27]. The scenario makes presumed pure serosorting between HIV-antibody negative persons potentially risky [28]. Conclusions on the net impact of seroadaptation on HIV transmission must therefore be made cautiously. We contend, nonetheless, that failure to adhere to consistent condom use or abstaining from sex, as were the case for HIV-negative MSM in our study, also make them vulnerable to acute infection transmission. On that note, a general warning is that adherence to any intended preventive behavior in our study (including condom use and seroadaptative strategies) was low.

Seroadaptive strategies could be improved. Increased reliability of perceived HIV status through greater coverage and frequency of testing is a first step. These aims are consistent with the recent push towards "test and treat" prevention efforts [22]. In fact, increased seroadaptation is a likely side effect of these efforts as more persons come to know their current HIV serostatus. The means of improving people's ability to seroadapt (e.g., increased testing frequency, disclosure efficacy, hierarchy of risk negotiation) can be evaluated in randomized controlled trials (RCTs). Most RCTs of behavioral interventions have focused on increasing consistent or overall condom use [29], although a few interventions for HIV-positive persons have focused on discordant UAI as the primary endpoint [30]. At least one recent RCT showed that it is possible to significantly increase serosorting as an explicit outcome through interventions among HIV-positive MSM [31]. Based on the high levels of intentions and their significant associations with adherence observed in our study, RCTs with endpoints such as pure serosorting, oral sex serosorting and only oral sex may meet with more success among HIV-negative MSM than 100% condom use. Our data also support the potential of several seroadaptive outcomes for RCTs of HIV-positive MSM to avoid transmission, including seropositioning and pure serosorting. Although doubts about the probabilities of HIV transmission through seroadaptive strategies remain, in practice condom promotion is also imperfect [32]. Future research on prevention interventions should match the realities of what MSM and other populations in the current era of the HIV pandemic are willing and able to do to reduce their risk of acquiring or transmitting infection.

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