



Awareness and Perceived Effectiveness of HIV Treatment as Prevention Among Men Who Have Sex with Men in New York City

Karolynn Siegel¹ · Étienne Meunier¹

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Abstract

To assess perceptions of HIV treatment as prevention (TasP), we conducted an online survey of MSM in New York City ($n = 732$) asking them to rate the effectiveness of different strategies to reduce HIV risk during serodiscordant condomless anal sex between men. Only 6.1% reported not knowing what TasP was, with significantly less awareness among non-gay-identified MSM, men with less education, men who reported fewer anal sex partners in the prior 3 months, and HIV-negative/unaware men who had never used PrEP. The strategy most frequently perceived to offer “a lot” or “complete” protection from HIV was daily PrEP (70.0%), followed by TasP (39.1%), intermittent PrEP (16.6%), strategic positioning (15.8%), and withdrawal before ejaculation (10.8%). Men who were HIV positive, who had ever used PrEP, and who identified as gay/homosexual were significantly more likely to see TasP as effective. Further studies should investigate MSM’s apparent skepticism towards TasP.

Keywords Treatment as prevention (TasP) · Men who have sex with men (MSM) · HIV prevention · Perceived effectiveness · Pre-exposure prophylaxis (PrEP)

Introduction

For most of the HIV/AIDS epidemic, condoms have been presented as the only effective way to prevent HIV transmission during sexual intercourse between serodiscordant partners. However, men who have sex with men (MSM) have also relied on other strategies for reducing the risks of acquiring or transmitting HIV during anal sex, for example, serosorting (having condomless sex only with seroconcordant partners), strategic positioning (where the HIV-negative partner assumes the insertive position and the HIV-positive one the receptive position), or withdrawal before ejaculation [1, 2]. More recently, pre-exposure prophylaxis (PrEP) and treatment as prevention (TasP) have become new strategies to prevent HIV infection, ending the notion that condomless sex is necessarily unprotected sex [3], which had prevailed for the prior three decades.

TasP represents a radically new way of thinking about HIV prevention by suggesting that condomless intercourse between serodiscordant partners poses no risk of HIV transmission as long as the HIV-positive partner is virally suppressed and taking ART consistently. Although some MSM started believing that ART lowered transmission risks soon after these medication became available [4, 5], only relatively recently has clinical evidence supporting the efficacy of TasP among MSM become available. In 2008, based on epidemiological data, the “Swiss Statement” proposed that HIV-positive people who had maintained an undetectable viral load for at least 6 months, who took ART every day as prescribed, and who did not have other STIs, did not transmit HIV to their sex partner [6]. Data showing the clinical efficacy of TasP among heterosexual serodiscordant couples became available in the years that followed [7], but it was only in July 2016 that the PARTNER clinical trial provided evidence of TasP efficacy among male–male couples [8]. All clinical trials including heterosexual and male–male serodiscordant couples have found no HIV transmissions through condomless vaginal or anal sex acts when the HIV-positive partners were virally suppressed (i.e., had less than 200 copies of HIV RNA per milliliter of blood) [7–9]. As a result, the U.S. Centers for Disease Control (CDC) and other

✉ Karolynn Siegel
ks420@cumc.columbia.edu

¹ Department of Sociomedical Sciences, Mailman School of Public Health, Columbia University Medical Center, 722 West 168th Street, 9th Fl, New York 10032, USA

agencies have recently endorsed a core message stating that “people with HIV who take HIV medication as prescribed and achieve and maintain an undetectable viral load have effectively no risk of transmitting HIV to their HIV-negative sexual partners” [10] (p. 1).

TasP represents “an essential component for ending the [HIV] epidemic” [11] and several organizations have been working at increasing awareness of it. In 2016, Prevention Access Campaign (a collective of people involved with HIV-related services and advocacy) have created the *Undetectable=Untransmittable (U=U)* message [12]. They produced a consensus statement about TasP (similar to that of the CDC above) and had it endorsed by over 700 “community partners” (public health agencies, healthcare facilities, community-based organizations) in over 100 countries. Since then, many public health agencies, for instance, the New York City Department of Health and Mental Hygiene (NYC DoHMH) and the CDC have stated their commitment in increasing awareness of TasP among healthcare providers and the general population [10, 13]. These agencies recognize the potential of TasP for decreasing HIV-related stigma, improve the quality of life of people affected by HIV, and benefit the public health by removing barriers to HIV testing, engagement in HIV care, and ART initiation and adherence.

So far, promotion of TasP has mostly been done through social media and HIV specialized clinics and healthcare providers. As such, awareness of TasP may be higher among those who frequent HIV clinics or who are connected to TasP advocates on social media. Indeed, surveys show that HIV-positive people are much more likely to be aware of TasP than those who are not [14–16]. A U.S. survey from 2017 showed that 93.3% of HIV-negative/unaware participants understood what an undetectable viral load meant, with higher awareness among those who had used PrEP, those who tested for HIV more frequently, and those who were out as gay [16]. TasP awareness thus needs to be increased, especially among those who are not already engaged in HIV or PrEP care.

However, awareness of TasP does not necessarily translate to believing in its effectiveness or being willing to rely on it. Despite scientific evidence and promotion efforts, MSM may be reluctant to believe in the effectiveness of TasP, especially after decades of public health messages emphasizing the importance of condoms for preventing HIV transmission during anal sex. While a few studies show that the percentage of MSM who believe in the effectiveness of TasP may be increasing, they still remain a relatively small minority. For instance, a survey study with Australian MSM found that the percentage who agreed that HIV treatment prevents transmission increased from 2.6% to 13.1% between 2013 and 2015 [17]. Perceived efficacy of TasP seems to be associated with HIV status,

as surveys in Australia, Canada, and the US have found that a minority of HIV-negative/unaware MSM believed TasP to be effective, while HIV-positive men were significantly more likely to do so [16–19]. Studies that included HIV-negative men who had ever taken PrEP also found that they were significantly more likely to believe in the effectiveness of TasP than those who had not [16, 17, 20]. Among HIV-negative/unaware MSM, those who identified as gay, those who tested for HIV the most regularly (at least every 6 months), and those who had higher educational achievements were more likely to perceive TasP as effective [16].

Considering that the CDC states that HIV-positive-undetectable people have “effectively no risk” of transmitting HIV to the sex partners [10], we could expect TasP to be perceived as the most effective HIV prevention strategy. In comparison, the CDC indicates that, when taken every day, PrEP can reduce the risk of HIV infection by up to 92% [21] and that condoms are “highly effective” in preventing the sexual transmission of HIV [22]. However, in survey data collected in 2016, Australian HIV-negative MSM rated condoms as the most effective strategy, followed by PrEP, and then TasP [20]. In the same survey, only 11% of HIV-negative/unaware MSM indicated being comfortable having condomless sex with an HIV-positive man with an undetectable viral load [20]. Even among participants who were on PrEP, only 48% said they would be comfortable having condomless sex with an HIV-positive-undetectable man, while 72% said they would be comfortable doing so with an HIV-negative man on PrEP. Although HIV-positive men are more likely to be aware and believe in the effectiveness of TasP, they may not be comfortable relying on it. For instance, in a 2012 survey of Australian MSM [18], only about half of HIV-positive participants said they would be willing to have condomless sex with an HIV-negative man if they were virally suppressed. As revealed in a qualitative study of men in same-sex serodiscordant relationships, worries about the risks of condomless anal sex remain hard to shake for both partners despite full knowledge about TasP [23].

Because promotion of TasP as an effective HIV prevention strategy for MSM is relatively recent, attitudes towards it may be changing quickly. In this article, we report on an online survey conducted between November 2016 and June 2017 among MSM in (New York City) NYC, in which they were asked to evaluate the effectiveness of different HIV prevention strategies for serodiscordant condomless anal sex. As the NYC DoHMH played a part in the launch of the *U=U* campaign in 2016, we could expect NYC MSM during our data collection period to be more aware of TasP and perhaps more confident in its effectiveness than they were at earlier points in time or than MSM in other locales would be.

Methods

Recruitment

Participants were recruited through advertisements on Facebook and on several sexual networking Internet and mobile resources popular among gay/bisexual men in NYC. Advertisements stated that researchers at Columbia University were conducting a survey about the sexual health of MSM that would take 20 to 30 min to complete, and that participants who complete the survey could enter a raffle to a \$200 electronic gift card.

Individuals who clicked on study advertisements were taken to the first page of the survey on Qualtrics, which was a consent form approved by Columbia University's Institutional Review Board. Participants who agreed to take the survey were first taken through a series of questions about demographics and sexual behavior to determine eligibility. Participants had to be at least 18 years old, male or transgender man or woman, resident of the NYC metropolitan area, and to have had sex with a man in the prior year. Transgender participants were not retained in the analysis for this paper as they represented only 2% of complete survey responses.

Measures

Eligible participants were directed to further survey questions asking about their age, racial/ethnic identification, education level, relationship status, sexual identity, sexual behavior in the prior 3 months (total number of sex partners, anal sex partners, and condomless anal sex partners), and their HIV testing history. Those who indicated being HIV positive were asked if they were taking ART and if their last viral load test result was undetectable. Those who said they never tested positive for HIV were asked if they knew about PrEP, and if they were currently taking it or had taken it in the past.

We conducted the survey with the goal of collecting preliminary data for different research projects on the sexual health of MSM. One topic area was the perceived effectiveness of different strategies to prevent HIV during serodiscordant condomless anal sex between men. In a series of items developed by our research team, participants were asked to rate the effectiveness of five strategies after being presented with the following question: "If an HIV-negative man and an HIV-positive man have anal sex together *without condoms*, how much protection would the following strategies provide against HIV transmission?" The five strategies were: (a) strategic positioning, defined as "The HIV-negative man limits himself to the top

position and the positive man to the bottom position"; (b) daily PrEP, defined as "The HIV-negative man is taking PrEP/Truvada[®] every day"; (c) intermittent PrEP, defined as "The HIV-negative man takes PrEP/Truvada[®] only soon before and after sex—like a day or two before and a day or two after"; (d) TasP, defined as "The HIV-positive man maintains an undetectable viral load"; and (e) withdrawal, defined as "If the HIV-positive man is the top, he makes sure to pull out before ejaculation." Participants could rate the effectiveness of each strategy on a five-point scale: (1) no protection at all; (2) only a little protection; (3) some protection; (4) a lot of protection; (5) complete protection. Additionally, for the two items on PrEP, participants could select "I don't know what PrEP is" and, for the question on TasP, "I don't know what undetectable viral load means."

Analysis

Data were analyzed with SPSS (version 24). In the first part of the analysis, we compared participants who indicated not knowing what PrEP was (either when they were asked if they ever took PrEP or when asked about its efficacy) and participants who indicated not knowing what an undetectable viral load meant to those who did not select those options. Participants who chose these options (i.e., who did not know what PrEP or undetectable viral load meant) were excluded for the second part of the analysis. We compared participants who selected "a lot of protection" or "complete protection" when asked about the effectiveness of different prevention strategies to those who selected "some protection," "only a little protection," or "no protection at all." The significance of differences was assessed using Pearson's Chi Square or, in cases where observed counts in cross-tabulations fell under the expected count, Fisher's Exact Test. When relevant, post hoc group comparisons were with partial Chi Square for each possible pair of comparisons and a z test to compare column proportions with p values adjusted with the Bonferroni method.

Results

The survey page was opened 1400 times and 786 eligible participants completed the survey. We retained an analytic sample of 732 after eliminating those who did not provide answers on all items of interest for this article (participants were free to leave any question unanswered).

Awareness of PrEP and TasP

Only a minority (12.7%) of the sample indicated that they did not know what PrEP or an undetectable viral load were (Table 1). Seventy-one men (9.7%) indicated not knowing

Table 1 Characteristics and awareness of PrEP and treatment as prevention (TasP) of men who have sex with men in New York City

| | Total | | Unaware of PrEP | | | | Unaware of UVL | | | |
|---------------------------------------|----------|---------------------|-----------------|--------------------|----------|-----------------------|----------------|--------------------|----------|-------------------|
| | <i>n</i> | (%) | <i>n</i> | (%) | χ^2 | <i>p</i> ^a | <i>n</i> | (%) | χ^2 | <i>p</i> |
| Total | 732 | (100.0) | 71 | (9.7) | | | 45 | (6.1) | | |
| Age | | | | | 1.09 | 0.296 | | | 0.41 | 0.524 |
| 18 to 33 | 373 | (51.0) ^b | 32 | (8.6) ^c | | | 25 | (6.7) ^c | | |
| 34 or over | 339 | (49.0) | 39 | (10.9) | | | 20 | (5.6) | | |
| Race/ethnicity | | | | | 6.35 | 0.139 | | | 2.58 | 0.539 |
| Black | 116 | (15.8) | 14 | (12.1) | | | 7 | (6.0) | | |
| Asian | 60 | (8.2) | 7 | (11.7) | | | 6 | (10.0) | | |
| Latino | 140 | (19.1) | 19 | (13.6) | | | 9 | (6.4) | | |
| White | 368 | (50.3) | 26 | (7.1) | | | 19 | (5.2) | | |
| Other/mixed | 48 | (6.6) | 5 | (10.4) | | | 4 | (8.3) | | |
| Relationship status | | | | | 1.89 | 0.169 | | | 0.17 | 0.679 |
| Single | 467 | (63.8) | 40 | (8.6) | | | 30 | (6.4) | | |
| In a relationship | 265 | (36.2) | 31 | (11.7) | | | 15 | (5.7) | | |
| Sexual identity | | | | | 55.37 | < 0.001 | | | 9.51 | 0.002 |
| Gay/homosexual/queer | 585 | (80.0) | 33 | (5.6) | | | 28 | (4.8) | | |
| Bisexual/heterosexual/other | 146 | (20.0) | 38 | (26.0) | | | 17 | (11.6) | | |
| Education | | | | | 14.48 | < 0.001 | | | 8.86 | 0.003 |
| Less than a bachelor's degree | 271 | (37.0) | 41 | (15.1) | | | 26 | (9.6) | | |
| Completed bachelor's degree or higher | 461 | (63.0) | 30 | (6.5) | | | 19 | (4.1) | | |
| Anal sex partners, past 3 months | | | | | 0.46 | 0.500 | | | 5.15 | 0.023 |
| Zero or 1 | 235 | (35.8) | 21 | (9.4) | | | 21 | (8.9) | | |
| 2 or more | 421 | (64.2) | 19 | (7.8) | | | 19 | (4.5) | | |
| CAS partners, past 3 months | | | | | 2.03 | 0.154 | | | 8.06 | 0.005 |
| Zero or 1 | 398 | (61.3) | 38 | (9.5) | | | 33 | (8.3) | | |
| 2 or more | 251 | (38.7) | 16 | (6.4) | | | 7 | (2.8) | | |
| HIV status (self-reported) | | | | | | 0.001 | | | 10.35 | < 0.001 |
| Negative/unaware | 602 | (82.2) | 68 | (11.3) | | | 45 | (7.5) | | |
| Positive | 130 | (17.8) | 3 | (2.3) | | | 0 | (0.0) | | |
| If HIV positive, UVL | | | | | 7.76 | 0.045 | | | N/A | |
| Yes | 113 | (86.9) | 1 | (0.9) | | | 0 | (0.0) | | |
| No | 17 | (13.1) | 2 | (11.8) | | | 0 | (0.0) | | |
| If HIV negative, PrEP use | | | | | N/A | | | | 12.58 | 0.001 |
| Never | 440 | (60.1) | 68 | (15.5) | | | 43 | (9.8) | | |
| Past user | 36 | (4.9) | 0 | (0.0) | | | 0 | (0.0) | | |
| Current user | 126 | (17.2) | 0 | (0.0) | | | 2 | (4.4) | | |

Values in bold are significant at the $p < .05$ level

UVL undetectable viral load, CAS condomless anal sex

^aP value of the Pearson's Chi Square test or, for variables with cell counts 5 or below, Fisher's Exact test

^bColumn percentage (e.g., % of total sample who are ages 18–33)

^cRow percentage (e.g., % of men ages 18–33 who are unaware of PrEP)

what PrEP was and 45 (6.1%) did not know what an undetectable viral load meant (including 23 who did not know about either). Age, race/ethnicity, and relationship status were not associated with awareness of either PrEP or TasP. Men who identified as gay, homosexual, or queer were significantly more likely to be aware of PrEP ($p < 0.001$) and TasP ($p = 0.002$) than those who reported another sexual

identification. Men who had completed at least a bachelor's degree were also more likely to be aware of PrEP ($p < 0.001$) and TasP ($p = 0.003$) than those with lower educational achievements. People who reported two or more anal sex partners ($p = 0.023$) and people who reported more than two condomless anal sex partners in the past 3 months ($p = 0.005$) were more likely to be aware of TasP; however,

number of partner was not associated with PrEP awareness. HIV-positive men were more aware of PrEP ($p < 0.001$) and none reported not knowing what an undetectable viral load meant. Among HIV-negative/unaware MSM, those who had never taken PrEP were less likely to be aware of TasP ($p = 0.001$); those who had discontinued PrEP use were not significantly different from the others.

Perceived Effectiveness of Different Strategies

The analyses that follow are based only on the 639 participants who were aware of both PrEP and TasP. Table 2 reports the percentage of participants who believed the different prevention strategies offered “a lot of” or “complete protection” from HIV during serodiscordant anal sex versus those who believed they offered “some,” “only a little,” or “no protection at all.” PrEP had by far the largest proportion of men believing in its effectiveness in the entire sample (70.0%) and within each HIV/PrEP subgroup. HIV-negative men who had ever taken PrEP were more likely to believe in the effectiveness of daily PrEP than those who had never taken PrEP and HIV-positive men (85.6% vs. 63.6% and 67.7%, respectively; $p < 0.001$). The next strategy perceived as most effective was TasP, although only a minority (39.1%) of the entire sample believed it offered a lot of or complete protection. HIV-positive men and HIV-negative/unaware men who had ever taken PrEP were significantly more likely than PrEP-naïve MSM to perceive TasP as effective (58.3% and 49.4% vs. 27.6%, respectively; $p < 0.001$). For the entire sample, perceived effectiveness was low for intermittent

PrEP (16.6%), strategic positioning (15.8%), and withdrawal (10.8%). HIV-positive men were significantly more likely than both PrEP-naïve and PrEP-experienced MSM to perceive intermittent PrEP as effective, though it was still only a minority of them who did (26.0% vs. 15.1% and 12.5%, respectively; $p = 0.005$). The bottom half of Table 2 shows the proportion of participant who believed the prevention strategies offered complete protection, which was small for each strategy. Notably, far fewer participants indicated that daily PrEP and TasP offered “complete” protection compared to “a lot of protection.”

Perceived Effectiveness of TasP

To further understand attitudes towards TasP, we analyzed differences in ratings of TasP (Table 3). Perceived effectiveness of TasP did not vary significantly by age group, race/ethnicity, educational achievement, relationship status, or number of sex partners. Men who identified as gay, homosexual, or queer were significantly more likely than those who did not identify as such to believe in the efficacy of TasP (42.2% vs. 22.5%; $p < 0.001$). A significantly higher proportion of HIV-positive men perceived TasP as effective than HIV-negative/unaware ones (58.3% vs. 34.4%; $p < 0.001$). Among HIV-negative/unaware MSM, those who were current users of PrEP were significantly more likely to perceive TasP as effective than those who had never used it (50.8% vs. 27.6%; $p < 0.001$) with no significant difference with those who had discontinued PrEP use.

Table 2 Percentage of participants who endorse the effectiveness of different strategies to prevent HIV transmission during serodiscordant condomless anal sex between two men ($n = 639$)

| | Entire sample (%) $n = 639$ | HIV undiagnosed never on PrEP (a) $n = 352$ | HIV undiagnosed PrEP experienced (b) (%) $n = 160$ | HIV positive (c) (%) $n = 127$ | χ^2 | p^a | Post Hoc Group Comparisons |
|--|--------------------------------|--|---|-----------------------------------|----------|----------------|----------------------------|
| % of participants who indicated strategy offered “a lot of” or “complete protection” | | | | | | | |
| Daily PrEP | 70.0 | 63.6 | 85.6 | 67.7 | 25.68 | < 0.001 | a,c ≠ b |
| TasP | 39.1 | 27.6 | 49.4 | 58.3 | 46.38 | < 0.001 | a ≠ b,c |
| Intermittent PrEP | 16.6 | 15.1 | 12.5 | 26.0 | 10.58 | 0.005 | a,b ≠ c |
| Strategic positioning | 15.8 | 14.5 | 15.0 | 20.5 | 2.62 | 0.270 | – |
| Withdrawal | 10.8 | 9.9 | 10.0 | 14.2 | 1.88 | 0.392 | – |
| % of participants who indicated strategy offered “complete protection” | | | | | | | |
| Daily PrEP | 17.5 | 13.6 | 23.8 | 20.5 | 8.74 | 0.013 | a ≠ b |
| TasP | 13.9 | 9.7 | 17.5 | 21.3 | 12.75 | 0.002 | a ≠ b,c |
| Intermittent PrEP | 8.5 | 8.0 | 8.1 | 10.2 | 0.65 | 0.724 | – |
| Strategic positioning | 9.1 | 9.4 | 8.8 | 8.7 | 0.09 | 0.958 | – |
| Withdrawal | 8.0 | 7.7 | 8.8 | 7.9 | 0.18 | 0.915 | – |

Values in bold are significant at the $p < .05$ level

^aP value of the Pearson’s Chi Square test

Table 3 Characteristics of participants who believe TasP offers “a lot of” or “complete” protection from HIV during serodiscordant condomless anal sex between men ($n = 639$)

| | Total | <i>n</i> | % | χ^2 | <i>p</i> ^a | Post hoc |
|---------------------------------------|-------|----------|--------|----------|-----------------------|---------------------|
| Age | | | | 0.11 | 0.738 | – |
| 18 to 33 | 327 | 130 | (39.8) | | | |
| 34 or over | 312 | 120 | (38.5) | | | |
| Race/ethnicity | | | | 4.54 | 0.338 | – |
| Black | 100 | 39 | (39.0) | | | |
| Asian | 50 | 22 | (44.0) | | | |
| Latino | 116 | 54 | (46.6) | | | |
| White | 332 | 120 | (36.1) | | | |
| Other/mixed | 41 | 15 | (36.6) | | | |
| Relationship status | | | | 0.41 | 0.520 | – |
| Single | 411 | 157 | (38.2) | | | |
| In a relationship | 228 | 93 | (40.8) | | | |
| Sexual identity | | | | 13.86 | < 0.001 | – |
| Gay/homosexual/queer | 536 | 226 | (42.2) | | | |
| Bisexual/heterosexual/other | 102 | 23 | (22.5) | | | |
| Education | | | | 1.56 | 0.211 | – |
| Less than a bachelor’s degree | 219 | 93 | (42.5) | | | |
| Completed Bachelor’s or higher degree | 420 | 157 | (37.4) | | | |
| Anal sex partners, past 3 months | | | | 1.56 | 0.212 | – |
| Zero or 1 | 203 | 73 | (36.0) | | | |
| 2 or more | 378 | 156 | (41.3) | | | |
| CAS partners, past 3 months | | | | 2.91 | 0.088 | – |
| Zero or 1 | 344 | 126 | (36.6) | | | |
| 2 or more | 231 | 101 | (43.7) | | | |
| HIV status | | | | 24.39 | < 0.001 | – |
| Negative/unaware | 512 | 176 | (34.4) | | | |
| Positive | 127 | 74 | (58.3) | | | |
| If HIV positive, UVL | | | | 0.17 | 0.680 | – |
| Yes | 112 | 66 | (58.9) | | | |
| No | 15 | 8 | (53.3) | | | |
| If HIV negative, PrEP use | | | | 23.71 | < 0.001 | <i>a</i> ≠ <i>c</i> |
| Never | 352 | 97 | (27.6) | | | |
| Past user | 36 | 16 | (44.4) | | | |
| Current user | 124 | 63 | (50.8) | | | |

Values in bold are significant at the $p < .05$ level

CAS condomless anal sex, UVL undetectable viral load

^aP value of the Pearson’s Chi Square test

Discussion

This online survey of NYC MSM showed that participants were generally aware of TasP but also that few seemed to believe it would offer adequate and reliable protection against HIV transmission for two serodiscordant men having condomless anal sex. In our survey, conducted between November 2016 and June 2017, only 7.5% of HIV-negative/unaware participants indicated not knowing what “undetectable viral load” meant when asked about its potential for preventing HIV transmission. In a U.S.-wide survey conducted in May/June 2017 and that used a similar question

[16], a comparable proportion (6.7%) of HIV-negative/unaware MSM said they did not know what undetectable meant when asked about their perception of TasP. In a 2012 survey from Italy [15], 58% of HIV-negative/unaware MSM were unaware of TasP and, in a 2012–2014 survey from Vancouver, Canada [14], that proportion was 59%. However, the measures used from one study to another are too different to confidently claim that there has been an increase in TasP awareness. For instance, giving participant the option, like we did, to say they do not know what undetectable means when asked about the effectiveness of TasP is different from asking if they have ever heard of TasP, which

was the measure used by Carter et al. [15]. Nevertheless, a higher level of awareness and perceived effectiveness of TasP would be expected in studies conducted from 2016 on given that this is when the first evidence that TasP was effective among MSM serodiscordant couples was published [8].

However, our findings also support that awareness of TasP is not tantamount to believing in its effectiveness. Similar to other studies [16–20], we found that HIV-negative/unaware MSM who had never taken PrEP were significantly less likely to believe in the effectiveness of TasP compared to those who had ever taken PrEP and to those who were HIV positive, both of whom rated it similarly. As concluded by Rendina and Parsons [16], it seems that men who more frequently utilize sexual health services are more likely to know of and believe in the effectiveness of TasP. It is likely that HIV care providers talk about TasP with their HIV-positive patients to motivate them to initiate and remain adherent to treatment and to encourage them to prevent forward transmission of the virus. Therefore HIV-positive men may be better informed about recent research developments on the efficacy of TasP for MSM. For them, that public health agencies like the NYC DoHMH and the CDC endorse TasP as an effective HIV prevention strategy may enable an important shift in how they perceive their own sexual possibilities. In qualitative interviews, HIV-positive people expressed a feeling of relief after learning about TasP, and believed that the strategy could enable serodiscordant relationships [24]. Similarly, men taking PrEP are supposed to have quarterly appointments with their prescribing providers, who may use these interactions to educate them about TasP. These men may in fact be taking PrEP because they have sex with partners they know to be HIV positive, and consequently are more informed about the risks involved and prevention strategies available. In sum, our study confirms a need to educate men who are not HIV positive and men who do not use PrEP about TasP. It also corroborates prior research showing that MSM who do not identify as gay, homosexual, or queer are less aware and more skeptical of TasP [16], and that efforts should be made to inform these men about the strategy.

This study also found that MSM seem to perceive TasP as less effective than daily PrEP, but more effective than intermittent PrEP, strategic positioning, and withdrawal before ejaculation. These rankings are not completely in line with what could be expected considering the evidence behind these strategies and their endorsement by public health agencies. The low perceived effectiveness of strategic positioning and withdrawal is expected considering evidence showing that these strategies only reduce risk relative to no prevention strategy [25], and because they are risk reduction behaviors that HIV-prevention workers would not recognize or endorse as safer sex. Regarding intermittent PrEP, although clinical trials have found it to be about as effective as daily PrEP when taken correctly (i.e., a double dose 2 to 24 h prior

to sex and a regular dose every 24 h until one day after sexual activities have concluded) [26, 27], in the US, Truvada® can only be prescribed to HIV-negative men for daily use and PrEP guidelines emphasize the importance of adherence. Studies have found that, when it is presented to them as an effective option, MSM are generally interested in intermittent PrEP [28, 29], and we could expect the perceived effectiveness of the strategy to be higher if it became endorsed by public health agencies. The low perceived effectiveness of TasP compared to that of daily PrEP is perhaps more dissonant with the current endorsement of these strategies and the science behind them. For instance, considering that the CDC indicates that PrEP reduces HIV risk by up to 92% while they state that HIV-positive people with undetectable viral loads present effectively no risk of transmission [10, 21], we could expect the perceived effectiveness of TasP to be at least as high as that of daily PrEP. We offer below a few explanations as to why this may be.

First, even though we presented participants with a scenario in which the HIV-positive man *had* an undetectable viral load, it is possible that participants evaluated the strategy keeping in mind the potential pitfalls of relying on TasP. For HIV-negative men, relying on TasP requires trusting that their HIV-positive partners are adherent to their ART regimen and are accurately representing their viral load. Indeed, in a qualitative study with Australian MSM in serodiscordant couples, HIV-negative men told that the degree of trust required to rely on TasP made the strategy irrelevant outside of an ongoing or committed relationship [23]. In a qualitative study with HIV-positive people, some who were skeptical about the effectiveness of TasP were concerned that the virus might still be present in semen even if it was undetectable in the blood [30]. As such, people who understand that TasP is efficacious in clinical trials might still be doubtful about the reliability of the strategy in real life because it requires them to rely on a measure that is intangible—their own or their partners' viral load. For HIV-negative men, PrEP might feel like a more reliable strategy as they are fully cognizant of their own adherence.

Second, participants may have perceived TasP as less effective because of the fact that the endorsement of the strategy was relatively new compared to PrEP when we conducted our survey. Clinical-trial evidence of the efficacy of TasP for MSM was first published in 2016, and the *U = U* campaign also launched during that year. Since our data were collected during the end of 2016 and the first half of 2017, many participants may still have only recently learned about the strategy. In comparison, by that time, PrEP had already been widely advertised in NYC, for example, with subway ads. Further, TasP promotion has also mostly been done through HIV specialized providers and social media, not public advertising, and those who are not in contact with HIV-related services or LGBTQ-related social media

may have been less exposed to TasP promotion. The lower ranking of TasP vis-à-vis daily PrEP in our study is consistent with Holt et al.'s recent survey in Australia that found that HIV-negative/unaware MSM (regardless of PrEP use) perceived TasP as less effective than daily PrEP [20]. The authors referred to the Precaution Adoption Process Model to explain how people may remain hesitant about using new strategies until the occasion for doing so presents itself more concretely. Holt et al. also refer to Diffusions of Innovations theory to explain how TasP could become more widely accepted among MSM as people in target communities hear about it from early adopters and as the strategy becomes more commonly discussed, accepted, and normative. In accordance to their perspective, we believe the perceived effectiveness of TasP may gradually increase as MSM hear about how it has been working from peers. In line with the Precaution Adoption Model, people may also increase their confidence in TasP as they start using the strategy. As shown in qualitative studies, some people feel that TasP makes serodiscordant condomless sex safer in conjunction with other prevention strategies, for example, in conjunction with PrEP, strategic positioning, or withdrawal before ejaculation [23, 24]. After repeated condomless sex with a serodiscordant partner and consistent HIV-negative test results for the uninfected partner, some may feel increasingly comfortable relying on TasP only and fully believe in the strategy's effectiveness [23]. Fears about HIV being highly infectious, which result from decades of HIV prevention, are difficult to shake and the perceived effectiveness of TasP may only increase very gradually, as more people try the strategy and share their experiences with others.

Finally, MSM might still perceive TasP as riskier than the practice of serosorting (favoring sex with partners of the same HIV status, especially for condomless sex), which has been documented among MSM in NYC for a long time [2]. Although some have hoped that PrEP and TasP could repair the divide between HIV-negative and HIV-positive men, serosorting seems to be replaced with practices such as "biomed matching" (where HIV-positive-undetectable men would favor sex partners that also are HIV-positive-undetectable, and where men on PrEP favor partners on PrEP) or "biomed sorting" (where men taking ART, either as HIV treatment or as PrEP, favor partners also taking ART) [31, 32]. Indeed, a 2016–2017 survey of 5021 MSM in the US found that most of the sex partners of HIV-positive-undetectable men were also HIV-positive-undetectable, and that most of the partners of men on PrEP were also on PrEP [31]. Our survey did not assess attitudes towards serosorting, but it is possible that MSM still find TasP to be less protective than choosing sex partners of the same serostatus. In the same survey, the serodiscordant partners of HIV-positive-undetectable participants were also more likely to be on PrEP than not [31]. MSM who use biomedical prevention

thus also seem to prefer their partner to also use such strategies, potentially making the use of PrEP or TasP redundant, and indicating that they may feel that TasP is effective only in combination with another strategy.

In light of our findings and discussion, it seems much still needs to be done to promote TasP and make the strategy acceptable among MSM and the general population. Our findings confirm that TasP promotion needs to reach out to people who are not already engaged in HIV or PrEP care, and to MSM who do not identify as gay. Qualitative studies might be needed to understand how to address the apparent skepticism of TasP among some MSM. Interventions may need to help MSM address the issue of trust regarding TasP use, guiding them through the discussions necessary to properly rely on TasP. TasP promotion could also draw from models like the Diffusions of Innovations theory to encourage adopters of the strategy to discuss its use and their experiences with their peers and in their community. Further, as TasP is a relatively new HIV prevention strategy, attitudes towards it may be changing rapidly and replicating the study today might already yield very different results. As such, HIV researchers should keep monitoring attitudes towards the strategy in order to allow public health professions to target and tailor TasP promotion to specific groups in which acceptability is lower.

There are study limitations which must be acknowledged when considering the findings. The generalizability of these findings is limited by the fact that participants self-referred into the study and were recruited through online advertisements on social and sexual networking media. Generalizability of the findings is also limited by the fact that we only collected data in NYC. MSM in NYC are likely more exposed to HIV prevention messages than in other regions of the US, where studies might find lower awareness and perceived efficacy for biomedical HIV prevention strategies. Although social desirability bias is likely to be minimal in an online anonymous survey, it is still possible to have affected participants' answers on attitudinal items or their self-reported awareness of PrEP and TasP. The incentive provided for the survey (the chance to enter a raffle for a \$200 electronic gift card) might also have biased the sample by increasing self-enrollment of people primarily motivated to participate by this incentive. Our questions only evaluated a limited number of prevention strategies; adding items assessing attitudes towards condoms or serosorting as prevention strategies would have offered more points of comparisons to understand the results. Although our items sought to measure only perceived objective effectiveness of different HIV prevention strategies, it is possible that participants' ratings took into account their individual willingness to use those strategies. The way we measured PrEP and TasP awareness (by giving participants the options of saying "I don't know what PrEP/undetectable means" when asked to

evaluate the effectiveness of the strategies) did not allow us to clearly distinguish between participants' awareness of these strategies (i.e., have they ever heard of PrEP/TasP) or their knowledge of them (i.e., did they understand enough about PrEP/TasP to rank their effectiveness). More thorough studies involving interviewer-administered questionnaires or in-depth interviews could better illuminate people's awareness, perception, willingness to use, and actual use of different HIV prevention strategies such as TasP.

Compliance with Ethical Standards

Conflict of interest Karolynn Siegel declares that she has not conflict of interest. Étienne Meunier declares that he has no conflict of interest.

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

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