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Development of an HIV vaccine attitudes scale to predict HIV vaccine acceptability among vulnerable populations: L.A. VOICES

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ABSTRACT

Background: Decade-long delays in successful implementation of Hepatitis B vaccines and ongoing obstacles in HPV vaccine roll-out suggest the importance of an implementation science approach to prepare for the effective translation of future HIV vaccines from clinical trials into routine practice. The objective of this study was to test HIV vaccine attitude items to develop reliable scales and to examine their association with HIV vaccine acceptability.
Methods: HIV vaccine attitude items were assessed as part of the L.A. VOICES survey, a large-scale study conducted among underserved residents of Los Angeles, to identify factors that may influence HIV vaccine acceptability. Participants ($n = 1225$) were randomly selected from public STD clinics, needle exchange sites and Latino community clinics using three-stage, venue-based time space sampling.
Results: Exploratory factor analysis across 20 items revealed four distinct factors – mistrust, HIV vaccine social concerns, risk compensation, and altruistic vaccination – with acceptable reliability coefficients for each subscale (Cronbach's α range 0.61–0.84). We found no significant differences in reliability by gender or by vaccine acceptability. Risk compensation (odds ratio (OR) = 1.49; 95% CI = [1.18, 1.89]; $p = 0.001$) and altruistic vaccination (OR = 1.40; 95% CI = [1.14, 1.71]; $p = 0.001$) were significantly and positively associated with HIV vaccine acceptability.
Conclusions: We identified four HIV vaccine attitude scales with sound internal reliability parameters. In the aftermath of the first candidate vaccine to demonstrate efficacy against HIV infection, these scales may be helpful in bridging expectable research-to-practice gaps in future HIV vaccine dissemination among populations at risk. As HIV vaccine trials progress in the United States and globally, these measures also may be useful as a tool to assess and facilitate effective responses to community concerns about HIV vaccine trials and to target interventions to support recruitment and mitigate risk compensation.

1. Introduction

The Thai RV144 phase III vaccine trial demonstrated for the first time that a vaccine can prevent HIV infection [1]. Subsequent clinical trials are underway to improve on the modest (31%) efficacy of the RV144 vaccine with the potential to achieve a licensable product [2]. Nevertheless, extensive research-to-practice gaps are evident for existing prophylactic vaccines in the U.S., in particular, vaccines licensed for sexually transmitted infections (STI). Decade-long delays in successful implementation of Hepatitis B vaccines [3] and ongoing obstacles in HPV vaccine roll-out with low coverage in young women (33.4% for 3-doses in 2012) and young men (6.8% for 3-doses in 2012) [4,5] suggest the importance of an implementation science approach to prepare for the effective translation of future HIV vaccines from clinical trials into routine practice.

An important challenge for future HIV vaccine uptake is in the domain of public attitudes [6,7]. Persistent negative attitudes toward vaccines in general and misconceptions about vaccine risks

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fueled by anti-vaccination propaganda [7,8] have contributed to vaccine hesitancy and parental refusal of licensed childhood vaccinations in the US; notably, this has resulted in outbreaks of diseases that had nearly been eradicated [9–11]. A systematic review and meta-analysis of future HIV vaccine acceptability further suggests the importance of public attitudes toward vaccines. Overall, the review revealed a moderate level of HIV vaccine acceptability (65.6 [SD = 21.1] on a 100-point scale) with a broad range (37.2 to 94.0) across 20 studies; vaccine attitudes and HIV risk perceptions were among the most significant correlates of acceptability [12]. Notably, most of the studies reviewed used disparate single-item measures of vaccine acceptability; these may be neither comprehensive nor adequate in terms of psychometric properties and are more prone to response bias than scales with established reliability. Assessments of STI and HIV vaccine acceptability that have employed multi-item scales similarly indicate the importance of attitudes and beliefs, including perceived HIV risk and fear of the HIV vaccine causing AIDS [13–16].

Additional challenges for future HIV vaccines may result from initial vaccines that are partially efficacious, requiring integration with rather than substitution for other HIV prevention technologies [15,17,18]. Risk compensation, that is, increases in sexual risk behavior (e.g., decreased condom use) as a result of perceived protection conferred by an HIV vaccine, have the potential to subvert the benefits of vaccination on a population level [19]. In addition to contributing to preparedness for HIV vaccine acceptance, accurate assessment and monitoring of public attitudes toward HIV vaccines may contribute to mitigating risk compensation, particularly among populations most at risk for HIV infection [17].

In order to advance an implementation science approach to future HIV vaccines, we conducted exploratory factor analysis to develop reliable scales to assess HIV vaccine attitudes by testing a number of HIV vaccine attitude items and examining how the scales relate to HIV vaccine acceptability. This investigation provides the basis for further independent sample assessment of the stability of the factor structure, internal reliability and factor scores of HIV vaccine attitudes scales for broader use.

2. Methods

2.1. Participants and procedure

This study uses data from a large-scale survey, L.A. VOICES, conducted among a random sample of racially/ethnically diverse men and women ($n = 1225$) attending venues serving populations at elevated risk for HIV infection in Los Angeles between August 2006 and May 2007 [18]. We used a three-stage time-space sampling strategy that involved random selection of (1) venues within specified geographic areas, (2) four-hour blocks of time within each venue, and (3) adults seeking services during each of the selected four-hour blocks of time to enroll participants from each of three types of public health venues ($n = 28$ venues total) that provide HIV testing and care: public sexually transmitted diseases (STD) clinics ($n = 12$), needle exchange sites ($n = 8$), and Latino community health clinics ($n = 8$). Research staff recruited participants when they presented on site for services. Inclusion criteria were age $\geq$18 years, never previously diagnosed as HIV-positive and not employed at the recruitment venue. Participants provided informed consent and completed face-to-face, computer-assisted personal interviews (CAPI) during their visit. For sensitive questions we used Audio Computer-Assisted Self-Interviewing (ACASI), in which participants entered responses themselves using a laptop and headphones. All participants received US $20 remuneration. The study protocol was reviewed and approved by the University of California at Los Angeles, Los Angeles County Department of Public Health, and University of Toronto institutional review boards.

3. Measures and analysis

Participants responded to 20 HIV vaccine attitude items. Items were developed based on formative qualitative [6,7] and quantitative research [20] conducted among the same populations in Los Angeles. The items were entered into an exploratory factor analysis. We used a combination of the scree plot method and the percentage of variance explained by successive factors to determine the number of factors to be retained, based on meaningful interpretability of the factors. We used varimax rotation to simplify and clarify the data structure [21]. We used a minimum factor loading method with 0.32 as a guideline for each item [22]. The factor loadings ranged from 0.46 to 0.84 in our analyses. For estimation of factor scores, we used the "sum scores by factors" method [23], which is appropriate and acceptable for exploratory factor analysis [22]. This involves summing raw scores corresponding to all items loading on a specific factor. For this method, we computed average scores to retain the scale metric to allow for easier interpretation. In addition, average scores are useful to foster comparison across factors with differing numbers of items. To measure internal reliability of the scales, we calculated Cronbach α values among 1225 participants, as well as reliability coefficients based on HIV vaccine acceptability (high vs. low) and gender (male vs. female). For this exploratory factor analysis we used an analytic sample of 1225 participants with complete data; therefore, we did not have to account for missing responses.

HIV vaccine acceptability was assessed using conjoint analysis [18,24]. Participants rated the acceptability of eight hypothetical HIV vaccines, each described as a bundle of seven dichotomous attributes based on efficacy, side effects, duration of protection, number of doses, route of administration, breadth of protection, and out-of-pocket cost. HIV vaccine scenarios were constructed using a Plackett–Burman fractional factorial design (see [18,24] for full details of the conjoint analysis method). HIV vaccine acceptability is derived from each participant's mean acceptability score across the eight vaccine scenarios. We used this continuous variable for multiple linear regression and a dichotomized HIV vaccine acceptability score for logistic regression based on the median value of the overall vaccine acceptability score.

Bivariate associations of vaccine attitude scales with HIV vaccine acceptability were assessed using the t statistic. Multiple linear regression was conducted to examine associations between HIV vaccine attitudes and overall HIV vaccine acceptability (as a continuous variable). Logistic regression models were then estimated to examine the association between HIV vaccine attitudes and HIV vaccine acceptability.

4. Results

The mean age of participants ($n = 1225$) was 37.4 years. The majority (56.7%) were men. Over one-third (38.2%) were Hispanic (non-primary English speakers), followed by African American (20.0%), White (17.7%), Hispanic (English speaking, 12.4%), and Asian Pacific Islander/American Indian/other (11.7%). About one-third (34.0%) were born outside the US. A majority (79.2%) identified as heterosexual, 15.8% as gay/bisexual men, and 5.0% lesbian/bisexual women. Almost one-third (29.6%) had less than high school education and almost half (49.2%) had a monthly income of $1000 or less. Over half (57.3%) reported an ongoing relationship with a spouse or partner. Over two-thirds (68.6%) reported having a regular place to go for medical care, but half (50.4%) were uninsured. About a quarter (25.7%) reported injection drug use in the past 30 days.

Factor analysis revealed four distinct factors (based on 20 items—see Appendix A) that made conceptual sense and accounted

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Table 1
Reliability coefficients* overall, by HIV vaccine acceptability, and by gender.

Scale	HIV vaccine acceptability			Gender	
	Overall (n = 1225)	Low (n = 632)	High (n = 593)	Male (n = 695)	Female (n = 530)
Mistrust	0.84	0.83	0.85	0.85	0.83
HIV vaccine social concerns	0.79	0.79	0.79	0.79	0.79
Risk compensation	0.65	0.65	0.64	0.63	0.67
Altruistic vaccination	0.61	0.62	0.60	0.63	0.59

* Cronbach's α for internal reliability.

Table 2
Interscale correlations of HIV vaccine attitude scales (n = 1225).

Scale	I	II	III	IV
I. Mistrust	1	–	–	–
II. HIV vaccine social concerns	0.13*	1	–	–
III. Risk compensation	−0.02	−0.11*	1	–
IV. Altruistic vaccination	−0.03	−0.03	−0.08*	1

* $p < 0.05$.

Table 3
Bivariate associations of HIV vaccine attitude scales with vaccine acceptability and gender.

Scale	HIV Vaccine Acceptability			Gender	
	Overall Mean (SD)	Low (n = 632)	High (n = 593)	Male (n = 695)	Female (n = 530)
Mistrust	2.43 (0.65)	2.43 (0.66)	2.43 (0.65)	2.51 (0.68)	2.34 (0.59)*
HIV vaccine social concerns	2.27 (0.58)	2.27(0.59)	2.27 (0.58)	2.27 (0.59)	2.26 (0.58)
Risk compensation	2.89 (0.49)	2.85 (0.49)	2.94 (0.48)*	2.92 (0.49)	2.86 (0.49)*
Altruistic vaccination	2.63 (0.57)	2.58 (0.59)	2.69 (0.55)*	2.66 (0.58)	2.60 (0.56)

* $p < 0.05$.
SD, standard deviation.

cumulatively for 50.6% of the variance: mistrust (5 items; 17.3% of the variance); HIV vaccine social concerns (6 items accounting for 13.3% of the variance); risk compensation (5 items; 10.9% of the variance); and altruistic vaccination (4 items; 9.1% of the variance). Means for the scales (computed range, 1–4 throughout) centered largely around the midpoint of 2.50: mistrust, 2.43 (SD = 0.65); HIV vaccine social concerns, 2.27 (SD = 0.58); risk compensation, 2.89 (SD = 0.49); and altruistic vaccination, 2.63 (SD = 0.57).

Table 1 shows the overall reliability coefficients of the four scales, as well as coefficients by vaccine acceptability and gender. The general guideline for internal reliability measured by Cronbach's alpha is a cut-off value of 0.7 [25]. We retained two factors with a cut-off of 0.6 given these are subscales in an exploratory factor analysis [26,27] which are supported by theory and previous empirical research [28,29]. In addition, reliability coefficients were stable when the sample was divided into low vs. high HIV vaccine acceptability and male vs. female participants.

Table 2 shows interscale correlations. HIV vaccine social concerns were positively associated with mistrust. Risk compensation was negatively associated with HIV vaccine social concerns. Altruistic vaccination was negatively associated with risk compensation. However, none of the scales were highly correlated with one another, supporting the four separate dimensions.

Table 3 shows the bivariate associations of HIV vaccine attitude scales with HIV vaccine acceptability and gender. Males reported higher mistrust (mean = 2.51) compared to female participants (mean = 2.34, $p < 0.001$). Participants who reported high HIV vaccine acceptability (n = 593) (mean = 2.94) scored higher on the risk compensation scale compared to those with low HIV vaccine acceptability (n = 632) (mean = 2.85 p = 0.002). Male participants (n = 695) reported higher risk compensation scores (mean = 2.92) compared to females (n = 530; mean = 2.86, p = 0.044). Participants with low HIV vaccine acceptability reported significantly lower altruistic vaccination (mean = 2.58) compared to those who reported high HIV vaccine acceptability (mean = 2.69, p = 0.002).

Table 4 shows multiple linear and logistic regression of the HIV attitudes scales on HIV vaccine acceptability. Controlling for gender, HIV vaccine acceptability was significantly associated

Table 4
Multiple linear and logistic regressions of HIV attitudes scales on HIV vaccine acceptability.

Predictors	Parameter estimate (β)* (95% confidence interval [CI])	p-Value	Odds ratio (OR)† (95% CI)	p-Value
Male	2.37 (0.21, 4.54)	0.03	1.35 (1.07, 1.70)	0.01
Mistrust	−0.20 (−1.85, 1.46)	0.82	0.98 (0.82, 1.17)	0.81
HIV vaccine social concerns	−1.15 (-3.00, 0.69)	0.22	1.05 (0.86, 1.27)	0.66
Risk compensation	3.51 (1.31, 5.70)	0.002	1.49 (1.18, 1.89)	0.001
Altruistic vaccination	4.90 (3.03, 6.76)	<0.0001	1.40 (1.14, 1.71)	0.001

* Parameter estimate (β) based on HIV vaccine acceptability as a continuous variable.
† Odds ratio (OR) based on HIV vaccine acceptability as a dichotomous variable (high vs. low).

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with higher risk compensation (β=3.51; 95% confidence interval (CI) = [1.31, 5.70]; $p = 0.002$) and higher altruistic vaccination ($\beta = 4.90$; 95% CI = [3.03, 6.76]; $p < 0.0001$). Similarly, when HIV vaccine acceptability was treated as a dichotomous measure, risk compensation (odds ratio (OR) = 1.49; 95% CI = [1.18, 1.89]; $p = 0.001$) and altruistic vaccination (OR = 1.40; 95% CI = [1.14, 1.71]; $p = 0.001$) were significantly associated with HIV vaccine acceptability.

5. Discussion

Widespread research-to-practice gaps between clinical trial efficacy and real-world effectiveness for existing vaccines suggest that the acceptability of future HIV vaccines cannot be taken for granted [6,18]. Reliable scales to assess HIV vaccine attitudes may prove a useful tool in building social-behavioral evidence to support an implementation science approach [30] to facilitate translation of future HIV vaccines into routine practice and public health policy. We identified four distinct scales among underserved residents of Los Angeles, each with acceptable internal consistency. Two of the scales, altruistic vaccination and risk compensation, are significantly associated with HIV vaccine acceptability.

Altruistic vaccination, that is accepting vaccination even if it doesn't completely protect the recipient but helps to protect other people and one's community, was significantly and positively associated with HIV vaccine acceptability. Simulation [29] and epidemiological game theory models [31] similarly provide support for altruism as a motivating factor in the case of influenza vaccine acceptance. To our knowledge, altruism has generally not been factored into either vaccine epidemiologic projections or vaccination policies. Communicating the social benefits of vaccination [32], in addition to directly promoting vaccine uptake, may help to mitigate free-riding. Free-riding describes a phenomenon whereby individuals may seek to maximize personal gain by benefitting from herd immunity while avoiding any personal costs (financial, logistical, perceived risks) by not being vaccinated themselves or vaccinating their children [29,33]. Evidence of increases in the number of US parents who refuse or delay vaccination for their children, and geographically clustered outbreaks of vaccine-preventable diseases [9,10], suggest the potential benefits of incorporating social appeals as one component of future HIV vaccine promotion.

Risk compensation is an important public health consideration for future HIV vaccines [6,18,19,28]. We found that participants with higher scores on risk compensation indicated significantly greater HIV vaccine acceptability, consistent with previous research among college students [34]. Van De Ven et al. [35] similarly identified a "sexual freedom" scale in the context of willingness to participate (WTP) in HIV vaccine trials, with higher scores among higher risk MSM, and a significant positive association with WTP. However, behavioral data from HIV vaccine trials do not provide broad evidence of risk compensation [36–38], in that case due to preventive misconception—a belief that the experimental vaccine tested in a placebo-controlled trial will confer protection [36,39,40]. Yet risk behavior increases were identified among a subsample of MSM in the Vaxgen trial who tested for HIV against provisos from the trial, presumably to determine if they had received the experimental vaccine [36].

Importantly, it would be erroneous to infer that the potential for risk compensation among select vaccine recipients compels an argument against HIV vaccination. Caution is also warranted in extrapolating from behaviors among self-selected volunteers in the context of controlled HIV clinical trials to the millions of potential recipients of a licensed product. The purpose of assessing risk compensation is to support an implementation science approach, with the development of evidence-informed interventions to enhance the effectiveness of future HIV vaccines as a component of a multifocal biomedical and behavioral prevention. A reliable risk compensation scale might be used to identify key populations at risk in order to support tailored community-level interventions.

Finally, the nonsignificant associations of mistrust and social concerns scales with HIV vaccine acceptability may reflect the particular history of mistrust of medical research and vaccines in Los Angeles. Local politicians, for example, invoked the Tuskegee syphilis study to raise cautions about an earlier planned HIV vaccine trial [41]. Greater variance in mistrust and social concerns may be found in other geographical areas and populations, which in turn may then be associated with HIV vaccine acceptability. Additionally, although social concerns, including stigma, constitute barriers to WTP in HIV vaccine trials [42,43], they may exert less influence on the acceptability of a licensed vaccine that is broadly available. In particular, universal rather than risk-targeted approaches to HIV vaccine deployment may help to mitigate the stigma historically associated with HIV/AIDS, thereby reducing social barriers to HIV vaccination [44]; they may also avoid the documented pitfalls of risk-targeted approaches, as evidenced in the history of HBV vaccine implementation in the US [3].

Limitations to this study exist in that the findings are based on exploratory factor analysis for scale construction, along with analysis of internal reliability within this sample, which is not generalizable to other populations. This study provides the first phase of evidence and underscores the need for further independent sample assessment of the stability of the four factors we identified, including the factor structure and internal reliability. Future investigations that test these scales in other populations, including adolescents and parents, youth from key populations at risk, and in locales beyond the Los Angeles area, will help to evaluate their generalizability. In particular, altruism [45] and risk compensation scales may function differently in parents' assessments of HIV vaccine acceptability. Additionally, while we used conjoint analysis, a well-supported method for assessing the acceptability of hypothetical products [46], attitudes and acceptability (as well as risk compensation) may shift once an actual HIV vaccine is available. New biomedical HIV prevention tools also suggest the value of updating these scales; for example, altruistic vaccination and risk compensation may change in light of combination approaches that might include pre-exposure prophylaxis (PrEP) and partially efficacious HIV vaccines. Although we do not have measures of acceptability or uptake of Hepatitis B or HPV vaccines (or PrEP) among the present sample, the substantial gaps between availability and uptake of existing vaccines in the US suggest the wisdom of conducting empirical research well before the availability of licensed HIV vaccines in order to develop evidence informed interventions to support effective rollout.

The evidence reported here is of four distinct HIV vaccine attitude scales with sound reliability. As HIV vaccine trials progress in the US and globally, these scales may be a useful adjunct to social research among underserved and vulnerable communities in order to monitor and be responsive to community concerns as well as to support trial recruitment. These HIV vaccine attitude scales also contribute evolving social-behavioral evidence for an implementation science approach to facilitate the translation of future efficacious HIV vaccines into safe and effective public health policy and practice.

Conflict of interest statement

The authors declare no conflicts of interest.

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Appendix A. HIV vaccine attitudes: Items and scales

Mistrust
1. There is a cure for AIDS, but the government is keeping it from the public
2. HIV is a man-made virus that was created to get rid of certain groups of people
3. Sometimes I think the government is using AIDS to kill off people who are not wanted by society
4. The government already has an AIDS vaccine but is keeping it from the public
5. Pharmaceutical companies cannot be trusted to produce an AIDS vaccine since it would cut into their drug profits

HIV vaccine social concerns
1. I would be concerned about how my family might react to my getting an AIDS vaccine
2. I would be concerned about how my sexual partner or partners might react to my getting an AIDS vaccine
3. I would be concerned about confidentiality (others finding out) if I received an AIDS vaccine
4. I would be concerned that getting an AIDS vaccine would affect my ability to get health insurance
5. I would be concerned that getting an AIDS vaccine would lead to discrimination against me
6. It concerns me that if I get an AIDS vaccine, the HIV antibody test might show me as being HIV-positive

Risk compensation
*1. Getting an AIDS vaccine means you can have sex without using condoms
*2. An AIDS vaccine will make safer sex less important
*3. If I get an AIDS vaccine, I would be more likely to have sex without using a condom
*4. HIV/AIDS will no longer be a threat when there is an AIDS vaccine
*5. Everyone who gets an AIDS vaccine will be protected against HIV/AIDS

Altruistic Vaccination
1. I would get an AIDS vaccine even if I thought the vaccine might not protect me 100% against HIV/AIDS infection
2. I would get an AIDS vaccine that would prevent me from being able to infect other people with HIV/AIDS, even if the vaccine might not protect me against HIV/AIDS
3. I would be one of the first people to get an AIDS vaccine
4. My willingness to get an AIDS vaccine is important for the good of all people

* These items were reverse-coded so that a higher score reflects higher perceived risk.

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