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Willingness to Use Pre-exposure Prophylaxis (PrEP) and Preferences Among Men Who have Sex with Men in Mumbai and Chennai, India: A Discrete Choice Experiment

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Abstract

Pre-exposure prophylaxis (PrEP) programs are planned for key populations in India. We examined PrEP awareness and willingness to use PrEP in order to support products and services for MSM. From December 2016 to March 2017, we conducted a survey and discrete choice experiment (DCE)—a technique to quantify the strength of participants' trade-off preferences among various product attributes—to assess willingness to use PrEP and related preferences. MSM were recruited from cruising sites and HIV prevention services in Mumbai and Chennai. DCE data were analyzed using mixed logit regression models and estimated marginal willingness-to-pay, the relative value participants' place on different PrEP attributes. Overall, 76.6% indicated willingness to use PrEP. Efficacy had the greatest effect on choice (high vs. moderate, aOR = 19.9; 95% CI 13.0–30.4), followed by dosing frequency (intermittent vs. daily regimen, aOR = 2.02; 95% CI 1.8–2.2). Participants preferred no (vs. minor) side-effects, subsidized (vs. market) price, and government (vs. private) hospitals. Findings suggest that educational and social marketing interventions should emphasize PrEP's high efficacy and minimal side effects, and programs should provide government-subsidized PrEP with choices of intermittent or daily dosing delivered by government and private hospitals/clinics in order to optimize PrEP uptake among MSM in India.

Keywords HIV prevention · PrEP · MSM · Stated preference methods · India

Introduction

India is estimated to have the third largest HIV epidemic in the world, and the highest number of people living with HIV in South Asia [1]; over 69,000 people were estimated to be newly infected in 2019 [2]. Similar to the global epidemic, men who have sex with men (MSM) in India bear a disproportionate HIV burden [3]; HIV prevalence among MSM is 15 times higher than among the general population (0.22%). Government reports of average national HIV prevalence among MSM in India range from 2.9 [4] to 7.0% [5], with an independent 12-city study indicating an upper-level estimate of 13.1% [5]. The high vulnerability to HIV infection among MSM, including those in sex work, is fueled by a psychosocial syndemic (synergistic epidemics) of discrimination and violence, including sexual violence [6–8]. Same-sex sexual behavior between adults was criminalized in India until September 2018, contributing to HIV vulnerability; pervasive stigma and discrimination against MSM persists post-decriminalization [7, 9].

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India's National AIDS Control Organization (NACO), operating under the Ministry of Health and Family Welfare, supports HIV prevention programs; this includes targeted interventions for key populations such as MSM. However, despite high levels of HIV knowledge and access to free condoms through these interventions [10], suboptimal rates of condom use persist among MSM amid ongoing stigma and discrimination. In a national survey of MSM (n = 23,081), 50–55% reported consistent condom use, with variations by type of male partner (e.g., primary, paying) [10]. In addition to promoting the use of condoms, which require correct and consistent application in every sexual encounter, it is crucial to support the scale-up of new biomedical HIV prevention technologies [11, 12]. Oral pre-exposure prophylaxis (PrEP) is a safe and highly effective prevention technology that can play a pivotal role in ending the HIV epidemic [13]. The World Health Organization (WHO) recommends oral PrEP as part of combination HIV prevention approaches for people at substantial risk of HIV infection, including MSM [13]. Despite NACO's intent to introduce PrEP for key populations [14], India was estimated to have less than 1500 PrEP users as of April 2020, possibly reflecting the number of female sex workers in two PrEP demonstration projects that provided free-of-cost PrEP [15]. A PrEP demonstration project for MSM is planned by the Indian Council of Medical Research.

Many studies, largely outside of India, have assessed PrEP awareness and willingness to use PrEP, including among MSM. A 2017 systematic review and meta-analysis of 23 studies with MSM (n = 15,014; 1 study from India, n = 61) in low- and middle-income countries reported that nearly two-thirds (64.4%, 95% CI 53.3–74.8) were willing to use PrEP, although less than one-third (29.7%; 95% CI 16.9–44.3) were previously aware of PrEP; doubts about PrEP effectiveness, fear of side-effects, and concern about dosing frequency reduced willingness to use PrEP [16]. In a multi-country study with a variety of potential user groups (n = 1790), 61% indicated willingness to use PrEP—approximately 90% willingness among the subsample of MSM (n = 128) in India [17]. Overall, participants reported willingness to use PrEP despite potential side-effects and having to pay a modest out-of-pocket price [17]. In an online survey of PrEP preferences among MSM (n = 554) in the U.S., affordability and dosing frequency were the most influential factors in determining choices among different hypothetical PrEP regimens [18].

In the Indian context, a study with MSM (n = 271) in Hyderabad recruited from targeted HIV intervention projects (84% with a history of transactional sex) indicated 7% were aware of PrEP, but 99% reported willingness to use it once explained [19]. Qualitative studies with MSM in Chennai, Mumbai, and Hyderabad have identified several potential barriers to PrEP uptake [12, 20]: fear of side-effects, out-of-pocket cost, lack of self-efficacy in adherence, and PrEP-related stigma from MSM communities. Furthermore, MSM reported diverse venue preferences for PrEP delivery: some preferred community-based organizations due to their familiarity and feeling accepted, while others preferred private or government hospitals to avoid other MSM in their local community finding out about their PrEP use. MSM in sex work largely preferred community-based organizations due to anticipated stigma in hospitals [12, 20] and as they are mostly open in community-based organizations about their sex work involvement.

Understanding end-user preferences is critical to the success of global public health programs [21], including HIV prophylaxis [22, 23], such as PrEP. Variability in awareness and willingness to use PrEP among MSM, and different end-user preferences by demographic factors, country/locale, and among MSM engaged in sex work, indicate the importance of understanding population-specific preferences to support PrEP roll-out. In the context of the Indian government's stated concerns about budgetary resources and potential diversion of funds from antiretroviral treatment [12], NACO has expressed the need for further evidence on the feasibility of PrEP programs for MSM and potential PrEP delivery models [14, 16]. To that end, we assessed willingness to use PrEP among MSM, and preferences for PrEP characteristics and implementation strategies, in order to optimize PrEP delivery and uptake.

Methods

From December 2016 to March 2017, we conducted a cross-sectional survey with a discrete choice experiment (DCE). A larger survey (n = 600) addressed preferences for three new HIV prevention technologies: one, PrEP, has already proven safe and effective; the other two, HIV vaccines and rectal microbicides, are still in the development pipeline. Participants were randomly assigned to one of three survey versions, each including a DCE for one technology; we aimed to reduce respondent burden and mitigate confusion among a community sample targeting lower socioeconomic status MSM. The present analysis addresses PrEP.

Study Sample

We used chain-referral sampling [24] in collaboration with local community-based organizations to recruit MSM in Mumbai and Chennai. Participant inclusion criteria were: self-identified as kothi (feminine gender expression, mostly receptive sexual role), gay, bisexual, versatile (insertive and receptive sexual roles, self-identified as "double-decker" in Chennai), panthi (masculine gender expression, primarily insertive sexual role) [7] or "MSM" (some MSM

in Chennai self-identify using the English-language abbreviation); ≥ 18 years of age; sexually active with another man in the previous month; willing to provide consent for participation; and willing to invite peers. Trained peer outreach workers were selected based on representing one of the specified identities (kothi, gay, bisexual, and panthi); they in turn recruited initial participants as seeds from cruising areas and HIV prevention drop-in centers. Seeds then referred additional participants until reaching the predetermined sample size (n = 200); this was deemed sufficient for modelling participant preferences with an efficient DCE experimental design [25]. As suggested by WHO guidelines for DCEs [26], a minimum of n = 30 is needed per identified subgroup: in our sample, MSM engaged and not engaged in sex work, and from two cities. Participants received an incentive of INR 300 (~ US $6) for completing the survey and INR 50 (~ US $1) for each successful referral. The study protocol was approved by the Research Ethics Boards of the University of Toronto, Canada, and The Humsafar Trust, Mumbai, India.

Survey

We used Tablet-Assisted Survey Interviewing (TASI) in Tamil and Hindi. Survey items were developed based on formative qualitative research on the acceptability of PrEP [12] and other biomedical HIV prevention technologies among MSM in India [27, 28] and Thailand [29]. The questionnaire was developed in English, translated into Tamil and Hindi, and back-translated into English to ensure accuracy. Items were then programmed on Android tablet devices, with Java for Android using Eclipse for the DCE, and administered by trained research staff. Survey items assessed participant demographics (age, education, sexual identity, employment status, and income), sex work (reported a paying partner, past month), and condomless anal sex (past month). Willingness to use PrEP was assessed by asking "Would you use PrEP as soon as it becomes available?" Participants responded using a 4-point Likert scale (1 = yes, definitely; 2 = yes, probably; 3 = no, probably not; 4 = no, definitely not); we also provided "don't know" and "decline to answer" options. Responses were dichotomized as "yes, definitely" (1 = yes) vs. the remaining responses (0 = no).

Discrete Choice Experiment

DCE is a preference elicitation technique that is increasingly being utilized to gain insight into end-user preferences in healthcare [30], including for HIV prevention technologies [31]. DCEs are used to quantify the strength of respondents' trade-off preferences [30] among various product attributes and implementation options, based on the economic theory of utility maximization [32, 33]. We used DCE to present survey participants with different multi-attribute PrEP regimens, based on actual characteristics of PrEP and possible implementation strategies.

We conducted a literature review and qualitative research with MSM in India [12] to guide the selection of PrEP attributes (i.e., efficacy) and levels (i.e., 50% vs 99%) for the DCE, in accordance with best practice guidelines [31]. Based on this formative research, we constructed PrEP alternatives with the following dichotomous attributes: 99% or 50% efficacy (to facilitate comprehension, participants were instructed that "99% effective" means it would protect 99 out of 100 people exposed to HIV, as depicted graphically in the cards presented on the tablet screen) (see Fig. 1); daily dosing or four times a week; cost of INR 300 (US $4) or INR 1500 (US $21) for a 1-month supply; no side-effects or minor side-effects; and access PrEP from public hospitals or private hospitals. We used 99% effective, approximating the real-world effectiveness of PrEP, to establish a clear referent for a partially (i.e., 50%) effective product, based on methodological recommendations for choice elicitation tasks [29]. We aimed to make the alternative attribute levels sufficiently distinct to be easily comprehensible to participants, including those with low educational attainment.

Participants were presented with a series of 8 choice scenarios. A choice scenario consists of 5 PrEP cards on the tablet screen, each a combination of 5 dichotomous attributes. Participants were instructed to select the best and worst PrEP options for themselves, and to drag and drop the "best" label into a box on top of their most preferred PrEP card and the "worst" label into a box on the top of their least preferred PrEP card on the tablet screen (Fig. 1). Participants then repeated the best–worst task with the remaining 3 PrEP cards, with the final (5th) card assigned by default to 3rd place. After a practice choice task on the tablet, this double best–worst procedure was repeated 8 times. The design of the instrument follows WHO guidelines for DCE [26], using methods we have previously implemented with MSM in Thailand [29].

Experimental Design

We created hypothetical PrEP scenarios using a Bayesian D-error minimizing design with dummy coded variables obtained using Ngene software (ChoiceMetrics, Sydney, Australia). A Bayesian D-error minimizing design allows one to incorporate information on an a priori distribution of parameters to minimize the probability of sampling error, thus increasing reliability and statistical power of the analysis at viable sample sizes [25, 33]. More specifically, Bayesian D-error minimization involves algorithmically choosing a subset of the full factorial design that will provide an efficient estimate (i.e., one with low sampling variance) by

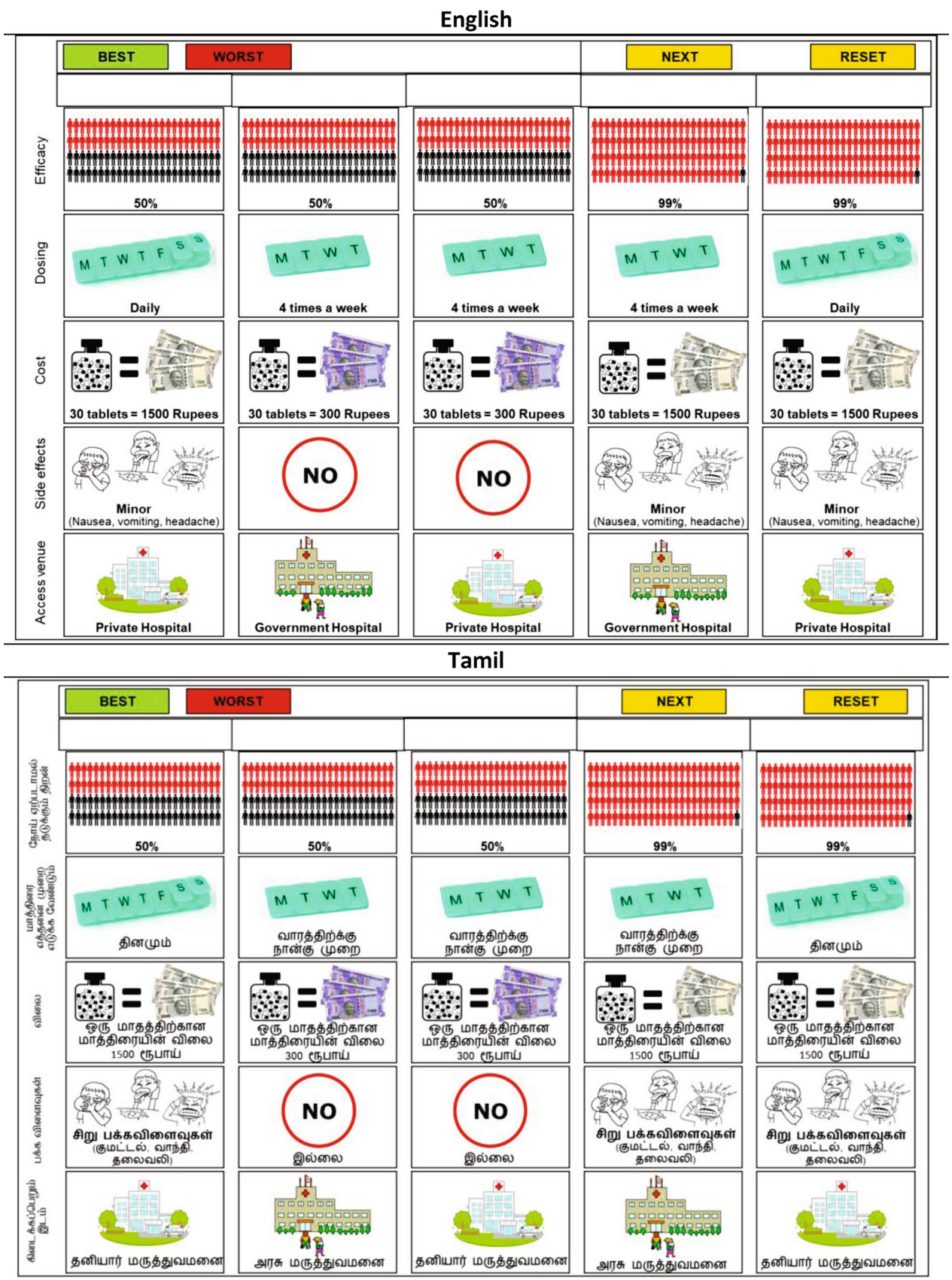

Fig. 1 Sample choice scenario presented on the tablet screen for the discrete choice experiment, in English and Tamil

incorporating empirically informed priors—estimates based on relevant previous data that are used to inform model coefficients [25]. We derived empirically informed priors from our formative qualitative research [12] and a pilot DCE study with MSM (n = 16) recruited from our community-based organization partners. This provided coefficient estimates for the Bayesian design that were incorporated in the final survey, and also ensured the validity and logic of the experimental design. The final design included 32 choice scenarios of 5 hypothetical PrEP alternatives, each blocked in 4 groups of 8 choice scenarios in order to reduce the cognitive burden on survey participants.

Data Analysis

The analytic sample includes 197 HIV-negative MSM; 3 participants who self-reported being HIV-positive were excluded. Sociodemographic and behavioural characteristics, and willingness to use PrEP, were examined using descriptive statistics: mean/SD for continuous variables and frequencies/percentages for categorical variables. DCE analyses were performed using random-parameters (mixed) logit choice models with the assumption of fully correlated random normal coefficients (i.e., correlations between the four independent variables: efficacy, side-effects, dosing frequency, and venue). All main effects were modelled as random normal parameters except for cost, which was fixed to yield marginal willingness-to-pay estimates with normal distributions [32]. The marginal willingness-to-pay measure is used to indicate relative preferences and rankings of the desirability of various PrEP attributes in widely understood monetary terms [34].

For comparative purposes, we conducted DCE analyses using two other models: random-parameters logit with independent random normal coefficients, and conditional logit models. The findings were qualitatively the same as those we report. Our selection of the random-parameters logit with correlation models was supported by the statistical significance of all random parameters and the smaller Akaike's information criterion and Bayesian information criterion for this model.

For ease of interpretation, we report odds ratios of the attributes instead of coefficients for the random-parameters logit with correlation models. Additionally, we estimated marginal willingness-to-pay, a measure of the relative value participants place on different product attributes in monetary terms. We conducted DCE analyses using mixed logit in willingness-to-pay space [32] to assess how much a participant is willing to pay for a particular attribute; this is estimated by using the ratio of each non-monetary random attribute coefficient to the coefficient on the cost attribute [35]. However, the willingness-to-pay measure should not be construed as participants' ability or commitment to pay out-of-pocket, but as a metric for comparing the relative importance of different product attributes.

Based on our formative qualitative research [12] in which we identified possible differences in PrEP preferences by sociodemographic and risk characteristics (e.g., sex work), we conducted additional analyses to explore potential differences in stated preferences among subgroups. We included one interaction term (e.g., cross-product of venue with sex work) at a time in the main model to examine PrEP preferences by age, income, sex work, condomless anal sex (past month), and sexual role and sexual identity. All analyses were conducted in Stata 16.1 (College Station, Tex., USA).

Results

Participant Characteristics

Detailed participant characteristics are reported in Table 1. Overall, participants' mean age was 26.5 years (SD 6.5), with median monthly income of INR 10,000 (US $138) (interquartile range, INR 6000–32,000 [US $83–$444]). One-third (33.5%) completed a college degree, 81.2% were single, and 44.6% reported engaging in sex work. Participants reported diverse identities related to their sexual orientation or sexual role: 28.4% kothi, 23.8% versatile/double-decker, 17.2% bisexual, 15.7% gay, and 14.7% panthi. The majority (58.4%) of participants reported condomless anal sex in the past month. Sex workers (vs. non-sex workers) were less likely to have completed a college degree (20.5% vs. 44.1%) and less likely to report condomless anal sex (past month) (41.3% vs. 79.6%). The average time for survey completion was 40 min as recorded on the tablet devices.

Awareness and Willingness to Use PrEP

Just over one-third (36.5%) of participants reported previous awareness of PrEP. Over three-fourths (76.6%) indicated willingness to use PrEP (i.e., "definitely use PrEP"), with no significant difference between sex workers (75.0%) and non-sex workers (77.9%).

PrEP Preferences

Results from the full rank DCE model in terms of estimated impact on PrEP choice are shown in Table 2. All PrEP attributes were significant ($p < 0.05$). On average, participants indicated nearly 20 times higher odds of choosing PrEP with 99% rather than 50% efficacy. An intermittent PrEP regimen (four times/week) increased the odds of choice twofold compared to a daily regimen. Minor (vs. no) side-effects reduced the odds of choice by 70% compared to PrEP with no side-effects. Participants indicated a marginal

Table 1 Bivariate associations between sociodemographic characteristics, condomless anal sex, and willingness to use PrEP by sex work status among MSM in India (N = 197)

Variable	Total (N = 197) n (%)	Engaged in sex work		χ^2 value	p value
		No (N = 109) n (%)	Yes (N = 88) n (%)		
Age group (years)	105 (53.3)	57 (52.3)	48 (54.6)	0.09	.75
≤ 25	92 (46.7)	52 (47.7)	40 (45.4)		
> 26					
Monthly income (INR)					
< 10,000 (US $138)	101 (51.3)	56 (51.4)	45 (51.1)	0.001	.97
10,000 and above	96 (48.7)	53 (48.6)	43 (48.9)		
Education				12.15	< .001
Higher secondary school or lower	131 (66.5)	61 (55.9)	70 (79.5)		
College degree or higher	66 (33.5)	48 (44.1)	18 (20.5)		
Marital status				0.03	.86
Married	37 (18.8)	20 (18.3)	17 (19.3)		
Single	160 (81.2)	89 (81.7)	71 (80.7)		
Sexual or sexual role-based identity[a]				6.25	.01
Kothi/double-decker/gay	134 (68.0)	66 (60.5)	68 (77.3)		
Others (panthi/bisexual)	63 (32.0)	43 (39.5)	20 (22.7)		
Prior awareness of PrEP				1.53	.21
No	125 (63.5)	65 (59.6)	60 (68.2)		
Yes	72 (36.5)	44 (40.4)	28 (31.8)		
Condomless anal sex (past month)				29.33	< .001
No	82 (41.6)	18 (20.4)	64 (58.7)		
Yes	115 (58.4)	70 (79.6)	45 (41.3)		
Willingness to use PrEP				0.24	.62
No[b]	46 (23.4)	24 (22.1)	22 (25.0)		
Yes[c]	151 (76.6)	85 (77.9)	66 (75.0)		

[a]For analytic purposes, identities were dichotomized on the basis of predominant sexual orientation: kothis, double-deckers, and gay men (predominantly attracted towards men); and panthi and bisexual-identified men (attracted towards both men and women)

[b]Includes those who reported "yes, probably" (22/197; 11.1%), "no, probably not" (9/197; 4.5%), "no, definitely not" (11/197; 5.5%) and "don't know"/"decline to answer" (4/197; 2.0%)

[c]Those who reported "yes, definitely"

preference for PrEP delivered at government hospitals: the odds of choice of PrEP accessed from private hospitals was 10% lower than for government hospitals.

Table 2 (2nd column) shows the results in terms of marginal willingness-to-pay (i.e., the indicative amount of money participants are willing to pay for particular attributes of PrEP). On average, MSM indicated willingness to pay INR 7297 (US $102) more for PrEP with 99% efficacy than 50% efficacy, and INR 1711 (US $24) more for intermittent use than daily use. The negative signs in the willingness-to-pay estimates for side-effects and venue of choice indicate that participants would prefer to *avoid* these attribute values, that is, preferences for no (vs. minor) side-effects and government (vs. private) hospitals.

Results from the random-parameters logit model with significant interactions are presented in Table 2. One PrEP attribute, venue, showed a significant interaction with sex work (yes vs. no). Table 3 presents results of preferences for PrEP attributes by sex work status and corresponding marginal willingness-to-pay results. Overall, the results follow the same pattern by involvement (or not) in sex work. However, MSM not engaged in sex work had lower odds (0.79; 95% CI 0.71, 0.89) of choosing a private hospital than a government hospital to obtain PrEP; among MSM in sex work (0.99; 95% CI 0.90, 1.09) there was no significant venue preference.

Discussion

This study with community-recruited MSM in Mumbai and Chennai, India, indicates that despite the majority of our sample being unaware of oral PrEP, once it was described to them, participants indicated high levels of willingness to

Table 2 PrEP preferences and marginal willingness-to-pay: main model and model with interaction term

Attributes	Main model		Model with a two-way interaction term	
	Adjusted odds ratio (95% CI)	Marginal willingness-to-pay (INR)[a] (95% CI)	Adjusted odds ratio (95% CI)	Marginal willingness-to-pay (INR) (95% CI)
Random parameters				
Efficacy (1 = 99% vs. 50%)	19.96*** (13.06, 30.49)	7297 (5725, 9641)	20.30*** (12.93, 31.81)	7329 (5537.34, 9964.28)
Dosing (1 = 4 times/week vs. daily)	2.02*** (1.80, 2.26)	1711 (1425, 2127)	2.02*** (1.80, 2.27)	1719 (1417, 2155)
Side-effects (1 = minor vs. none)	0.29*** (0.23, 0.36)	− 2982 (− 3455, − 2599)	0.29*** (0.22, 0.36)	− 3007 (− 3489, − 2609)
Venue (1 = private hospital vs. government hospital)	0.90** (0.84, 0.97)	− 239 (− 409, − 62)	0.79*** (0.71, 0.88)	− 550 (− 850, − 276)
Fixed parameters				
Cost (INR 1000)	0.66*** (0.60, 0.72)	NA	0.66*** (0.60, 0.72)	NA
Two-way interaction term				
Venue × Sex work (Yes = 1 vs. No)			1.23 (1.08, 1.40)**	5166 (1946, 8869)

**p < .01, ***p < .001

[a]*INR* Indian rupees

Table 3 PrEP preferences and marginal willingness-to-pay among MSM by sex work involvement

Attributes	MSM engaged in sex work		MSM not engaged in sex work	
	Random-parameters logit with correlations-adjusted odds ratio (95% CI)	Marginal willingness-to-pay (INR)[a] (95% CI)	Random-parameters logit with correlations-adjusted odds ratio (95% CI)	Marginal willingness-to-pay (INR) (95% CI)
Random parameters				
Efficacy (1 = 99% vs. 50%)	24.93* (15.08, 41.21)	8050 (5983, 11,725)	16.85* (10.36, 27.39)	6720 (5130, 9621)
Dosing (1 = 4 times/week vs. daily)	1.94* (1.64, 2.29)	1667 (1244, 2331)	2.12* (1.81, 2.46)	1785 (1379, 2494)
Side effects (1 = minor vs. none)	0.29* (0.21, 0.42)	− 3047 (− 3783, − 2516)	0.29* (0.20, 0.42)	− 2869 (− 3619, − 2309)
Venue (1 = private hospital vs. government hospital)	0.99 (0.90, 1.09)	− 6 (− 225, 252)	0.79* (0.71, 0.89)	− 543 (− 837, − 293)
Fixed parameter				
Cost	0.67* (0.59, 0.75)		0.65* (0.57, 0.75)	

*p < .05

[a]*INR* Indian rupees

use PrEP. High efficacy was the most preferred attribute of PrEP, followed by intermittent (vs. daily) dosing, no (vs. minor) side-effects, and subsidized cost. PrEP is a highly effective and WHO-recommended [13] HIV prevention tool but has not yet been implemented among MSM in India. Our findings provide direct evidence to support PrEP roll-out and optimize uptake among at-risk MSM in India.

To our knowledge, this is the first study to apply DCE to assess preferences for PrEP in India. The analyses build on previous studies of PrEP acceptability and preferences among MSM in India [12, 19], increasing their relevance for program implementation. Overall, the high level of willingness to use PrEP among MSM in this study is similar to that reported in other studies with MSM [19] and

female sex workers [15] in India. A global review of 48 studies (published from 2007 to 2016, none from India) indicated PrEP acceptability of 57.8% among MSM, with higher levels (84.0%) among MSM engaged in sex work (2 of 48 studies) [36]. PrEP acceptability may be contingent on the samples of MSM and geographical locales studied, as well as the year in which data were collected, and the measures employed. The high PrEP acceptability demonstrated in the present study may reflect the fact that the overall sample was recruited through cruising sites and organizations that provide HIV prevention services to low socioeconomic status MSM, the majority of whom reported inconsistent condom use—an at-risk sample per our intentions.

All five attributes included in the DCE—efficacy, dosing frequency, side-effects, venue, and cost—were significantly associated with PrEP acceptability [12]. Participants' preference for intermittent PrEP does not conflict with their primary preference for high efficacy given the equal effectiveness of daily and intermittent use, with the latter also endorsed by WHO for MSM [37]. It is possible that the preference for intermittent PrEP may be due to the reduction in the overall number of pills required (i.e., 4 days vs. 7 days/week), which might implicitly be equated with decreased cost. Even as we assessed cost as a separate attribute, other studies have similarly suggested that intermittent use may be construed by end-users as a cost-saving measure [38]. A study of PrEP preferences among MSM in the U.S., albeit a very different sample—87% white, 94% associates/college-degree or more, and 72% employed fulltime—identified an overall preference for daily (vs. intermittent) dosing; however, within-group differences were observed [18]. Alternately, a scoping review of 84 studies of PrEP service delivery preferences among MSM across multiple countries identified a preference for intermittent dosing [38], similar to the present findings. And although our formative qualitative research [12] suggested that MSM engaged in sex work might prefer daily (vs. intermittent) PrEP due to having a higher number of male partners and less predictability around the timing of sexual encounters, this was not born out in our analysis. We identified no difference in dosing preferences by sex work involvement.

The key issues for implementation may be addressing the complexities of PrEP in response to differences in HIV risk behaviors among MSM, different demands posed by daily and intermittent (or "on demand") dosing regimens, and healthcare providers' competence and attention to collaboratively engaging with individual MSM to identify the best option for themselves [38, 39]. This suggests that PrEP programs in India should provide MSM with options of daily or intermittent dosing regimens, along with training healthcare providers to competently counsel individual MSM on the optimal regimen to meet their needs.

MSM preferred PrEP with no side-effects, as would be expected. A systematic review of PrEP preferences across multiple populations identified concerns about side-effects as a barrier to uptake [40]. The inclusion of side-effects in the DCE provides a measure of its relative importance vis a vis other attributes, such as efficacy and dosing regimen, a strength of this method. Additionally, our formative research indicates that some MSM perceived side-effects to be a proxy for high effectiveness [12]—i.e., an indicator that the product is "working"—which may help to explain its relatively lower impact in the present study compared to efficacy and dosing. Overall, the impact of side-effects on willingness to use PrEP highlights the need for implementation programs to accurately convey the nature and severity of side-effects, when side-effects may be expected, and what can be done to prevent or manage them. Accuracy and openness in communication about possible side-effects can promote uptake among MSM who may harbor misconceptions that would otherwise prevent them from using PrEP [12].

As most participants were of lower or middle socioeconomic status–populations who generally receive free condoms and water-based lubricant from targeted HIV interventions–the preference for PrEP at subsidized (INR 300/month) versus market price (INR 1500/month at the time of the survey; now < INR 1000/month) PrEP was expected. MSM and advocates in India have indicated that free or subsidized PrEP would particularly benefit lower socioeconomic status MSM and MSM engaged in sex work [12]. Similar preferences for subsidized or free PrEP were reported in PrEP demonstration projects with female sex workers in India [41], as well as among MSM in the U.S. [18]. Government programs should provide PrEP for free or at subsidized cost in the interest of optimizing coverage for low socioeconomic status MSM, especially those engaged in sex work.

Finally, participants indicated a marginal preference to obtain PrEP from government versus private hospitals. MSM in India generally express concerns about government hospitals due to past experiences of discrimination, long waiting times, and perceived poor quality of care [7, 12, 42]. It is possible that participants associated subsidized PrEP with government hospitals; and these also might be seen as providing greater anonymity than community-based organizations where one might be more likely to be seen by friends or acquaintances when obtaining PrEP [43]. The lack of venue preference among MSM engaged in sex work may stem from their likelihood of being affiliated with community-based organizations in which they are already open about their sex work involvement. Avoidance of local venues has been identified as a response to anticipated PrEP stigma among MSM in many contexts [39, 44, 45]. Providing access to PrEP in different types of venues may accommodate the

varied preferences and concerns of diverse MSM, thereby optimizing coverage [38, 45].

Strengths and Limitations

The study has several limitations in addition to its strengths. First, given the relatively small sample size and the use of non-probability sampling techniques, the results may not be generalizable to MSM in the two study cities. However, we followed practical guidelines for DCE to determine the sample size [26, 46], and we successfully reached a community sample of MSM at substantial risk for HIV infection. Second, we used formative qualitative research to develop PrEP attributes and levels; nevertheless, other attributes beyond those included in the DCE might influence PrEP uptake. Although long-acting injectable (LAI) PrEP is not yet licensed in India, it may be a preferred mode of administration for some MSM [18, 38]; however, government regulations requiring products to be tested in-country prior to licensure suggest it is unlikely that LAI-PrEP will be introduced concurrent with existing PrEP regimens. Third, stated intentions to use PrEP and product preferences may shift when PrEP is broadly introduced in India; our findings from data collected in 2017 need to be interpreted in the context of evolving research and PrEP awareness. Nevertheless, PrEP awareness and coverage in India remain very low, absent targeted rollout for MSM, supporting the continued relevance of our findings. Additionally, the lack of a neutral midpoint in the Likert scale assessing willingness to use PrEP could have forced some individuals to state willingness or not to use PrEP; however, overall willingness was similar to that reported in other studies among MSM [38]. It is crucial to assess end-user preferences *prior* to PrEP dissemination in order to inform social marketing efforts to accelerate uptake among at-risk MSM. This is evidenced by low PrEP uptake among at-risk MSM in many countries in which it is licensed, often in the absence of data on preferences among community-based populations [38]. We successfully implemented robust DCE methods among a sample of MSM at substantial risk for HIV infection.

Fourth, it is challenging to elicit multiple product preferences among a sample with relatively low educational attainment; we developed and field-tested pictorial cards to support comprehension and reduce cognitive burden for the choice scenarios, and the results indicate meaningful choices, supporting the effectiveness of our methods. Nevertheless, possible misunderstanding of the illustration on the pictorial cards that intended clinics in community-based organizations to be subsumed under private (vs. government) hospitals may have influenced the findings around preferred venue for PrEP distribution. Modest concerns about access venue have similarly been identified in other studies of PrEP with MSM [38, 47]. Finally, our engagement with community-based organizations in conducting formative qualitative research, and in successful recruitment and implementation of the present study, suggest pathways to support dissemination of PrEP through national HIV programs; these organizations serve substantial and diverse populations of at-risk MSM in two large Indian cities.

Conclusion

We found high levels of willingness to use PrEP among MSM in Mumbai and Chennai, cities with a combined population of over 31 million people. Identifying PrEP preferences among likely end-users in various locales is pivotal to promoting coverage. Educational and social marketing interventions emphasizing PrEP's high efficacy and minimal side-effects, and programs providing government-subsidized PrEP with choices of intermittent or daily dosing, delivered in government and private hospitals, and community-based clinics, will support PrEP uptake among at-risk MSM, including MSM engaged in sex work. Implementation projects should monitor uptake, adherence, and evolving preferences to optimize PrEP scale-up among MSM in India.

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Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose.

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Consent to Participate Informed consent was obtained from all individual participants included in the study.

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