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Young men who have sex with men's awareness, acceptability, and willingness to participate in HIV vaccine trials: Results from a nationwide online pilot study

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ABSTRACT

Background: New cases of human immunodeficiency virus (HIV) among young men who have sex with men (YMSM) underscore the need to examine their willingness to use biomedical prevention methods, including an acceptable and efficacious HIV vaccine. We examined whether YMSM's vaccine altruism and vaccine-related socials concerns factors were associated with HIV vaccine acceptability across two vaccine efficacy scenarios, and their awareness and willingness to participate in HIV vaccine research.
Methods: This secondary analysis uses data from a mHealth trial with YMSM at heightened HIV risk (N = 137; 50% racial/ethnic minority; M = 21.7 years). Most YMSM (91.2%) had tested for HIV, and 17.5% (N = 24) reported a prior STI. We used paired-samples *t*-test to compare differences in efficacy acceptability (50% vs 85%), followed by multivariable regressions examining whether vaccine attitudes (altruism and social concerns) were associated with vaccine acceptability and awareness and willingness to participate in HIV vaccine trials. We controlled for age, education, race/ethnicity, prior HIV testing, and STI diagnosis in our analyses.
Results: Acceptability for the HIV vaccine with 85% efficacy (M = 8.86; SD = 1.76) was greater than acceptability in the 50% efficacy scenario (M = 7.60; SD = 2.58). Altruistic attitudes were associated with greater vaccine acceptability at 50% (β = 0.62) and 85% (β = 0.59) efficacy. Higher educational attainment was negatively associated with a vaccine with 50% efficacy (β = −0.20, but not for 85% efficacy. Greater vaccine-related social concerns were negatively associated with HIV vaccine research awareness (AOR = 0.38 (95% CI: 0.22, 0.67). Willingness to participate in a HIV vaccine trial was positively associated with age (β = 0.18) and altruism (β = 0.60), and negatively associated with education (β = −0.21).
Conclusions: YMSM find HIV vaccines as an acceptable prevention modality and are willing to participate in HIV vaccine trials. Findings highlight the need to consider YMSM's altruistic and social concerns attitudes in HIV vaccine research and explore how to leverage these attitudes in research campaigns.
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1. Introduction

Young men who have sex with men (YMSM) accounted for more than 67% of new HIV diagnoses in men aged 13 or older in 2017 [1], with racial/ethnic minorities accounting for more than two thirds of new infections [2]. Over the past three decades, these epidemiological shifts have been accompanied by a sustained focus on the development of novel HIV prevention methods designed to intervene on groups who hold the majority of the burden of the epidemic.

While daily oral pre-exposure prophylaxis (PrEP) remains the only pharmacological HIV prevention modality on the market, an increased awareness regarding the challenges of maintaining adherence to achieve systemic protection have re-energized the pursuit of long-acting, systemic products (e.g., HIV vaccines) [3–5]. At the 2018 HIV Research for Prevention (R4P) Meeting [6], NIH representatives discussed the evolving forecast for biomedical HIV prevention methods, focusing heavily on the development of HIV vaccines given recent breakthroughs in HIV antibody optimization to prevent infection. Nevertheless, given the challenges to vaccine development, it is unclear what the level of efficacy

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would be for a vaccine candidate suitable for testing human clinical trials. While the hope of many researchers is that the HIV vaccine—similar to other modalities like daily oral PrEP—would have an efficacy rate of around 85%, NIH representatives have stated that a vaccine with a 50% efficacy may be a more realistic target and would be successful enough to roll out for clinical use. Given the wide range between 50% and 85% efficacy, it remains unclear whether YMSM at high-risk for HIV acquisition would differentiate the acceptability of a vaccine candidate based on these two efficacy rates.

As HIV vaccines trials are conceptualized and designed, researchers must identify and address challenges and opportunities related to vaccine acceptability across a variety of efficacy scenarios (e.g., different efficacy rates, side effects, monetary costs, duration of immunity, and number of doses necessary to achieve protection) [7–9]. Although these different scenarios have been integrated into measures examining HIV vaccine acceptability, the absence of a vaccine candidate has limited researchers' ability to make definitive conclusions about the factors that could contribute to vaccine uptake once available. In a systematic review and meta-analysis published in 2010, for example, researchers found that these different scenarios contributed to a wide range in hypothetical acceptability across studies and a large deviation within studies [10]. In fact, efficacy of the vaccine was found to be the most salient and influential factor in the meta-analysis [10] whereas other elements (e.g., costs, side effects, perceived HIV susceptibility, perceived benefits) had small effects on vaccine acceptability.

Attitudes about vaccines have been correlated with their hypothetical acceptability, with greater vaccine altruism being associated with higher acceptability scores [11–14]. Chimoyi et al. [14], for example, conducted a 1:1 randomized controlled trial using a three-dose hepatitis B vaccine as a surrogate for a potential HIV vaccine and found that 75% of men in the trial who would be willing to participate in a future vaccine trial would be motivated to do so by altruism. Conversely, researchers have noted that, while participants' reactions towards a HIV vaccine are often positive, they may also report disbelief, suspicion, fear of being stigmatized, as well as criticism of pharmaceutical companies' financial interests surrounding new biomedical prevention products, including a potential vaccine [15]. Given the on-going anti-vaccination campaigns, it remains unclear whether negative attitudes towards vaccines (e.g., stigma, distrust) could influence YMSM's acceptability of a HIV vaccine as a future prevention modality. Given that research examining YMSM's acceptability of an efficacious HIV vaccine is limited, we examined YMSM's vaccine attitudes (i.e., altruism and social concern) and explored whether these attitudes were associated with vaccine acceptability across two efficacy scenarios (i.e., 50% and 85%).

As HIV vaccines trials are conceptualized and designed, researchers must examine the factors that may facilitate or hinder participation in these trials [15–17]. The recruitment of diverse groups at high-risk for HIV acquisition (e.g., YMSM, racial/ethnic minorities) who may be suitable for inclusion in these trials remains a priority given their historical underrepresentation in HIV treatment and prevention research, including vaccine safety trials [17]. For example, in a sample of South African men, researchers found that more men reported altruism as a motivating factor in their participation in a future HIV vaccine trial than the reported financial incentives [15], despite concerns about safety. These findings elucidate an important factor in determining the feasibility of HIV vaccine trial recruitment. Therefore, in this study, we also sought to examine YMSM's awareness of on-going HIV vaccine trials and their willingness to participate in a potential HIV vaccine trial in the future.

2. Methods

2.1. Participants and procedures

Data for this paper come from a secondary analysis of a pilot randomized trial (N = 180) of an online—and mobile-optimized—sexual health education and online dating coaching intervention seeking to reduce HIV risks among YMSM in the United States [18]. In the two-arm trial, the intervention was compared to a control website with similar navigation and mobile-optimization but standard HIV information created by the Centers for Disease Control. The study included a sample of young men who have sex with men (YMSM) at high risk for HIV infection. To be eligible, YMSM were between the ages of 18–24 (inclusive) years old, identified as a cisgender male, reported being single, having a HIV-negative/HIV-unknown status, using online sites to meet partners, and at least one condomless anal intercourse event in the prior 6 months. By design, 50% of the sample had to identify as a racial/ethnic minority. Participants were primarily recruited through advertisements on two popular social and sexual networking sites (Grindr and Facebook). Social network advertisements were viewable only to men who fit our age range and who lived in the United States. There were no set regional or state geographic quotas for the sample.

Participants had a mean age of 21.7 years (SD = 1.83). Based on the Census Bureau division of states into regions, our participants reported lived across the United States: Southern states (n = 51; 37.2%), Midwestern states (n = 22; 16.1%), Western states (n = 26; 19.0%), Northeastern states (n = 33; 24.1%), and Puerto Rico (n = 5; 3.6%). Our sample's distribution of by race and Latino ethnicity was: Non-Hispanic White (n = 69; 50.4%), Hispanic/Latino (n = 43; 31.4%), Multiracial (n = 14; 10.2%), Asian/Pacific Islander (n = 8; 5.8%), and non-Hispanic Black (n = 3; 2.2%). The majority of YMSM identified as gay (87.6%) and had graduated from high school (see Table 1). Most participants (91.2%; N = 125) had ever tested for HIV, and 17.5% (N = 24) had been diagnosed with an STI in the past.

2.2. Procedures

Upon entering the study site, participants were asked to complete a study screener. If eligible, participants created a study account and received a detailed consent form that explained the purpose of the study and their rights as participants. Consented participants then answered a baseline 30-minute questionnaire including questions regarding their sociodemographic characteristics, HIV prevention behaviors, sexual behaviors, and acceptability to rectal microbicide products. Participants completed additional surveys at 30-, 60-, and 90-days. Participants were compensated with $30 Amazon gift card via email upon completion of the baseline questionnaire and received additional incentives for completing the subsequent surveys ($15 for 30-day, $20 for 60-day, and $25 for 90-day follow-up).

The information analyzed in this paper was primarily collected during the baseline (e.g., demographics) and 60-day surveys (e.g., vaccine trial awareness, acceptability, and willingness to participate in future trial). Analyses were conducted using a subset of participants (N = 137) who completed the 60-day follow-up (76.1% participation rate). There were no baseline differences across sociodemographic characteristics between YMSM who completed the 60-day follow-up and those who did not complete the survey. We also found no differences in HIV vaccine-related variables by study arm; therefore, we pooled our data for this analysis and computed means and frequencies for our variables of interest.

Table 1
Demographic characteristics of the sample (n = 137).

		Overall	
		N	%
Age (m, SD)		21.70	1.83
Race			
	White	88	64.2
	Black/African American	13	9.5
	Asian	8	5.8
	Middle Eastern or Native American	2	1.5
	Multiracial	26	19.0
Ethnicity			
	Non-Hispanic/Latino	94	68.6
	Hispanic/Latino	43	31.4
Education			
	8th Grade or Less	–	–
	Some High School	3	2.2
	Graduated High School/GED	16	11.7
	Technical School	5	3.6
	Associate Degree	7	5.1
	Some College	52	38.0
	College	40	29.2
	Some Graduate School	12	8.8
	Graduate School	2	1.5
Sexual Orientation			
	Gay	120	87.6
	Bisexual	13	9.5
	Queer	4	2.9
Prior HIV Test			
	Yes	126	92.0
	No	11	8.0
Prior STI Diagnosis			
	Yes, STI Diagnosis	24	17.5
	No, no STI Diagnosis	113	82.5
Heard of an HIV vaccine trial			
	No	87	63.5
	Yes	50	36.5
Likely to get vaccine at 50% efficacy (m, SD)		7.60	2.58
Likely to get vaccine at 85% efficacy (m, SD)		8.86	1.76
Likely to participate in a trial (m, SD)		7.98	2.50
Altruism Score (m, SD)		3.01	0.68
Social Concern Score (n, SD)		2.19	0.77

Study data were protected with a 256-bit SSL encryption and kept within a university firewalled server. Our Institutional Review Board approved the study procedures.

2.3. Measures

2.3.1. HIV vaccine trial awareness

In a section on HIV vaccines at the end of the 60-day follow-up survey in the parent trial, participants were initially asked whether they were aware of HIV vaccine trials ("Have you heard about HIV vaccine trials before?"; 0 = No; 1 = Yes). Those who reported having heard of HIV vaccine trials were then asked to indicate how they had heard about them (e.g., online, on television, from a friend).

2.3.2. HIV vaccine acceptability

We assessed two efficacy-based examples common in the previous literature [19]. In two items, participants were asked to rate how likely they would be to get an HIV vaccine if it provided either 50% or 85% protection against HIV. Participants used a 10-point scale (1 = "Extremely Unlikely"; 10 = "Extremely Likely") to answer these questions.

2.3.3. HIV trial participation likelihood

To assess hypothetical HIV vaccine trial participation, participants were then asked in a single item their likelihood of participating in an HIV vaccine trial if one was recruiting in their area. Participants were asked to rate their willingness on a 10-point scale (1 = "Extremely Unlikely"; 10 = "Extremely Likely").

2.3.4. Attitudes towards trial participation

At the end of the survey section on HIV vaccines, we assessed attitudes towards HIV vaccines with two subscales previously developed by Lee, Newman, Duan, and Cunningham [12]. These subscales measure both altruistic attitudes towards getting vaccinated, as well as social concerns around getting vaccinated. The altruistic attitude subscale had 4 items addressing health promotive reasons in favor of becoming vaccinated (e.g., "My willingness to get an HIV vaccine is important for the good of all people."; $\alpha = 0.81$), and the social concern scale had 6 items addressing many previously studied barriers to becoming vaccinated having to do with perceptions of others (e.g., "I would be concerned that getting an HIV vaccine would lead to discrimination against me."; $\alpha = 0.87$). Both subscales ask participants to indicate their level of agreement with each statement presented, on a 4-point scale (1 = Strongly Agree; 2 = Agree; 3 = Disagree; 4 = Strongly Disagree). We computed a mean score for each subscale. Full text of all items from each subscale—along with correlations with the vaccine acceptability and likelihood of trial participation items—are presented in Table 2 (Social Concern) and Table 3 (Altruism).

2.3.5. HIV & STI testing

Participants were asked about if they have ever been tested for HIV (0 = No; 1 = Yes), and whether they had a diagnosed STI by a provider (0 = No; 1 = Yes).

2.3.6. Sociodemographic characteristics

Participants were asked to report their date of birth (in years), race (Black/African American, White, American Indian/Alaskan Native, Middle Eastern, Asian, Native Hawaiian or Other Pacific Islander, Other), and Hispanic/Latino ethnicity. For analytical purposes, race/ethnicity (0 = Non-Hispanic Whites; 1 = Racial/Ethnic Minorities) was dichotomized due to small numbers within some racial/ethnic categories in our regression analyses. Participants also reported their sexual orientation (gay, bisexual, queer, other), and their highest level of educational attainment (8th grade or less, some high school, graduated high school/GED, technical school, associate degree, some college, college, some graduate school, graduate school). The education level variable was also dichotomized for analysis (0 = high school degree or less; 1 = greater than high school degree).

2.4. Analyses

After conducting descriptive analyses on our variables of interest, we conducted a paired-sample *t*-test to compare differences in vaccine acceptability between the two efficacy levels. We then examined whether HIV vaccine acceptability at both efficacy levels was associated with prior HIV testing, prior STI diagnosis, and two vaccine attitude subscales (e.g., altruism and social concern) using a multivariable regression framework. In these regression models (see Table 4), we controlled for age, education, and racial/ethnic identity by creating referent groups. Finally, we examined whether YMSM had heard of HIV vaccine trials and their willingness to participate in a future HIV vaccine trial was associated with their sociodemographic characteristics (e.g., age, education, race/ethnic-

Table 2
Vaccine social concern items and correlations.

	Correlation with 50% Acceptability: *r* (p)	Correlation with 85% Acceptability: *r* (p)	Correlation with Trial Participation Likelihood: *r* (p)
"I would be concerned about how my family might react to my getting an HIV vaccine."	−0.15	−0.13	−0.07
"I would be concerned about how my sexual partner or partners might react to my getting an HIV vaccine."	−0.08	−0.16	−0.05
"I would be concerned about confidentiality (others finding out) if I received an HIV vaccine."	−0.07	−0.10	0.06
"I would be concerned that getting an HIV vaccine would affect my ability to get health insurance."	−0.04	−0.09	−0.06
"I would be concerned that getting an HIV vaccine would lead to discrimination against me."	0.03	−0.03	0.10
"It concerns me that if I were to get an HIV vaccine, the HIV antibody test might show me as being HIV- positive."	−0.07	0.03	−0.10
Total Composite Score	−0.08	−0.10	−0.02

*$p < .05$, **$p < .01$.

Table 3
Vaccine altruism items and correlations.

	Correlation with 50% Acceptability: *r* (p)	Correlation with 85% Acceptability: *r* (p)	Correlation with Trial Participation Likelihood: *r* (p)
"I would get an HIV vaccine even if I thought the vaccine might not protect me 100% against HIV infection."	0.49**	0.59**	0.45**
"I would get an HIV vaccine that would prevent me from being able to infect other people with HIV, even if the vaccine might not protect me against HIV."	0.38**	0.38**	0.24**
"I would be one of the first people to get an HIV vaccine."	0.47**	0.34**	0.49**
"My willingness to get an HIV vaccine is important for the good of all people."	0.52**	0.55**	0.49**
Total Composite Score	0.58**	0.57**	0.51**

*$p < .05$, **$p < .01$.

Table 4
Likelihood of receiving vaccine with 50% and 85% efficacy.

	50% Efficacy Scenario				85% Efficacy Scenario			
	b (SE)	β	t	p	b (SE)	β	t	p
Age	0.14 (0.11)	0.10	1.31	0.19	0.07 (0.08)	0.07	0.85	0.40
Education	−1.46(0.58)	−0.20	−2.54	0.01	−0.55 (0.41)	−0.11	−1.36	0.18
Racial/Ethnic Minority	0.07 (0.37)	0.01	0.20	0.85	0.07 (0.26)	0.02	0.27	0.79
Ever HIV Test	−0.07 (0.68)	−0.005	−0.07	0.95	−0.17 (0.48)	−0.03	−0.36	0.72
STI Diagnosis	−0.12(0.50)	−0.02	−0.23	0.82	−1.3 (0.35)	0.00	0.00	1.00
Vaccine Concern	0.17 (0.25)	0.05	0.70	0.48	0.03 (0.17)	0.01	0.18	0.86
Vaccine Altruism	2.36(0.29)	0.62	8.29	0.001	1.53 (0.20)	0.59	7.66	0.001
Model Fit	$F_{(7, 129)} = 10.77$, $p < .0001$				$F_{(7, 129)} = 9.12$, $p < .0001$			

ity), prior HIV testing, prior STI diagnosis using multivariable regressions.

3. Results

3.1. Vaccine acceptability

Acceptability for the HIV vaccine with 85% efficacy (M = 8.86; SD = 1.76) was greater than acceptability in the 50% efficacy scenario (M = 7.60; SD = 2.58); ($t(136) = 7.69$, $p < .001$). In bivariate comparisons between YMSM's sociodemographic characteristics and HIV vaccine acceptability with 50% efficacy, we found no differences across race/ethnicity groups ($F(4,132) = 1.26$, $p = .29$), educational attainment ($F(7,129) = 0.34$, $p = .93$), sexual orientation ($F(2,134) = 0.59$, $p = .55$), prior HIV test ($t(135) = -0.72$, $p = .47$) or STI diagnosis ($t(135) = 1.43$, $p = .16$). We also observed not differences in HIV vaccine acceptability with 85% efficacy across race/ethnicity groups ($F(4,132) = 1.64$, $p = .17$), educational attainment ($F(7,129) = 0.41$, $p = .89$), sexual orientation ($F(2,134) = 1.80$, $p = .17$), prior HIV test ($t(135) = -0.57$, $p = .57$) or STI diagnosis ($t(135) = 1.11$, $p = .27$). Age was not associated with vaccine acceptability at 50% efficacy ($r = 0.05$, $p = .57$) or 85% efficacy ($r = 0.04$, $p = .61$).

Mean social concern scores were moderately low (2.19; SD = 0.77), and mean vaccine altruism scores were moderately high (3.01; SD = 0.68). As shown in Table 2, we observed no association between the vaccine social concern items and HIV vaccine acceptability at either 50% or 85% efficacy, or with likelihood to participate in a HIV vaccine trial in the future. Vaccine altruism items, on the other hand, were correlated with HIV vaccine acceptability at 50% and 85% efficacy, respectively, and YMSM's willingness to participate in a HIV vaccine trial (see Table 3).

In multivariable regressions (see Table 4), altruistic attitudes were associated with greater vaccine acceptability at 50% ($\beta = 0.62$, $p < .001$) and 85% ($\beta = 0.59$, $p < .001$) efficacy. YMSM with more than a high school education were less likely to accept a vaccine with 50% efficacy ($\beta = -0.20$, $p < .05$), yet this association was

not observed for the 85% efficacy scenario. No other covariates were related to either vaccine efficacy scenario.

4. Awareness of HIV vaccine trials

A third of the sample (36.5%; N = 50) reported having heard of HIV vaccine trials, with most reporting having learned about these trials through the internet (60%; N = 30). Most YMSM aware of HIV vaccine trials had a positive opinion of them (72%; N = 36). We observed no differences in vaccine trial awareness by participants' race/ethnicity (X^2(df = 4, n = 137) = 4.25, p = .37), educational attainment (X^2(df = 7, n = 137) = 3.09, p = .88), sexual orientation (X^2(df = 2, n = 137) = 0.46, p = .79), prior HIV test (X^2(df = 1, n = 137) = 0.75, p = .38) or STI diagnosis (X^2(df = 1, n = 137) = 0.01, p = .91). Age was not associated with vaccine trial awareness (t (135) = 0.29, p = .77).

In multivariable logistic regression analysis (X^2(df = 7, n = 137) = 17.69, p = .01), HIV vaccine trial awareness was negatively associated with vaccine social concerns (AOR = 0.38 (95% CI: 0.22, 0.67), p < .001). We observed no associations between vaccine trial awareness and age (AOR = 0.90 (95% CI: 0.71, 1.12), p = .34), education (AOR = 1.22 (95% CI: 0.37, 4.06), p = .75), racial/ethnic minority status (AOR = 0.68 (95% CI: 0.32, 1.45), p = .32), prior HIV testing (AOR = 1.36 (95% CI: 0.30, 6.19), p = .69), prior STI diagnosis (AOR = 1.08 (95% CI: 0.39, 2.98), p = .89), or vaccine altruism (AOR = 1.14 (95% CI: 0.63, 2.07), p = .66).

5. Willingness to participate in future HIV vaccine trials

Once informed about HIV vaccine trials, most participants (85%; N = 137) reported being willing to participate in a vaccine trial in their area. In bivariate comparisons between YMSM's sociodemographic characteristics and willingness to participate in a HIV vaccine trial, we found no differences across race/ethnicity groups (F (4,132) = 1.33, p = .26), educational attainment (F(7,129) = 0.66, p = .70), sexual orientation (F(2,134) = 0.34, p = .71), prior HIV test (t(135) = −0.72, p = .47) or STI diagnosis (t(135) = 1.43, p = .16). We also observed not differences in HIV vaccine acceptability with 85% efficacy across race/ethnicity groups (F(4,132) = 1.64, p = .17), educational attainment (F(7,129) = 0.41, p = .89), sexual orientation (F(2,134) = 1.80, p = .17), prior HIV test (t(135) = 0.03, p = .98) or STI diagnosis (t(135) = −0.32, p = .75). Age was not associated with willingness to participate in a HIV vaccine trial (r = 0.12, p = .17).

In a multivariable logistic regression model (F(7, 129) = 9.40, p < .001), willingness to participate in a trial was associated with age (β = 0.18, p = .03), a high school education (β = −0.21, p = .01), and vaccine altruism (β = 0.60, p < .001). We found no association between willingness to participate in HIV vaccine trials and race/ethnicity (β = −0.02, p = .79), prior HIV test (β = −0.10, p = .18), STI diagnosis (β = 0.14, p = .07), or social concerns regarding vaccine (β = 0.11, p = .13).

6. Discussion

In this study, we examined high-risk YMSM's HIV vaccine acceptability across two efficacy scenarios (50% and 85%). As expected, YMSM's vaccine acceptability levels were greater at 85% efficacy compared to 50% efficacy; however, our sample still found a vaccine of 50% efficacy to be moderately acceptable. Participants who had more than a high school education were less accepting of a 50% vaccine than counterparts with less educational attainment, but this difference was not evident in the 85% efficacy scenario. This difference underscores the importance of promoting a variety of HIV prevention modalities, especially if an eventual vaccine is of lower efficacy. It is also possible that educational attainment is a proxy for health literacy, yet we are unable to test this hypothesis in this study. Future research examining how YMSM understand product efficacy across different socioeconomic strata and degrees of health literacy is warranted.

Consistent with prior research [11–14], vaccine acceptability was associated with prospective users' attitudes towards an HIV vaccine. YMSM who exhibited greater altruistic attitudes (e.g., vaccination could contribute to end the HIV epidemic) were more likely to perceive the 50% and 85% efficacy scenarios as acceptable. YMSM reporting greater vaccine altruism were also more likely to express willingness to participate in future HIV vaccine trials. Although vaccine social concerns were not associated with either vaccine efficacy scenario or willingness to participate in a future HIV trial, YMSM expressing greater vaccine social concerns were less likely to be aware of HIV vaccine research. Taken together, these findings may suggest that YMSM may benefit from educational campaigns regarding HIV vaccine research as a potential strategy to allay vaccine-related concerns and to promote altruism among potential participants. Future research examining how to optimize YMSM's awareness of HIV vaccine trials and their willingness to participate in future HIV trials though health promotion campaigns is warranted.

Advancements in vaccine research will require active engagement from key populations. Overall, just over one third of YMSM in our sample (36.5%) reported having heard about HIV vaccine trials, suggesting lower vaccine trial awareness among YMSM than prior trials with older MSM populations [20,21]. Allen and colleagues, for example, found that 73.8% of MSM in their sample reported awareness of HIV vaccine trials [20]. While one study identified low trial awareness among racial and ethnic minorities [16], our study found that these differences were not a factor of vaccine trial awareness or vaccine acceptability. Given the underrepresentation of racial and ethnic minorities in HIV vaccine acceptability trials [17], however, it remains a key priority to gain a greater understanding of disparities in awareness. It is possible that the differences between studies could be attributed to diverse recruitment and sampling strategies used. Consistent with Alio et al.'s recommendations [22], understanding the social environments where racial/ethnic minorities reside (e.g., Deep South vs. coastal cities across the United States) might influence their access and awareness of on-going HIV vaccine trials. Importantly, YMSM had high willingness to participate in a future HIV vaccine trial, with no sociodemographic differences observed. These findings are encouraging and support efforts to include YMSM in on-going HIV trials and suggest the need to build YMSM's awareness of on-going preventive research such as vaccine trials. Future studies should more closely examine the variance in HIV vaccine trial awareness, both among MSM and between racial and ethnic groups.

Our study also has some limitations deserving mention. First, our sample is an online-recruited, national convenience sample of high-risk YMSM participating in a mHealth prevention intervention. Thus, it may be preemptive to extrapolate the current findings to the larger population of YMSM. Second, while the sample includes YMSM from across the United States, there was no specific regional geographic quota set for the sample. This was a convenience sample recruited through online advertisements, thus we cannot generalize our findings to the entire United States. The nature of our sampling and analyses also limits our ability to generalize or make distinctions across multiple non-white racial and ethnic categories, as we merely compared white participants to non-white participants. Third, our study assessed acceptability to products presenting two distinct efficacy rates. In the absence of an available product, hypothetical acceptability may not be indicative of vaccine willingness and intention to use it in the future

among YMSM. We recognize that the assessment of vaccine acceptability will require greater details regarding the regimen (e.g., dosage, number of treatment visits required), user characteristics and contexts, treatment-related costs (e.g., out-of-pocket expenses, insurance), and potential management of side effects from the vaccine (e.g., long drug tails, toxicity). Building on lessons learned from daily oral PrEP as well as our study findings, we encourage future research to apply sociobehavioral perspectives that examine how these vaccine-related scenarios through choice experiments (e.g., conjoint analysis) and/or placebo trials.

7. Conclusion

High-risk YMSM are mostly unaware of ongoing HIV vaccine trials yet report willingness to participate once informed of these prevention efforts. Community engagement, particularly within online spaces, may help educate and recruit YMSM into these trials. YMSM find HIV vaccines as an acceptable prevention modality. Our findings highlight the need to consider YMSM's altruistic attitudes within the context of HIV vaccine research and, if a vaccine is found to be efficacious, explore how to leverage these attitudes in future public health campaigns. Given the HIV field's optimism for long-acting, systemic prevention and care, future research in vaccine acceptability is warranted.

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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.

Informed consent

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

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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