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Journal

Vaccine, 96

ISSN

0264-410X

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Publication Date

2027

DOI

10.1016/j.vaccine.2026.129325

Peer reviewed

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Vaccine 96 (2027) 129325

Contents lists available at ScienceDirect

Vaccine

journal homepage: www.elsevier.com/locate/vaccine

Original article

Defining and validating an HPV vaccination motivation score in Kenya and Malawi: A tool for use in low- and middle-income countries

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ARTICLE INFO

Keywords:
HPV vaccination
Cervical cancer prevention
Global health
Survey research
Kenya
Malawi

ABSTRACT

Background: Studies have evaluated reasons for low HPV vaccine uptake globally but use instruments that were validated only in high-income countries. Our objectives were to (1) determine factors associated with vaccination against human papillomavirus (HPV) in two low- and middle-income countries; and (2) use them to develop and validate a simple score to measure motivation to vaccinate one's daughter against HPV.

Methods: We undertook 3 rounds of data collection: Kenya 2022 (1345 parents/guardians of girls aged 10–16 years, via nationwide mobile phone random-digit dialing), Malawi 2022 (288 parents/guardians of girls aged 9–13 years, via household surveys in three communities), and Kenya 2024 (re-survey of 678 Kenya 2022 respondents who reported having no vaccinated daughters in 2022). The survey included items from the Vaccine Hesitancy Scale-Child and Vaccine Hesitancy Scale-HPV, the Human Papillomavirus Attitudes and Beliefs Scale, and the Wellcome Global Monitor, and parent-reported HPV vaccination of eligible girl(s) in the household.

Results: We found four latent constructs significantly associated with vaccination status in the Kenya 2022 data: Confidence in Vaccine Benefits, Safety Concerns About the HPV Vaccine, Talks About HPV With Others, and Perceives Pro-HPV Vaccination Social Norms. We use these to create an HPV Vaccination Motivation Score; in the Malawi 2022 data (external validity), a 3-point increase in this score was associated with greater odds of having a vaccinated daughter (OR = 1.55; $p < 0.0001$), and in the Kenya 2024 data (predictive/temporal validity), a 3-point increase in the score was associated with significantly greater odds of vaccination in the intervening two years (OR = 1.14; $p = 0.0008$).

Conclusions: This HPV Vaccination Motivation Score can be used to investigate factors associated with HPV vaccination in diverse global settings – and this information can be used to design more effective interventions and programs to increase vaccine coverage and improve health outcomes.

1. Introduction

Vaccines are an essential public health tool: over the past 50 years, vaccination has averted approximately 154 million deaths and is responsible for an estimated 40% of the observed decline in global mortality over this period [1]. Unfortunately many people worldwide are not fully immunized; globally, approximately 20% of children are un- or under-vaccinated [2], and one-third of adults have not received

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https://doi.org/10.1016/j.vaccine.2026.129325
Received 4 July 2026; Received in revised form 1 November 2026; Accepted 2 November 2026
Available online 6 November 2026
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the primary COVID-19 vaccine series [3]. Similarly, only 27% of eligible girls globally have received any doses of the human papillomavirus (HPV) vaccine which prevents many types of cancer including cervical cancer [4] – and uptake of the HPV vaccine is particularly low in many low- and middle-income countries (LMICs) [4,5].

There are many factors that affect people's vaccination behavior, operating at the intrapersonal, interpersonal, community, system/societal, and policy levels—and numerous frameworks posit ways to understand and measure these [6]. Through an improved understanding of these factors, we can better design interventions and policies that will increase vaccine uptake. This, in turn, requires valid and reliable measurement of determinants of vaccination behavior.

The literature contains validated vaccination frameworks and constructs, including approaches to measuring factors associated with uptake of routine childhood vaccines, which have been validated in many countries [7–12]. Surprisingly, for HPV vaccination behavior, psychometric data have come exclusively from high-income countries [13–16] despite the far greater burden of cervical cancer in LMICs [17]. There is a need for valid instruments to increase our understanding of the reasons why people do, and do not, vaccinate against HPV in low- and middle-income countries.

We aim to fill this gap in the literature in three ways: first, by validating existing tools to measure HPV vaccination determinants in two LMIC contexts; second, by determining what factors are associated with HPV vaccination; and finally, by developing a simple HPV Vaccination Motivation Score.

To design this score, we did an initial round of data collection in Kenya using survey items drawn from existing tools validated in high-income countries. We used these survey results to identify latent constructs and the strongest predictors of vaccination status, and to develop a concise 14-item HPV Vaccination Motivation Score.

We tested two key properties for validation. First, the HPV Vaccination Motivation Score should be applicable in populations outside where it was designed; to test this external validity, we administered the survey to parents in Malawi and tested for an association between the score and daughters' vaccination status. Second, the score should be associated with future behavior; to test this predictive/temporal validity, we conducted a follow-up survey two years later with the Kenyan respondents who had reported having no vaccinated daughters, and tested for an association between the score and daughters' subsequent vaccination status. While motivation is not a guarantee of future behavior, we expect it to be an important pre-condition, and potentially directly amenable to intervention. Note that the original 2022 Kenya vaccine motivation score is serving a dual role: we first test its association with vaccination status in 2022; and then, in the unvaccinated group, we test the 2022 motivation score's association with vaccination status in 2024.

Our goal is to provide a tool for use in diverse global contexts to assess determinants of motivation to vaccinate against HPV, which would ultimately help in the design and targeting of interventions to increase HPV vaccination.

2. Methods

2.1. Approach & data collection

Our approach follows best practices for survey development and validation [18]. We developed a 44-item survey that incorporated existing instruments (validated in high-income countries), to measure theoretical constructs associated with vaccine behavior, per the World Health Organization's Behavioral and Social Drivers of Vaccination (BeSD) framework [19] – namely, factors related to what people "think and feel" and "social processes" both of which are hypothesized to impact vaccination motivation in the BeSD framework. We conducted three rounds of data collection to enable us to evaluate, refine, and validate a simple and efficient HPV Vaccination Motivation Score: first, with 1367 parents/guardians of vaccine-eligible daughters in Kenya in 2022 (we refer to this cohort as Kenya 2022); second, with 253 parents/guardians of vaccine-eligible daughters in Malawi in 2022 (we refer to this cohort as Malawi 2022); and third, we followed up with the parents/guardians of unvaccinated daughters in the initial Kenya dataset (we refer to this cohort as Kenya 2024). More information about the survey and about data collection can be found in Online Resource 1; briefly, the 2022 phone survey in Kenya used random-digit dialing on a national sample (for more information please see [20]) and those who consented were followed up also by phone in 2024; and the 2022 household surveys in Malawi were conducted in three rural communities in the southern area of the country (more information can be found at [21]). Eligible respondents in both countries were parents/caregivers of currently and recently vaccine-eligible girls per each country's HPV vaccination guidelines. The surveys (in both countries) were interviewer-administered. For the Kenya 2024 surveys, we recontacted participants who had been interviewed in 2022 using contact information they provided in 2022 (a primary phone number and alternative contact information) and the participant's identity was verified by confirming their name against study records. Each participant was called up to a maximum of six times across different days and times to maximize the likelihood of successful recontact.

2.2. Analysis

Analysis was conducted in R version 4.4.1 (structural equation modeling) and Python version 3.12.7 (associations between the score and outcome). The analysis code is available at https://github.com/nyu-bc3/HPV_vaccine_motivation/.

Validating existing measures: We used Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) to assess the internal validity of the instrument. The EFAs were conducted with between 2 and 14 latent factors using principal axis factoring with oblimin (oblique) rotation, and we considered the scree plot, interpretability, and the theoretical basis of the survey to settle on a final model. Variables with factor loadings less than 0.3 were considered a poor fit and were set to 0. We then used a CFA to finalize the measurement model, with the results of the EFA as a starting point. Model refinement proceeded by inspecting modification indices, and adapting the model where theoretically justifiable. Goodness-of-fit was assessed via the Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Squared Residual (SRMR). Cutoff guidelines of TLI and CFI >0.90, RMSEA <0.08, and SRMR <0.08 were used to evaluate acceptable model fit. Missing data were handled using full information maximum likelihood (FIML) approach. As an additional approach to evaluate internal consistency, we produced item-item Pearson correlation matrices using multiple imputation to address missing data. While most survey items were found to load into latent factors, several items were found not to cluster with any of the other items.

Determining factors associated with vaccination: Next, to assess the association with vaccination status (i.e., criterion validity) and to determine the underlying drivers of vaccination, a Structural Equations Model (SEM) was developed. The survey validation and structural equations modeling approach we adopted followed the best practices of Schumaker and Lomax [22], and a similar analysis of a childhood vaccination conducted using survey data from Guinea, Nigeria, and Uganda [7]. The outcome of interest was having at least one eligible daughter who had received at least one dose of the HPV vaccine as reported in the survey. Our initial SEM model considered how the latent factors (together with the additional survey items that did not cluster with any other items) were associated with this outcome. As a sensitivity analysis, we considered the latent factors and these additional items separately, first by fitting an SEM model to test the association between the latent factors and the outcome (without the additional items), and then by using univariate logistic regressions to test the association

between each of the remaining items and the outcome individually.

Defining an HPV vaccination motivation score: To define the final, parsimonious vaccine motivation score, we fit another SEM model restricted to just the latent factors and survey items that were strongly associated with the outcome. We produced a simple scoring rubric for "HPV vaccination motivation" from the survey questions by considering the factor loadings and associations in this SEM model. Since the factor loadings were all within a factor of 2 of each other, we decided to weight all items the same: all Likert survey items were scored from 0 to 3, and the binary items were scored 0 or 3.

External validity: HPV Vaccination Motivation Scores and associated sub-scores were computed for each survey respondent. We tested the association between these scores and the outcome of having at least one eligible daughter who had received any doses of the HPV vaccine using a simple linear regression. Survey participants were allowed to skip questions, and 26% of participants in Kenya, and 40% in Malawi, skipped at least one question; these skips were handled using multiple imputation with chained equations (MICE) with 20 replications. We only used questions included in the HPV Vaccination Motivation Score for imputation (no auxiliary predictors) in order to best reproduce how missing data would be handled in future studies that use the scale. In addition, to assess whether the latent factor structure identified in Kenya 2022 generalized to this setting, we fit a CFA using the same measurement model and goodness-of-fit criteria. Some of the trust-in-institutions items had not been administered in Malawi, and the confidence-in-vaccine items exhibited substantial ceiling effects (i.e., were nearly at their maximum), so both were excluded from the model. We tested whether the measurement model was equivalent across the Kenya 2022 and Malawi 2022 cohorts with a multi-group CFA. Specifically, we fit three nested models to test three levels of measurement invariance: configural (model 1: same factor structure across cohorts), metric (model 2: same factor structure and loadings), and scalar (model 3: same factor structure, loadings, and intercepts). Invariance was assessed against the criteria of Chen (2007) [23]: ΔCFI $\leq$0.010 and ΔRMSEA $\leq$0.015 between nested models. Where scalar invariance was not supported, we refit a partial-scalar model (model 4) with the non-invariant intercepts treated as free parameters across groups. We also fit a corresponding SEM model to test whether the factors and items that were unassociated with vaccination in Kenya 2022 were still unassociated with vaccination in Malawi 2022.

Predictive/temporal validity: For this analysis, we restricted to the subset of Kenyan parents/guardians with both 2022 and 2024 survey data, and who reported having no vaccinated daughters in the 2022 survey. We tested for an association between the HPV Vaccination Motivation Score computed from the 2022 survey and the outcome of at least one of their daughters having received any doses of the HPV vaccine in the subsequent 2 years. Like with the Malawi 2022 dataset, we used a univariate logistic regression model, and missing data were addressed using MICE.

2.3. Ethical review

Data collection in Kenya was reviewed and approved by the University of California at Los Angeles (UCLA) Institutional Review Board (#22-000005) and by the Kenya Medical Research Institute Scientific and Ethics Review Unit (#SERU4456), and was granted a research permit by the Kenya National Commission for Science, Technology and Innovation (#821192). Data collection in Malawi was reviewed by the UCLA Institutional Review Board (#21-001174) and by the Malawi National Health Sciences Research Committee (#21/04/2685). The New York University Institutional Review Board determined the study was exempt from review (#IRB-FY2023-7919). All subjects gave their informed consent for inclusion before they participated in the study. The study was conducted in accordance with the Declaration of Helsinki.

3. Results

There were 1345 Kenyan parents/guardians who contributed data to the internal validity analyses, 288 Malawian parents/guardians who contributed data to the external validity analysis, and 678 Kenyan parents/guardians who contributed data to the predictive/temporal validity analysis (Table 1).

In the Kenya 2022 dataset, 38.2% of respondents had a daughter/daughters who had received at least one dose of the HPV vaccine (Table 1). The Kenya 2022 sample respondents were on average 38.4 years old, and 54.9% of respondents were female. Most respondents were employed (80.6%) and married (76.4%). Over 40% of the respondents had greater than secondary-level education. The sample was split between residents from urban areas (22.1%), towns (32.7%), and rural areas (45.2%).

Kenya 2022: We identified 8 latent factors, which we labeled as: confidence in vaccine benefits, safety concerns about routine vaccines, safety concerns about the HPV vaccine, change in vaccination attitudes due to the pandemic, knowledge about HPV and about vaccination, trust in institutions, follows vaccination advice from non-clinicians, and talks about HPV vaccination with others (first 8 rows of Online Resource 2). There were also 7 survey items which had low loadings onto all of these factors (remaining 7 rows of Online Resource 2). The results of the EFA scree plot are shown in Online Resource 3, and the item-item Pearson correlation matrices are shown in Online Resources 4 and 5. To improve the fit, we allowed some of the residual terms within the same construct to co-vary, as suggested by the modification indices (see footnote of Online Resource 2). The final 8-factor measurement model, with factor loadings and significance levels is shown in Online Resource 6; the measurement model fits the data well (internal validity; RMSEA = 0.031, TLI = 0.946, CFI = 0.952, SRMR = 0.036).

The eight latent factors identified in the measurement model (shown in Online Resource 2) correspond well with the theoretical basis of the survey. The World Health Organization's BeSD framework posits that motivation to vaccinate (which ultimately results in vaccination behavior, conditional on factors related to access) is shaped by what people think and feel, and social processes [19]. We identified five factors related to the domain of "thinking and feeling:" one related to the benefits of vaccination, two related to vaccine safety (these differentiate routine childhood vaccines and the HPV vaccine), one related to changes

Table 1
Characteristics of the three study samples.

	KENYA 2022	MALAWI 2022	KENYA 2024
n	1345	288	678
Age (years):			
Mean (std dev)	39.0 (9.6)	40.2 (11.0)	40.05 (11.3)
Median [IQR]	38 [26–50]	38 [32–47]	41 [33–47]
Gender, n (%):			
Female	738 (54.9%)	251 (87.2%)	324 (47.8%)
Male	607 (45.1%)	37 (12.8%)	354 (52.2%)
Employed, n (%):			
Yes	1091 (81.1%)	235 (81.6%)	602 (88.8%)
No	254 (18.9%)	53 (18.4%)	76 (11.2%)
Marital status, n (%):			
Married	1024 (76.1%)	219 (76.0%)	520 (76.7%)
Not married	321 (23.9%)	69 (24.0%)	158 (23.5%)
Educational attainment (highest level completed), n (%):			
Less than primary	66 (4.9%)	190 (66.0%)	35 (5.2%)
Primary	318 (23.7%)	67 (23.3%)	162 (23.9%)
Secondary	408 (30.3%)	18 (6.3%)	207 (30.5%)
Higher	553 (41.1%)	13 (4.5%)	274 (40.4%)
Residence n, (%):			
Urban	303 (22.5%)	0	221 (32.6%)
Town	445 (33.1%)	49 (17.0%)	205 (30.2%)
Rural	597 (44.4%)	235 (83.0%)	252 (37.2%)
Daughter(s) has/have received any doses of the HPV vaccine, n (%):			
Yes	514 (38.2%)	138 (47.9%)	322 (47.5%)
No	831 (61.8%)	150 (52.1%)	356 (52.5%)

in vaccine confidence (benefits and safety) due to the COVID-19 pandemic, and one related to knowledge about HPV and the HPV vaccine. Within the domain of "social processes," our analysis found three factors: constructs of trust (a "social process" although not in the BeSD framework), following vaccination advice from non-clinicians (we expanded the BeSD construct to "recommendation from a trusted source"), and social norms.

Three latent factors (Confidence in vaccine benefits, Safety concerns about the HPV vaccine, and Talks about HPV with others) as well as one additional survey item (Perceives pro-HPV vaccination social norms) were found to be significantly associated with the outcome of having at least one eligible daughter with at least one dose of the HPV vaccine (Online Resource 2). These results were consistent in the sensitivity analysis that used an alternative SEM specification (Online Resource 7) and in the univariate models (Online Resource 8). An SEM model restricted to these three latent factors plus the additional survey item fit the data well (RMSEA = 0.043, TLI = 0.950, CFI = 0.960, SRMR = 0.043), and associations with the outcome remained significant (Online Resource 9). These model results were used to define the HPV Vaccination Motivation Score and its scoring rubric (Table 2).

In the Kenya 2022 sample overall, the average Vaccine Motivation Score was 29.7 out of 42; and the motivation score was associated with the outcome of vaccination status (a 3-point increase in motivation score corresponds to OR = 1.49 [95% CI: 1.40, 1.59]; $p < 0.0001$) (first pair of columns in Table 3). Fig. 1 (top row) shows the distribution of motivation scores for the vaccinated and unvaccinated groups: average motivation score for parents of unvaccinated daughters was 29.9, compared to 32.6 for parents of vaccinated daughters. All 4 components of the score were associated with vaccination status ($p \leq 0.0001$) (Table 3). The component that is least strongly associated with the outcome is "confidence in vaccine benefits," likely because it is already nearly saturated with an average value of 17.04 out of 18.

Malawi 2022: The Malawi 2022 sample comprised 288 people, and characteristics are shown in Table 1. In contrast to the Kenya 2022 sample, the Malawi 2022 sample included a higher proportion of women (87.2% of the sample), had less educational attainment (two-thirds of respondents had not completed primary school), and were more rural-dwelling (83.0%). Nearly half (47.9%) of Malawi 2022 respondents said their daughter had been vaccinated against HPV.

Despite these differences in sample composition and prevalence of the HPV vaccination outcome among respondents, the Vaccine Motivation Score was associated with vaccination status in Malawi, showing external validity (second pair of columns in Table 3) (a 3-point increase in vaccination score corresponds to OR = 1.55 [1.36, 1.76]; $p < 0.0001$). The average score for parents of unvaccinated children was 27.7, compared to 33.7 for parents of vaccinated daughters (Fig. 1, middle row). Again, all 4 components were associated with the outcome, though "confidence in vaccine benefits" was again nearly saturated (mean = 17.3 out of 18).

The latent factor structure identified in Kenya 2022 replicated in Malawi 2022 (Online Resource 10), with the exception of the confidence-in-vaccine-benefits factor, which could not be reliably estimated due to ceiling effects on the constituent items (i.e., mean confidence was nearly maxed out).

Results of our multi-group CFA confirm that the measurement model is invariant between Kenya and Malawi (Online Resource 11). Configural invariance (same factor structure) was supported, with the six-factor structure fitting both cohorts acceptably (CFI = 0.921, RMSEA = 0.046, SRMR = 0.045). Metric invariance (same factor structure and loadings) was also supported (ΔCFI = −0.007, ΔRMSEA = +0.001), indicating that factor loadings were statistically equivalent across countries. Full scalar invariance was not supported, driven by three HPV-knowledge items with different intercepts across settings: "HPV can cause cervical cancer," "HPV is passed on during sex," and "men can get HPV." These three questions all had substantially higher correct answers (≥16 percentage points) in Malawi compared to Kenya. A test of partial scalar invariance, freeing these three intercepts, met invariance criteria (ΔCFI = −0.006, ΔRMSEA = +0.001 versus the metric model). And, importantly, these knowledge questions were not retained for the final Vaccine Motivation Score due to low association with vaccination status.

Table 2
Score construction.

Factor	Component variables	Scoring rule	Total points possible
Confidence in vaccine benefits	Vaccines are important for my children's health Getting vaccines is a good way to protect my child from disease I do what the clinician recommends about vaccines The HPV vaccine is important for my daughter's health Getting the HPV vaccine is a good way to protect my daughter from disease I do what the clinician recommends about HPV vaccine	0 points for strongly disagree, 1 point for somewhat disagree, 2 points for somewhat agree, 3 points for strongly agree	0–18
Safety concerns about the HPV vaccine	The HPV vaccine carries more risks than older vaccines I am concerned about mild to moderate short-term effects of HPV vaccine I am concerned about serious short-term effects of HPV vaccine I am concerned about long-term effects of HPV vaccine (mild, moderate or serious)	0 points for strongly agree, 1 point for somewhat agree, 2 points for somewhat disagree, 3 points for strongly disagree	0–12
Talks about HPV with others	I have talked about cervical cancer or HPV vaccine with my daughter I have talked about cervical cancer or HPV vaccine with other parents I have talked about cervical cancer or HPV vaccine with a doctor / nurse / other health care worker	0 points for no, 3 point for yes	0–9
Perceives pro-HPV vaccination social norms	I feel that other parents in my community are vaccinating their daughters against HPV	0 points for strongly disagree, 1 point for somewhat disagree, 2 points for somewhat agree, 3 points for strongly agree	0–3
Overall motivation score		Sum all the above	0–42

Finally, the corresponding SEM produced a similar pattern of associations: the factors that were not significantly associated with vaccine status in the original Kenya 2022 likewise showed no significant association in Malawi 2022 (Online Resource 12).

Kenya 2024: Among girls reportedly unvaccinated in the Kenya 2022 survey, 47.4% had received the HPV vaccine by 2024 (Table 1). Parents/guardians' HPV Vaccination Motivation Score measured in 2022 was associated with their daughter(s)' subsequent vaccination, showing predictive/temporal validity (third pair of columns in Table 3) (a 3-point increase in vaccination score corresponds to OR = 1.14 [1.06;

Table 3
Associations between the overall HPV vaccination motivation score and vaccination status.

	Kenya 2022		Malawi 2022		Kenya 2024	
n parents	1345		288		678	
Overall motivation score [a] [range: 0–42]	Mean ± 95% CI 29.6 ± 0.3		Mean ± 95% CI 30.6 ± 0.9		Mean ± 95% CI 26.8 ± 0.3	
	Odds ratio [95% CI], 1-point increase	Odds ratio [95% CI], 3-point increase	Odds ratio [95% CI], 1-point increase	Odds ratio [95% CI], 3-point increase	Odds ratio [95% CI], 1-point increase	Odds ratio [95% CI], 3-point increase
	1.14[i] [1.12, 1.17]	1.49[i] [1.40, 1.59]	1.16[i] [1.11, 1.21]	1.55[i] [1.36, 1.76]	1.05[h] [1.02, 1.07]	1.14[h] [1.06, 1.23]
Components	Mean ± 95% CI	Odds ratio [95% CI], 1-point increase	Mean ± 95% CI	Odds ratio [95% CI], 1-point increase	Mean ± 95% CI	Odds ratio [95% CI], 1-point increase
Confidence in vaccine benefits [b] [range: 0–18]	17.0 ± 0.1	1.14[h] [1.07, 1.22]	17.3 ± 0.2	1.19[g] [1.01, 1.40]	16.07 ± 0.15	1.02 [0.94, 1.10]
Safety concerns about the HPV vaccine [c] [range: 0–12]	7.1 ± 0.2	1.08[i] [1.05, 1.10]	7.6 ± 0.5	1.15[h] [1.07, 1.23]	6.47 ± 0.21	1.04[g] [1.00, 1.08]
Talks about HPV with others [d f] [range: 0–9]	3.8 ± 0.2	1.26[i] [1.21, 1.30]	3.7 ± 0.4	1.27[i] [1.17, 1.37]	2.79 ± 0.17	1.06[g] [1.01, 1.11]
Perceives pro-HPV vaccination social norms [e] [range: 0–3]	1.7 ± 0.1	1.91[i] [1.68, 2.17]	2.0 ± 0.2	2.12[i] [1.67, 2.68]	1.47 ± 0.04	1.21[g] [1.04, 1.42]

[a] Combines all items below; full item can range 0–42.
[b] Combines: childhood vaccines are important for my child's health, childhood vaccines are a good way to protect my child from disease, HPV vaccine is important for my child's health, HPV vaccine is a good way to protect my child from disease, I do what the clinician recommends for routine childhood vaccines, I do what the clinician recommends for HPV vaccine (each ranges 0–3 for strongly disagree to strongly agree); full item can range 0–18.
[c] Combines: I am concerned about mild or moderate short-term effects of the HPV vaccine, I am concerned about serious short-term effects of the HPV vaccine, I am concerned about long-term effects of the HPV vaccine, the HPV vaccine carries more risks than older vaccines (each ranges 0–3 from strongly agree to strongly disagree); full item can range 0–12.
[d] Combines: I have ever talked about cervical cancer or HPV vaccination with my daughter; I have ever talked about cervical cancer or HPV vaccination with other parents; I have ever talked about cervical cancer or HPV vaccination with a health worker; (each ranges 0–3 for no or yes); full item can range 0–9.
[e] I feel that other parents in my community are vaccinating their daughters against HPV (ranges 0–3 for no or yes); full item can range 0–3.
[f] $p < 0.01$.
[g] $p < 0.05$.
[h] $p < 0.01$.
[i] $p < 0.001$.

1.23]; $p = 0.0008$). The average score for parents who did not vaccinate their daughters over the subsequent two years was 27.5, compared to 29.1 for those who did (Fig. 1, bottom row). While 3 components of the score were significantly positively associated with vaccination status ($p < 0.05$), "confidence in vaccine benefits" was unassociated with the outcome in for this cohort.

4. Discussion

In order to collect high-quality information about determinants of HPV vaccination in different settings – which ultimately can help design interventions to improve vaccine uptake – tools must be validated in diverse contexts. Our study leveraged an established vaccination behavior theory and incorporated questions from survey instruments that had been previously validated in high-income countries, including the Vaccine Hesitancy Scale-Child and the Vaccine Hesitancy Scale-HPV [14], and the Human Papillomavirus Attitudes and Beliefs Scale [16], which have been validated in several countries across North America, Europe, and Asia [8,14,24–27] – but there is little evidence to date from the global South.

This paper presents a novel HPV Vaccination Motivation Score that shows promise for use in LMICs in order to identify potential points for intervention and ultimately increase HPV vaccine uptake. We found that this HPV Vaccination Motivation Score was significantly associated with the outcome of having any daughter(s) vaccinated against HPV in Kenya and Malawi, and with future vaccination status in Kenya. The score is parsimonious – ultimately including fourteen questions – and reflects four constructs (confidence on vaccine benefits, safety concerns about the HPV vaccine, talking about HPV vaccination with others, and perceiving pro-HPV vaccination social norms) which correspond to the underlying theoretical framework of the BeSD. It also has similarities to previously-validated survey tools such as the VHS and the HABS, but offers several innovations, such as more specificity in types of side effects, inclusion of constructs about routine childhood vaccination as well as HPV vaccination, and inclusion of social factors, which prior tools (like the VHS and HABS did not). We note that per the BeSD, access to vaccination services impacts behavior subsequent to motivation so this was not explored here but may well be an important moderator of the relationship between motivation and vaccination and this should be rigorously explored in future research.

We created a comprehensive survey tool with potential domains and constructs beyond what has been included in previous instruments. This included recent changes in attitudes toward vaccines, which we felt was important to include in light of increasing vaccine hesitancy globally [28–33]; knowledge about HPV and the HPV vaccine, which we included because previous studies have found that such knowledge is low in many African countries [34–39]; and questions about institutional trust, reflecting rising interest in trust as an important determinant of vaccination attitudes and behavior [40–44]. Additionally, although the BeSD (and the VHS-Child and VHS-HPV) focuses on health worker recommendation, we also asked whether the respondent would follow a vaccination recommendation from religious and traditional leaders, as these may be important and highly trusted messengers in a range of contexts [45–47]. These factors were identified in the exploratory factor analysis but ultimately did not predict the outcome, which suggests they may not significantly shape HPV vaccination decisions at the aggregate level.

We also added facets to certain topics in the survey tool, allowing for a more expansive definition and interpretation of some BeSD constructs. For example, we distinguished between vaccine side effects' severity and duration (going beyond how this was treated in the VHS-Child or VHS-HPV) because the literature suggests that parents in Africa have

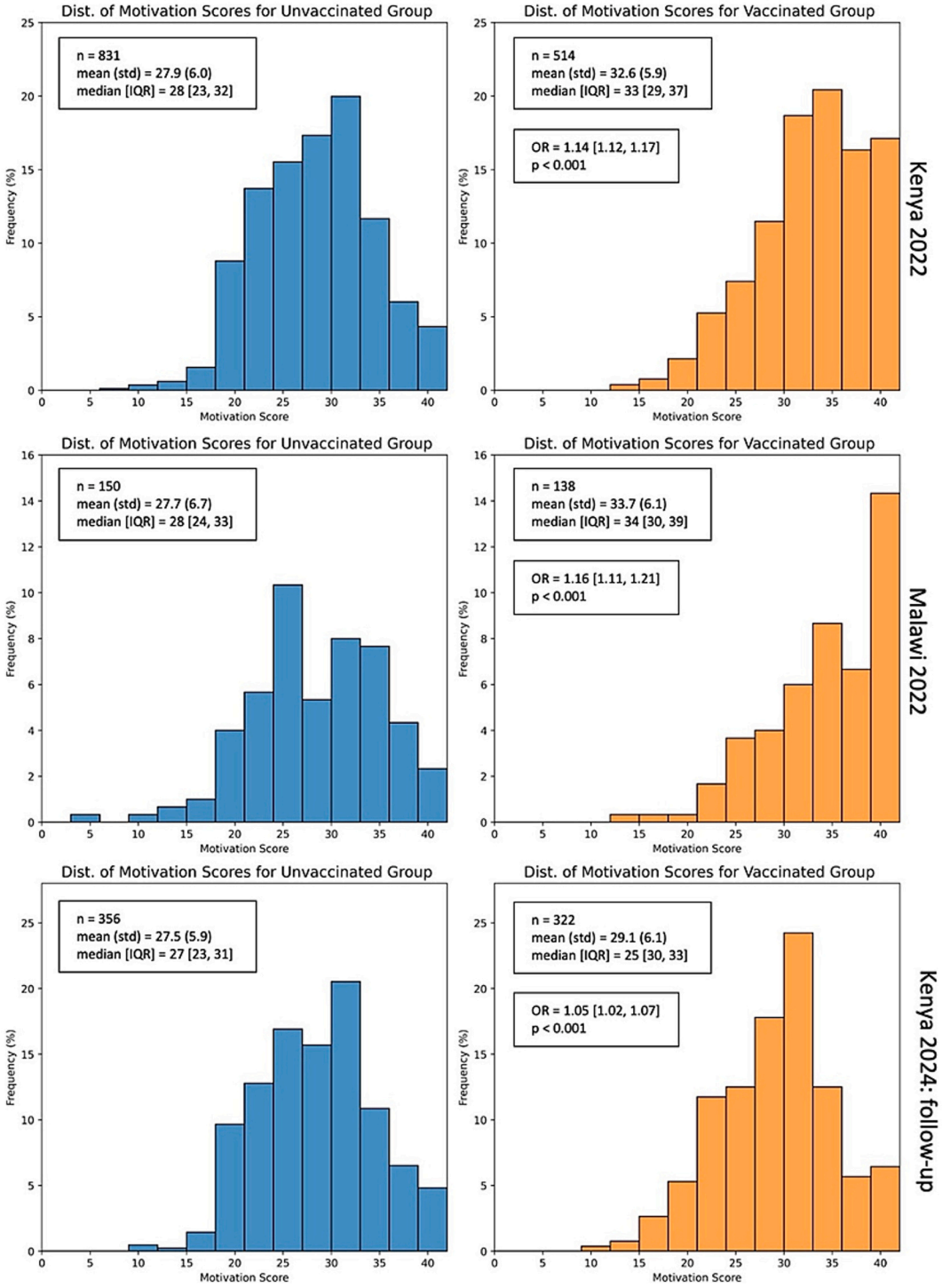


Fig. 1. For each of the 3 cohorts (Kenya 2022, Malawi 2022, and Kenya 2024), we plot the distribution of HPV Vaccination Motivation Scores for parents of unvaccinated and vaccinated daughters, respectively.

particular concerns about long-term safety including impacts on girls' fertility later in life [48–58]. Concerns about the HPV vaccine's safety—across levels of severity and duration of impact—were significantly associated with HPV vaccination in both the Kenya and Malawi samples, but this factor had among the lowest effect sizes among all score components, suggesting that this factors into parents' motivation to vaccinate but is not a strong driver. On the other hand, talking with other people (one's daughter, other parents, and health workers) was a very strong factor in all three samples, which may mean that social networks and informal communications may be an important lever for HPV vaccination promotion interventions. Future research should seek to better understand these issues and how they affect motivation to vaccinate and ultimate vaccination behaviors, including whether they vary by respondent characteristics or by social environments.

In the Kenya cohort, the score (measured from responses given in 2022) effectively distinguished between three distinct groups of parents: those whose daughters were vaccinated in 2022 (mean score of 32.6), those whose daughters were unvaccinated in 2022 but became vaccinated in 2024 (mean score of 29.1), and those whose daughters were still unvaccinated in 2024 (mean score of 27.5). This monotonic gradient

suggests that greater vaccine motivation was associated with earlier action in this group. The formal association between motivation score and vaccination status in the Kenya 2024 data remained statistically significant despite a two-year gap between measurement of motivation and of outcome.

We observed broad measurement invariance across Kenya and Malawi, which further supports the score's use across LMIC settings. The exception was three HPV knowledge items which differed between the two countries and may reflect variation in the reach and effectiveness of public health communications. Importantly, no item with substantial between-country difference was retained in the final Vaccination Motivation Score. Nonetheless, applications of the score in settings with substantially different contexts should begin by validating the score locally.

Some additional limitations to this study should be noted. First, the samples reflected here may not generalize to all settings: the Kenya 2022 data were from a phone survey so there may be representation bias owing to phone ownership; the Malawi 2022 data were from household surveys in only three parts of the country so do not reflect national variation; and the Kenya 2024 data were only among those with eligible daughters in 2022 who were unvaccinated (i.e., people who did not take up a recommended health behavior when it was offered) and who were successfully re-contacted two years later (which may introduce bias if there was meaningful differential sample attrition – although our team has found little evidence of differential loss to follow up in these samples [20]). Second, parents/guardians in these surveys were asked to report on their daughters' HPV vaccination status so there may be measurement bias, although our team's prior work has suggested this is minimal [59]. In addition, the outcome variables here of having at least one daughter who received at least one dose of the HPV vaccine does not capture all girls in the household; our team's prior analyses have found little intra-household variation in vaccination behaviors but future research might wish to interrogate the relationship between motivation and vaccination status by birth order. Third, the surveys were all interviewer-administered so we cannot rule out social desirability bias as parents answered these questions. Lastly, while we have identified a significant association between motivation score and subsequent vaccination behavior, it was in an observational setting that cannot rule out confounding; likewise, it is possible that parents'/guardians' motivation changed in Kenya over the two-year follow-up period between surveys and we did not examine this.

5. Conclusions

Incorporating data from three study samples with identical survey tools based on modules and questions that have been validated in high-income contexts, we developed an HPV Vaccination Motivation Score that demonstrates high validity and shows promise for use in the Global South. The latent constructs—Confidence in Vaccine Benefits, Safety Concerns About the HPV Vaccine, Talks About HPV with Others, and Perceives Pro-HPV Vaccination Social Norms—correspond well to the World Health Organization's Behavioral and Social Drivers of Vaccination framework. We encourage continued research that deepens our understanding about the factors affecting HPV vaccination motivation and behavior, and we hope other studies will incorporate this HPV Vaccination Motivation Score in order to build a harmonized research evidence about this important topic.

CRediT authorship contribution statement

Corrina Moucheraud: Writing – review & editing, Writing – original draft, Supervision, Methodology, Funding acquisition, Conceptualization. **Guanghao Li:** Writing – review & editing, Writing – original draft, Visualization, Software, Formal analysis. **Eric Ochieng:** Writing – review & editing, Project administration, Investigation. **Ginger Golub:** Writing – review & editing, Supervision, Funding acquisition. **Khumbo Phiri:** Writing – review & editing, Project administration. **Symon Chibaka:** Writing – review & editing, Resources, Project administration, Investigation. **George Ganda:** Writing – review & editing, Resources, Project administration, Investigation, Data curation. **Sam Phiri:** Writing – review & editing, Supervision, Resources. **Sara Hyman:** Writing – review & editing, Visualization, Software, Formal analysis. **Risa M. Hoffman:** Writing – review & editing, Supervision. **Peter G. Szilagyi:** Writing – review & editing, Methodology, Funding acquisition, Conceptualization. **Alex Dahlen:** Writing – review & editing, Writing – original draft, Visualization, Supervision, Methodology, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Corrina Moucheraud reports financial support was provided by Jonsson Comprehensive Cancer Center. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

We thank the research assistants who led the data collection efforts for all three samples, as well as the respondents who generously shared their time and experiences with us. We thank Pericles Kalande for his assistance with data collection in Malawi. We also thank Rophence Ojiambo who helped generate the Kenya 2024 analytic sample from the dataset. This research was supported by the Jonsson Comprehensive Cancer Center.

All authors attest they meet the ICMJE criteria for authorship.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.vaccine.2026.129325.

Data availability

The data that has been used is confidential.

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