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Parental knowledge, health-worker information and safety concerns as correlates of HPV vaccine uptake among girls aged 9 to 14 years in Kogi State, Nigeria: A cross-sectional study

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Parental knowledge, health-worker information and safety concerns as correlates of HPV vaccine uptake among girls aged 9 to 14 years in Kogi State, Nigeria: A cross-sectional study

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Abstract

Background. Nigeria added the human papillomavirus (HPV) vaccine to routine immunization in October 2023, but uptake remains low, and evidence from north-central states is scarce. We estimated parent-reported uptake and correlates among parents of girls aged 9 to 14 years in three Kogi State local government areas (LGAs).

Methods. In a cross-sectional survey, we interviewed 336 parents and guardians in Lokoja, Igalamela, and Ibaji; we analyzed 329 with at least one eligible daughter. The outcome was the report of at least one vaccinated daughter. Knowledge was the count of nine awareness items answered yes. With 61 vaccinated parents, associations were estimated with Firth-penalized logistic regression, and 30 bivariate tests were corrected for multiplicity.

Results. Sixty-one parents (18.5%, 95% CI 14.7 to 23.1) reported a vaccinated daughter; 118 of 326 (36.2%) had never heard of the vaccine. Uptake rose from 0.9% to a knowledge score of 0 to 48.6% at 7 to 9. After adjustment, each additional item known (adjusted odds ratio [aOR] 1.56, 95% CI 1.36 to 1.82) and naming a health worker as the main source versus other sources (aOR 3.85, 1.89 to 8.32) were associated with higher odds of uptake, and concern about side effects with lower odds (aOR 0.40, 0.18 to 0.88). Education, income, religion, and LGA were not independently associated.

Conclusions. Uptake was concentrated among informed parents, those informed by health workers, and those not worried about side effects. Vaccination itself exposes parents to information, so these associations are not causal. Health-worker communication and safety messaging merit priority.

Keywords: human papillomavirus vaccines; vaccination coverage; parents; health knowledge; health personnel; Firth logistic regression; Nigeria

INTRODUCTION

Cervical cancer is almost entirely preventable, yet it remains one of the most common cancers in women worldwide (Sung et al., 2021). The 2020 estimates for the world recorded 604,127 new cases and 341,831 deaths, with an age-standardised incidence of 13.3 per 100,000 against the elimination threshold of fewer than 4 per 100,000 (Singh et al., 2023). The World Health Organization's elimination strategy asks countries to fully vaccinate 90% of girls by age 15 against HPV, alongside screening and treatment targets (World Health Organization, 2020). The evidence behind that target is strong. Swedish registry data showed that girls vaccinated before 17 years had a markedly lower incidence of invasive cervical cancer (incidence rate ratio 0.12) (Lei et al., 2020), and a randomised trial in Kenya reported single-dose efficacy of 97.5% against persistent infection (Barnabas et al., 2022). WHO now accepts single-dose schedules for girls aged 9 to 14 years (World Health Organization, 2022).

Nigeria introduced the vaccine into routine immunisation in October 2023 (Adewole et al., 2026). Before and since the introduction, uptake figures have been low and uneven. A systematic review of Nigerian studies found acceptance ranging from 32.7% to 97.3% but uptake of only 1% to 15%, with most studies set in southern Nigeria (Aminu et al., 2026). A pooled analysis of schoolgirl uptake in sub-Saharan Africa gave 28.53% overall and 3.77% for Nigeria, with knowledge and attitudes among the factors linked to vaccination (Asgedom et al., 2024). Local surveys fit that picture: 4% of girls were vaccinated in Lagos although 79.2% of parents were willing (Akinleye et al., 2020); 23.4% of adolescents in Benin City had been vaccinated, and fear of side effects was frequently reported (Imarengiaye et al., 2025); 9.3% of rural schoolgirls in Oyo State were vaccinated during the national rollout (Adewole et al., 2026); and in Kano only 4.2% of 1,071 parents of children aged 9 to 14 years had heard of HPV, while safety concerns and the lack of a doctor's

recommendation were tied to hesitancy (Yusuf et al., 2024). In Abia State, 63.0% of parents accepted the vaccine, and health workers were the source for 43% (Amuzie et al., 2025). Earlier surveys of mothers, caregivers, and students in Nigerian cities examined willingness, awareness, and uptake in the same way (Azuogu et al., 2019; Bisi-Onyemaechi et al., 2018; Ezeanochie & Olasimbo, 2020).

International literature points to a small set of correlates. Pooled parental hesitancy was 39.6% across studies (Wang et al., 2025), higher parental education has been linked to greater acceptability in sub-Saharan Africa (pooled odds ratio about 2.06) (John et al., 2025), and a high-quality provider recommendation was associated with much higher odds of vaccinating among United States parents (odds ratio 9.31) (Gilkey et al., 2016). A systematic review of predictors of HPV vaccine acceptability identified provider recommendation among the factors linked to acceptability (Brewer & Fazekas, 2007), and a survey of providers across Africa examined their knowledge, training, and recommendation practices (Fokom Domgue et al., 2024). Qualitative work from Ibadan describes worry that vaccination signals promiscuity and the influence of religious and traditional leaders (Balogun & Omotade, 2018), and a Cochrane synthesis of caregivers' and adolescents' views reaches comparable themes (Cooper et al., 2025). Reviews of communication and of interventions to improve adolescent vaccination exist (Abdullahi et al., 2020; Foss et al., 2019), and service disruptions in Abuja have prompted social-media outreach (Agha et al., 2026). A study of parents in Ogun State reported that most had heard discouraging messages about the vaccine (Olubodun et al., 2024).

What is thin in this literature is evidence from North-Central Nigeria that relates parents' awareness and information source to actual vaccination in the same sample, with analysis that respects the small number of vaccinated respondents typical of early rollout. Kogi State, with its mix of Igala, Yoruba and Ebira communities and its Christian and Muslim populations, is one such setting. This study therefore aimed to describe parent-reported HPV vaccine uptake and to identify its correlates among parents of girls aged 9 to 14 years in three Kogi State LGAs. To do so, we first estimated the proportion of parents who report that at least one daughter in this age group has been vaccinated. We then described parents' awareness of HPV and the vaccine, their main source of information and their beliefs about the vaccine, and examined which sociodemographic, knowledge, information-source, and belief factors were associated with uptake after adjustment for confounding, using methods suited to a small number of vaccinated respondents. Finally, we described the reasons non-vaccinating parents gave and their stated willingness to vaccinate.

METHODS

Study design and setting

A cross-sectional survey was conducted in 2024 across three purposively selected LGAs in Kogi State, north-central Nigeria: Lokoja (state capital; urban), Igalamela (rural), and Ibaji (most rural). Selecting LGAs along this urban-rural gradient allowed the information environment to vary across settings. The study is reported according to the STROBE statement for observational studies (von Elm et al., 2007). It was not registered, and the analysis plan was specified after data collection.

Participants and sampling

Eligible respondents were parents or guardians who answered the questionnaire. Multistage cluster sampling across three stages (LGA, ward and community) yielded 336 participants, a response rate of 93.0%. The sample size was calculated with Cochran's formula ($n = Z^2pq/d^2$, with $Z = 1.96$, $p = 0.31$, $q = 0.69$ and $d = 0.05$), giving a minimum of 329, which was adjusted to 361 to allow for 10% non-response. Respondents who reported no daughter aged 9 to 14 years were excluded from the primary analysis because the uptake question does not apply to them.

Data collection and instrument

Data was collected using an interviewer-administered questionnaire. The dataset contained 37 variables: sociodemographic characteristics, nine yes, no, or not sure items on HPV and vaccine awareness, eight attitude and belief statements, main source of vaccine information, uptake of the vaccine by the respondent's daughters, reasons for non-vaccination, and willingness to vaccinate if the vaccine were free.

Outcome and exposure variables

The outcome was parent-reported vaccination, defined as a yes answer to whether any daughter aged 9 to 14 years had received the HPV vaccine. It is a parent-level outcome, not a child-level one. Vaccination status was self-reported, without vaccination cards or registry confirmation.

Sociodemographic variables were sex, age group (20 to 39, 40 to 49, 50 or more years), marital status, religion (Christianity, Islam, other), ethnic group, LGA, education (primary or less, secondary, tertiary), monthly income (up to NGN 100,000, above NGN 100,000, not disclosed), number of daughters aged 9 to 14 years (1, 2, 3 or more), and health-care occupation. Health-care occupation was coded from the free-text occupation field (nurse, nursing, doctor, pharmacist, health worker), and respondents with no recorded occupation (n = 18) were coded as not healthcare. Sparse categories were merged before analysis (religion: traditional and other; education: no formal education with primary; age: 20 to 29 with 30 to 39). One invalid religion code, two education answers of 'don't want to say ', and one invalid answer on the information-source item were set to be missing.

Knowledge was the count of yes answers across nine items: heard of HPV, knows what HPV is, knows how it is transmitted, knows it can lead to cancer, heard of the vaccine, knows what the vaccine is for, knows the recommended age, knows the number of doses, and knows the vaccine is available in Nigeria. Answers of no and not sure scored 0. The score, from 0 to 9, therefore measures self-reported awareness, not tested knowledge. The main source of vaccine information was grouped as health worker, other source (television or radio, internet or social media, community sensitisation, school programme, friends or family), and never heard of the vaccine. Eight belief statements were dichotomised as agree or strongly agree versus disagree or strongly disagree.

Scale properties were assessed before any composite was used. The knowledge score had a Cronbach's alpha of 0.90 (disease items 0.86, vaccine items 0.86), and its first eigenvalue was 5.09 (Tavakol & Dennick, 2011). Composites of the attitude items had alphas between 0.34 and 0.48, which is too low to treat them as scales; the attitude items were therefore analysed one by one and not summed.

Statistical analysis

Categorical variables are shown as counts and percentages, and the knowledge score as median and interquartile range with mean and standard deviation. Wilson intervals were used for proportions. Bivariate associations with uptake were tested using the chi-square test, Fisher's exact test for 2 by 2 tables with any expected count below 5, and a Monte Carlo chi-square test (100,000 permutations, fixed seed) for larger sparse tables. Knowledge scores were compared with the Mann-Whitney test, and Cohen's d and the rank-biserial correlation were reported as effect sizes. Because 30 bivariate tests were run (21 variable-level tests, the knowledge score and nine awareness items), p-values were adjusted with the Holm method for family-wise error and the Benjamini-Hochberg method for false discovery rate (Benjamini & Hochberg, 1995).

Only 61 parents reported vaccination, so the multivariable models had about 6 to 7 events per estimated parameter, below the conventional 10 (Peduzzi et al., 1996), and some categories were nearly separated (for example, 2 of 118 parents who had never heard of the vaccine reported vaccination). Ordinary maximum likelihood is then biased and can fail. We used Firth's penalised-likelihood logistic regression, with profile penalised-likelihood confidence intervals and likelihood-ratio p-values (Firth, 1993; Heinze & Schemper, 2002), and we avoided data-driven variable selection, which is unreliable at this sample size (Vittinghoff & McCulloch, 2007). The Firth routine was written in Python and checked against maximum likelihood on simulated well-behaved data, against a known 2 by 2 table, and on a completely separate data set, where it returned finite estimates.

Four models were specified before examining results. Model 1 contained sex, education, income, LGA, and health-care occupation. Model 2, the primary model, added the knowledge score per one-point increase. Model 3 replaced knowledge with the information source, to avoid placing two closely related measures in one model. Model 4 added belief that the vaccine is safe and concern about side effects to Model 2. Variables were chosen for plausibility as correlates; no causal diagram was assumed, and the models describe association. Model 2 was checked with variance inflation factors, leverage and Cook's distance, a quadratic term for knowledge, the Hosmer-Lemeshow test, the Brier score, apparent and bootstrap optimism-corrected area under the curve (500 resamples) and a calibration slope.

Sensitivity analyses for the knowledge association were: all 336 respondents; complete cases; excluding seven vaccinated parents whose awareness answers were internally inconsistent; excluding respondents with missing occupation; excluding health-care workers; a model with education, health-care occupation and knowledge only; knowledge scores omitting the vaccine-awareness item or the vaccine awareness and availability items; separate disease and vaccine sub-scores; ordinary maximum likelihood; a modified Poisson model with robust variance for

prevalence ratios (Zou, 2004); and bootstrap percentile intervals. Missing data were handled by complete-case analysis in the models (at most 5 observations lost). A two-sided p-value below .05 was used for the adjusted models; bivariate results are interpreted after multiplicity adjustment. Analyses were run in Python 3 with pandas, SciPy, and statsmodels, and the code is available on request.

RESULTS

Participants

Of 336 respondents, 7 reported no daughter aged 9 to 14 years, leaving 329 in the primary analysis (Table 1). Most respondents were women (70.5%), married (82.1%), and had tertiary education (62.4%); 43.8% were aged 20 to 39 years, and 64.0% were Christian. Respondents were spread evenly across LGAs (Lokoja 113, Igalamela 108, Ibaji 108). Thirty-two respondents (9.7%) held a health-care occupation, and 30 of them lived in Igalamela or Ibaji. Most respondents had two (45.3%) or three or more (29.2%) eligible daughters.

Vaccine uptake

Sixty-one parents (18.5%, 95% CI 14.7 to 23.1) reported that at least one daughter had been vaccinated; in all 336 respondents, the figure was 18.2% (14.4 to 22.6). Parents reported 91 vaccinated daughters among 701 eligible daughters (13.0%), a lower bound because the number was missing for one vaccinating parent. Where the place of vaccination was given, 41 parents used a public hospital, 9 a school-based programme, and 7 a private hospital; 2 gave another place, and 2 gave no answer. Uptake did not differ by LGA (Lokoja 19.5%, Igalamela 19.4%, Ibaji 16.7%, p = .829).

Awareness, knowledge and information sources

Awareness was low (Table 2). Of 329 parents, 193 (58.7%) had heard of HPV and 160 (48.6%) of the vaccine, but only 86 (26.1%) knew that HPV can lead to cancer, 38 (11.6%) knew the number of doses and 105 (31.9%) knew the vaccine was available in Nigeria. A score of 0 was recorded for 111 parents (33.7%). The median score was 3 (IQR 0 to 6; mean 3.27, SD 3.12). Of 326 parents who named a main source, 126 (38.7%) cited a health worker, 82 (25.2%) another source (television or radio 27, internet or social media 18, community sensitisation 14, school 13, friends or family 10), and 118 (36.2%) had never heard of the vaccine. Answers were not always consistent: 63 respondents said they had not heard of the vaccine but named an information source, 15 said they had heard of it yet chose 'never heard of it', and 7 vaccinating parents reported not having heard of it.

Bivariate associations

Among sociodemographic characteristics, only health-care occupation was associated with uptake after correction: 17 of 32 health-care workers (53.1%) reported a vaccinated daughter, against 44 of 297 others (14.8%) (crude OR 6.43, 95% CI 3.03 to 13.83, Holm-adjusted $p = 2.3 \times 10^{-6}$). Education showed an unadjusted association (p = .019) that did not survive Holm correction (adjusted p = .279; Benjamini-Hochberg q = .035), and uptake was 10.3%, 10.7%, and 23.0% across primary or less, secondary, and tertiary education. Sex, age, marital status, religion, ethnic group, LGA, income, and number of daughters were not associated (Table 1).

Knowledge was strongly associated with uptake (Table 2, Figure 2A). The median score was 7 (IQR 5 to 8; mean 6.41, SD 2.37) among vaccinating parents and 2 (IQR 0 to 4; mean 2.55, SD 2.82) among others (Mann-Whitney U = 13,725, $p = 2.7 \times 10^{-17}$; rank-biserial correlation 0.68; Cohen's d 1.41). Uptake was 0.9% (1 of 111) with a score of 0, 11.1% (8 of 72) at 1 to 3, 23.0% (17 of 74) with scores of 4 to 6, and 48.6% (35 of 72) with scores of 7 to 9. All nine awareness items were associated with uptake after Holm correction. Uptake differed by information source (Table 3, Figure 2B): 36.5% among parents citing a health worker, 15.9% among other sources, and 1.7% among parents who had never heard of the vaccine ($p = 2.1 \times 10^{-11}$).

Of the eight belief statements, concern about side effects was associated with lower uptake (15.1% among concerned parents against 32.8% among others; crude OR 0.36, 95% CI 0.20 to 0.68; Holm-adjusted p = .019), and agreeing that a health professional's recommendation would influence the decision was associated with higher uptake (21.2% against 2.2%, only 1 of 46 non-agreeing parents vaccinated; crude OR 8.21, 95% CI 2.14 to 73.67; Holm-adjusted p = .035, an unstable estimate because of the sparse reference cell). Believing the vaccine is safe was associated with uptake before but not after Holm correction (adjusted p = .289; q = .036). Beliefs about sexual activity, religion, community objections, and insufficient information were not associated with uptake. In total, 14 of 30 tests were significant after Holm correction and 18 after Benjamini-Hochberg adjustment.

Multivariable models

In Model 1, health-care occupation was the only variable associated with uptake (aOR 6.18, 95% CI 2.72 to 14.36, p = 1.6×10^{-5}), and the apparent AUC was only 0.70. In the primary model (Model 2, n = 327, 60 events), each additional awareness item was associated with 1.56 times higher odds of uptake (95% CI 1.36 to 1.82, p = 1.2×10^{-12}), while health-care occupation fell to an OR of 2.11 (0.82 to 5.41, p = .121) and education, income, sex, and LGA were not associated (Table 4). The apparent AUC rose to 0.86; the optimism-corrected AUC was 0.83 and the calibration slope 0.92, suggesting modest overfitting. The Hosmer-Lemeshow test showed no lack of fit (chi-square 11.22, 8 df, p = .189); the Brier score was 0.110; the quadratic term for knowledge was not significant (p = .358); the largest variance inflation factor was 2.85; the largest leverage was 0.25; and the largest Cook's distance was 0.09.

In Model 3, which used the information source instead of knowledge (n = 324), parents who cited a health worker had 3.85 times the odds of uptake of those citing other sources (95% CI 1.89 to 8.32, p = 1.5×10^{-4}), and parents who had never heard of the vaccine had 0.14 times the odds (0.03 to 0.50, p = .002); the corrected health-care occupation estimate was 2.97 (1.23 to 7.35, p = .016). In Model 4, concern about side effects remained associated with lower odds after adjustment for knowledge (aOR 0.40, 95% CI 0.18 to 0.88, p = .022), and the knowledge estimate was stable (aOR 1.53, 1.34 to 1.78); belief that the vaccine is safe was not (aOR 2.02, 0.76 to 6.21, p = .162). The apparent AUC of Model 4 was 0.86 (Figure 1).

Sensitivity analyses

The knowledge association was stable across the planned sensitivity analyses. The adjusted odds ratio ranged from 1.53 to 1.68, for example 1.58 (95% CI 1.38 to 1.84) in all 336 respondents, 1.57 (1.37 to 1.84) in complete cases, 1.68 (1.44 to 2.01) after excluding seven vaccinating parents with inconsistent awareness answers and 1.62 (1.40 to 1.93) after excluding health-care workers. Dropping the vaccine-awareness item, or the awareness and availability items, from the score gave 1.60 and 1.66. Ordinary maximum likelihood gave 1.60 (1.38 to 1.86), a modified Poisson model gave a prevalence ratio of 1.41 (1.29 to 1.54), and bootstrap percentile limits were 1.41 to 1.89. In a model with separate sub-scores, the vaccine sub-score (five items) carried the association (aOR 1.98, 1.52 to 2.63, p = 1.3×10^{-7}), whereas the disease sub-score (four items) did not (aOR 1.16, 0.85 to 1.59, p = .337).

Reasons for non-vaccination and intention

Among 267 non-vaccinating parents with an answer, the main reasons were lack of awareness (113, 42.3%), fear of side effects (57, 21.3%), vaccine not available (26, 9.7%), other reasons (25, 9.4%), and not being interested (22, 8.2%); cost, distance, and cultural or religious reasons were each given by 10 parents or fewer (Table 5). Overall, 292 of 329 parents (88.8%) said they would vaccinate if the vaccine were free, including 233 of 268 non-vaccinating parents (86.9%, 95% CI 82.4 to 90.5). Among these willing non-vaccinators, 44.8% cited lack of awareness and 18.5% fear of side effects. Almost all respondents (325 of 329, 98.8%) wanted more awareness creation.

Table 1. Characteristics of respondents and parent-reported HPV vaccine uptake (n = 329 parents with at least one daughter aged 9 to 14 years)

Variable	Category	n (%)	Vaccinated n (%)	Crude OR (95% CI)	p	Holm p
Sex	Female	232 (70.5)	40 (17.2)	Reference	.348	1.000
	Male	97 (29.5)	21 (21.6)	1.34 (0.73 to 2.38)		
Age group (years)	20-39	144 (43.8)	25 (17.4)	Reference	.887	1.000
	40-49	138 (41.9)	27 (19.6)	1.16 (0.64 to 2.11)		
	50+	47 (14.3)	9 (19.1)	1.16 (0.48 to 2.58)		
Marital status	Married	270 (82.1)	55 (20.4)	Reference	.068	0.813
	Not married	59 (17.9)	6 (10.2)	0.47 (0.18 to 1.05)		
Religion	Christianity	210 (64.0)	41 (19.5)	Reference	.441	1.000
	Islam	112 (34.1)	19 (17.0)	0.85 (0.46 to 1.53)		
	Other	6 (1.8)	0 (0.0)	0.31 (0.00 to 2.75)		
Ethnic group	Igala	205 (62.3)	37 (18.0)	Reference	.773	1.000
	Yoruba	67 (20.4)	15 (22.4)	1.33 (0.67 to 2.55)		
	Ebira	22 (6.7)	4 (18.2)	1.09 (0.33 to 3.02)		
	Others	35 (10.6)	5 (14.3)	0.81 (0.28 to 2.01)		
LGA of residence	Lokoja	113 (34.3)	22 (19.5)	Reference	.829	1.000
	Igalamela	108 (32.8)	21 (19.4)	1.00 (0.51 to 1.94)		
	Ibaji	108 (32.8)	18 (16.7)	0.83 (0.42 to 1.64)		
Education	Primary or less	39 (11.9)	4 (10.3)	Reference	.019	.279
	Secondary	84 (25.7)	9 (10.7)	0.99 (0.31 to 3.59)		
	Tertiary	204 (62.4)	47 (23.0)	2.38 (0.93 to 7.67)		
Monthly income (NGN)	<=100,000	206 (62.6)	36 (17.5)	Reference	.076	.840
	>100,000	100 (30.4)	24 (24.0)	1.50 (0.83 to 2.66)		
	Not disclosed	23 (7.0)	1 (4.3)	0.31 (0.03 to 1.27)		
Health-care occupation	No	297 (90.3)	44 (14.8)	Reference	1.2×10^{-7}	0.001
	Yes	32 (9.7)	17 (53.1)	6.43 (3.03 to 13.83)		
Daughters aged 9-14	1	84 (25.5)	17 (20.2)	Reference	.676	1.000
	2	149 (45.3)	29 (19.5)	0.94 (0.49 to 1.86)		
	3+	96 (29.2)	15 (15.6)	0.73 (0.34 to 1.56)		

OR = odds ratio from Firth-penalized logistic regression. p-values are from the chi-square test, Fisher's exact test, or a Monte Carlo chi-square test (100,000 permutations) when expected counts were below 5, and Holm p-values adjust across 30 bivariate tests. Percentages use respondents with non-missing data (religion n = 328, education n = 327, income n = 329). Health-care occupation was coded from free text.

Table 2. Awareness and knowledge by parent-reported uptake (n = 329)

Item answered yes	All, n (%)	Vaccinated, n (%)	Not vaccinated, n (%)	p	Holm p
Ever heard of HPV	193 (58.7)	58/61 (95.1)	135/268 (50.4)	1.6×10^{-10}	3.4×10^{-9}
Knows what HPV is	169 (51.4)	54/61 (88.5)	115/268 (42.9)	1.2×10^{-10}	2.9×10^{-9}
Knows how HPV is transmitted	100 (30.4)	37/61 (60.7)	63/268 (23.5)	1.2×10^{-8}	2.6×10^{-7}
Knows HPV infection can lead to cancer	86 (26.1)	29/61 (47.5)	57/268 (21.3)	2.5×10^{-5}	4.8×10^{-4}
Has heard of the HPV vaccine	160 (48.6)	55/61 (90.2)	105/268 (39.2)	6.4×10^{-13}	1.7×10^{-11}
Knows what the vaccine is used for	125 (38.0)	46/61 (75.4)	79/268 (29.5)	2.5×10^{-11}	6.1×10^{-10}
Knows the recommended age for vaccination	99 (30.1)	44/61 (72.1)	55/268 (20.5)	2.2×10^{-15}	6.3×10^{-14}
Know how many doses are required	38 (11.6)	23/61 (37.7)	15/268 (5.6)	1.4×10^{-12}	3.7×10^{-11}
Knows the vaccine is available in Nigeria	105 (31.9)	45/61 (73.8)	60/268 (22.4)	7.8×10^{-15}	2.2×10^{-13}
Knowledge score (0 to 9), median (IQR)	**3 (0 to 6)**	**7 (5 to 8)**	**2 (0 to 4)**	**2.7×10^{-17}**	**8.1×10^{-16}**
Knowledge score, mean (SD)	3.27 (3.12)	6.41 (2.37)	2.55 (2.82)		

Knowledge score = number of yes answers; Cronbach's alpha 0.90. Item p-values are from chi-square tests; the score p-value is from the Mann-Whitney test (U = 13,725; rank-biserial correlation 0.68; Cohen's d 1.41). Holm p-values adjust across 30 tests.

Table 3. Information source and beliefs about the vaccine by parent-reported uptake

Variable	Category	n	Vaccinated n (%)	Crude OR (95% CI)	p	Holm p
Main source of HPV vaccine information	Other source	82	13 (15.9)	Reference	2.1×10^{-11}	5.3×10^{-10}
	Health worker	126	46 (36.5)	2.97 (1.53 to 6.08)		
	Never heard	118	2 (1.7)	0.11 (0.02 to 0.38)		
Believes vaccine is safe	Disagree / no	68	6 (8.8)	Reference	0.021	0.289
	Agree / yes	261	55 (21.1)	2.58 (1.17 to 6.69)		
Health-professional recommendation would influence decision	Disagree / no	46	1 (2.2)	Reference	0.002	0.035
	Agree / yes	283	60 (21.2)	8.21 (2.14 to 73.67)		
Concerned about side effects	Disagree / no	64	21 (32.8)	Reference	0.001	0.019
	Agree / yes	265	40 (15.1)	0.36 (0.20 to 0.68)		
Believes vaccine promotes early sexual activity	Disagree / no	236	41 (17.4)	Reference	0.385	1.000
	Agree / yes	93	20 (21.5)	1.31 (0.72 to 2.36)		
Feels information is insufficient	Disagree / no	55	10 (18.2)	Reference	0.940	1.000
	Agree / yes	274	51 (18.6)	1.00 (0.49 to 2.18)		
Own religious beliefs affect decision	Disagree / no	242	43 (17.8)	Reference	0.548	1.000
	Agree / yes	87	18 (20.7)	1.22 (0.65 to 2.22)		
Perceives community religious/cultural objections	Disagree / no	240	41 (17.1)	Reference	0.264	1.000
	Agree / yes	89	20 (22.5)	1.42 (0.77 to 2.55)		
Would allow child to be vaccinated	Disagree / no	86	7 (8.1)	Reference	0.004	0.059
	Agree / yes	242	54 (22.3)	3.06 (1.45 to 7.42)		
Willing to vaccinate if free	Disagree / no	37	2 (5.4)	Reference	0.029	0.378
	Agree / yes	292	59 (20.2)	3.62 (1.16 to 18.01)		

Crude odds ratios are Firth estimates; sparse reference cells (for example, 1 of 46 for health-professional recommendation) make some estimates imprecise. Belief items are agreed or strongly agree versus disagree or strongly disagree; one respondent with an invalid answer is excluded from 'would allow'.

Table 4. Multivariable Firth logistic regression of parent-reported HPV vaccine uptake: adjusted odds ratios (95% CI)

Term	Model 1	Model 2 (primary)	Model 3	Model 4
Male sex (ref. female)	1.25 (0.65 to 2.36) p = .508	1.25 (0.60 to 2.54) p = .546	1.71 (0.83 to 3.54) p = .146	1.24 (0.58 to 2.59) p = .572
Secondary education (ref. primary or less)	0.82 (0.25 to 3.02) p = .743	0.74 (0.20 to 3.04) p = .657	0.93 (0.25 to 3.80) p = .893	0.58 (0.15 to 2.42) p = .437
Tertiary education (ref. primary or less)	1.33 (0.46 to 4.56) p = .611	0.69 (0.21 to 2.62) p = .559	1.76 (0.54 to 6.68) p = .356	0.57 (0.17 to 2.18) p = .392
Income above NGN 100,000 (ref. up to 100,000)	1.08 (0.56 to 2.05) p = .823	0.51 (0.24 to 1.08) p = .078	0.74 (0.35 to 1.50) p = .402	0.56 (0.26 to 1.20) p = .137
Income not disclosed (ref. up to 100,000)	0.33 (0.03 to 1.44) p = .154	0.47 (0.04 to 2.64) p = .417	0.26 (0.03 to 1.23) p = .095	0.50 (0.05 to 2.64) p = .443
Igalamela LGA (ref. Lokoja)	0.62 (0.29 to 1.29) p = .201	1.17 (0.49 to 2.85) p = .728	1.18 (0.51 to 2.71) p = .696	1.30 (0.53 to 3.28) p = .571
Ibaji LGA (ref. Lokoja)	0.52 (0.24 to 1.10) p = .087	0.91 (0.38 to 2.21) p = .837	1.19 (0.50 to 2.82) p = .685	1.07 (0.44 to 2.62) p = .880
Health-care occupation (ref. other)	6.18 (2.72 to 14.36) $p = 1.6 \times 10^{-5}$	2.11 (0.82 to 5.41) p = .121	2.97 (1.23 to 7.35) p = .016	1.97 (0.75 to 5.14) p = .165
Knowledge score, per 1-point increase	-	1.56 (1.36 to 1.82) $p = 1.2 \times 10^{-12}$	-	1.53 (1.34 to 1.78) $p = 1.1 \times 10^{-11}$
Health worker as main source (ref. other source)	-	-	3.85 (1.89 to 8.32) $p = 1.5 \times 10^{-4}$	-
Never heard of the vaccine (ref. other source)	-	-	0.14 (0.03 to 0.50) p = .002	-
Believes vaccine is safe (ref. no)	-	-	-	2.02 (0.76 to 6.21) p = .162
Concerned about side effects (ref. no)	-	-	-	0.40 (0.18 to 0.88) p = .022
Observations/events	327 / 60	327 / 60	324 / 60	327 / 60
Apparent AUC	0.70	0.86	0.84	0.86

Odds ratios from Firth penalised-likelihood logistic regression with profile penalised-likelihood 95% confidence intervals; a dash means the term was not in the model. Model 2 optimism-corrected AUC 0.83 (500 bootstrap resamples), calibration slope 0.92. Events per parameter were about 6 to 7. Exact p-values (penalized likelihood-ratio tests) are shown under each estimate.

Table 5. Main reason for not vaccinating among non-vaccinating parents (n = 267)

Reason	n	%
Lack of awareness	113	42.3
Fear of side effect	57	21.3
Vaccine not available	26	9.7
Others	25	9.4
Not interested	22	8.2
Distance to facility	10	3.7
Cost	7	2.6
Cultural/religion reasons	7	2.6

One of 268 non-vaccinating parents gave no reason.

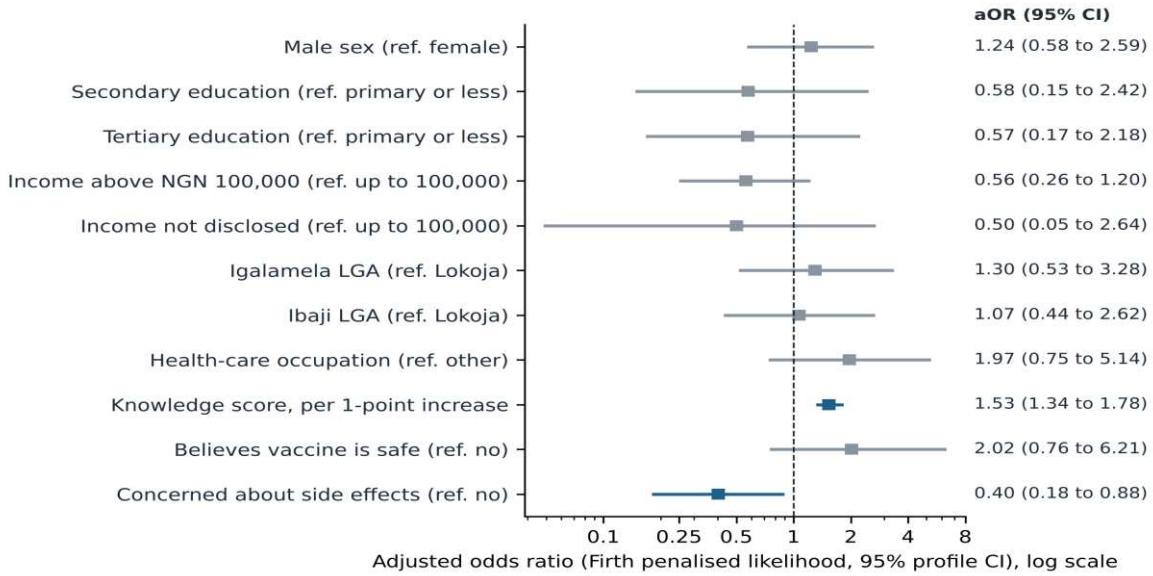


Figure 1. Adjusted odds ratios from Model 4 (Firth penalized logistic regression, n = 327, 60 events). Highlighted terms are those whose 95% interval excludes 1.

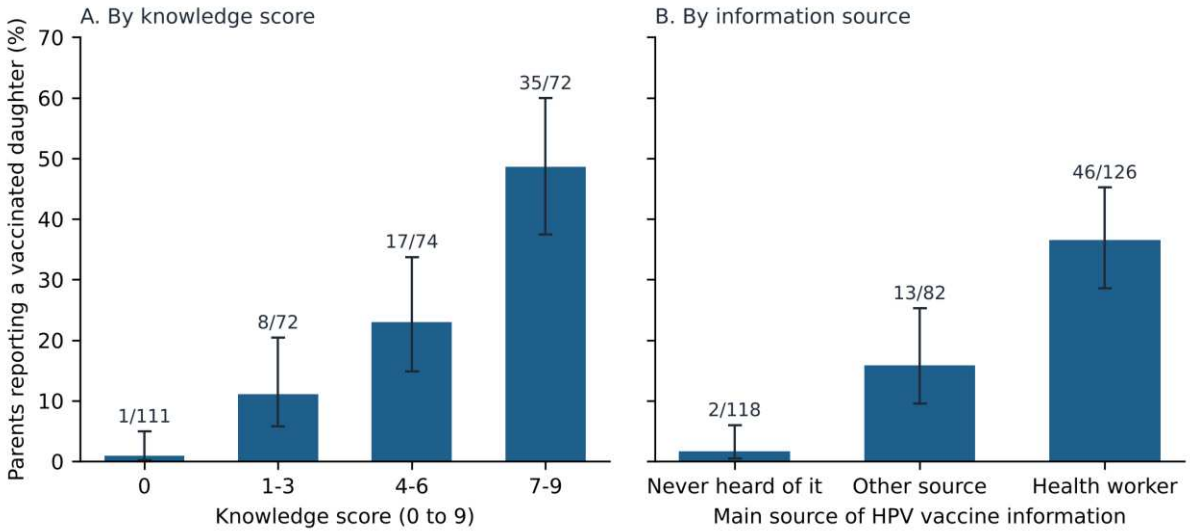


Figure 2. Parent-reported vaccine uptake by (A) knowledge score and (B) main source of vaccine information, with Wilson 95% confidence intervals and counts (n = 329 and 326).

DISCUSSION

Findings

About one in five parents (18.5%) in three Kogi State LGAs reported that a daughter aged 9 to 14 years had been vaccinated, and just over a third had never heard of the vaccine. Three findings stand out. First, uptake rose steeply with the number of awareness items a parent could affirm, from 0.9% at a score of 0 to 48.6% at 7 to 9, and the association persisted after adjustment for sociodemographic factors. Second, parents who named a health worker as their main source were far more likely to report vaccination than those who learned of the vaccine elsewhere. Third, concern about side effects was associated with lower uptake even among parents with equal knowledge. Education, income, religion, ethnic groups, and LGA showed no independent association once knowledge was in the model.

Comparison with other studies

The parent-level figure of 18.5% sits above the Nigerian pooled schoolgirl estimate of 3.77% (Asgedom et al., 2024) and the 4% found in Lagos (Akinleye et al., 2020) and is closer to the 23.4% in Benin City (Imarengiaye et al., 2025) and well above the 9.3% in rural Oyo State (Adewole et al., 2026). These figures are not strictly comparable. Ours counts a parent as vaccinating if any daughter was vaccinated, relies on parental report, and was collected in 2024, after the national introduction of the vaccine; the child-level figure of 13.0% is the fairer comparison. The gap between 88.8% stated willingness and 18.5% uptake mirrors the acceptance-uptake gap in the Nigerian review (Aminu et al., 2026), and the dominance of lack of awareness and fear of side effects among reasons matches Kano and Benin City (Imarengiaye et al., 2025; Yusuf et al., 2024).

The role of health workers agrees with findings from the United States, Africa, and Abia State, where provider recommendation or health workers as an information source were linked to acceptance (Amuzie et al., 2025; Brewer & Fazekas, 2007; Fokom Domgue et al., 2024; Gilkey et al., 2016). The null association for education, once knowledge was included, differs from the pooled positive association with education in sub-Saharan Africa (John et al., 2025). Our data cannot say whether education operates through knowledge, and we did not test mediation. The weak bivariate education signal (uptake 23.0% for tertiary against about 10% for lower levels) is consistent with that pathway, but it is also consistent with confounding by occupation, since many health-care workers hold tertiary qualifications.

Interpretation and cautions

The knowledge association should not be read as showing that teaching parents raises uptake. Parents whose daughters were vaccinated met health workers, received counselling and were told about doses, age and availability at the time, so some of the score is a consequence of vaccination. Two features of the data support this reading. The association was carried by vaccine-specific items (aOR 1.98 per item) and not by disease items (aOR 1.16), which is what one expects if knowledge reflects contact with the vaccination service, and 7 vaccinating parents answered that they had never heard of the vaccine, which shows that recall and reporting are imperfect. The estimate was nonetheless stable when vaccine-awareness items were removed (aOR 1.60 to 1.66), so the association is not an artefact of items that restate the outcome. The same caution applies to the health-worker finding that parents who vaccinate are more likely to name the vaccinator as their source.

Health-care occupation illustrates why adjustment matters. Health-care workers were 9.7% of the sample, concentrated in Igalamela and Ibaji, and their uptake was 53.1%. The adjusted odds ratio fell from 6.18 to 2.11 once knowledge was added, and the interval was wide because only 32 parents were involved. We read this as healthcare workers being better informed, with possible additional access, but the data cannot separate the two. The odds ratio for income above NGN 100,000 was below 1 in Models 2 to 4, in contrast to its positive crude direction; with a wide interval including 1, we regard it as unstable and do not interpret it.

Concern about side effects was held by 80.5% of parents and was the second most common reason for non-vaccination. Its association with lower uptake persisted when knowledge was held constant, which suggests that safety concern is not simply another face of low awareness. Evidence from Ogun State that many parents hear discouraging messages (Olubodun et al., 2024), and qualitative accounts of fears about promiscuity and religious influence in Ibadan (Balogun & Omotade, 2018), indicate where such concern may come from; our data on sexual activity, religion, and community objection showed no association with uptake, so we cannot confirm those mechanisms here.

Strengths and limitations

The strengths are a clearly defined parent-level outcome, a raw-data audit with disclosed handling of invalid codes, a knowledge scale that

met reliability checks, penalised estimation suited to sparse events, explicit multiplicity control, and a stable knowledge association across the sensitivity analyses. The limitations are material. The study is cross-sectional, so temporality is unknown and reverse causation is likely for knowledge and information source. Vaccination status and knowledge were self-reported, and some answers were internally inconsistent. The outcome is parent-level, not child-level.

Only 61 parents were vaccinators, so estimates are imprecise, and the model is prone to overfitting despite penalisation; the calibration slope of 0.92 and the corrected AUC of 0.83 reflect this. Sampling was multistage within three purposively selected LGAs, and the 336 respondents fell short of the calculated target of 361, so selection bias cannot be ruled out; three LGAs cannot represent Kogi State, and the high proportion of respondents with tertiary education (62.4%) suggests the sample is more educated than the general population.

Health-care occupation was coded from free text, and missing occupation was treated as non-healthcare. Attitude items could not be combined into scales, so beliefs were analysed singly, and the study did not measure all constructs of health behaviour theories; no theory test is claimed. Residual confounding is possible, notably by the age of the daughters, which was not recorded.

Implications

If the association with health-worker information reflects a causal contribution, even partly, then counselling by nurses and doctors at every child and maternal contact is a practical channel in settings where over a third of parents have not heard of the vaccine. The prevalence of safety concerns and the large share of non-vaccinators who say they would accept the vaccine if free suggest that unmet demand exists and that clear, repeated safety messaging may matter. Prospective or programme-based studies with verified vaccination records are needed to test these inferences.

CONCLUSION

In three Kogi State LGAs, parent-reported HPV vaccine uptake was 18.5% and was concentrated among parents who knew more about the vaccine, who had heard of it from a health worker, and who were not worried about side effects. These associations held across the analytic choices examined, but the cross-sectional design and self-reported measures mean they describe who vaccinated, not why. Awareness gaps, safety concerns and the reach of health workers deserve first attention in local programme planning.

Recommendations

i. Use routine contacts (immunisation sessions, antenatal and child welfare clinics, school health talks) for health-worker counselling that covers what HPV is, its link to cervical cancer, the age group, the dose schedule and where to obtain the vaccine.
ii. Prepare short, consistent safety messages for health workers and community channels that address side-effect fears directly, because concern was common and independently associated with lower uptake.
iii. Reach the third of parents who have heard nothing about the vaccine through channels beyond health facilities, such as radio and community sensitisation, which together reached about a quarter of parents in this sample.
iv. Record vaccination status from cards or registers in future surveys, and capture the child's age, so that uptake can be analysed at child level and the direction of association examined.
v. Test the health-worker counselling pathway in a pragmatic trial or stepped programme evaluation before drawing causal conclusions.

DECLARATIONS

Ethics approval and consent to participate. Ethical approval was obtained from the Kogi State Ministry of Health Ethical Research Committee (Approval Number: MOH/PRS/465/V.1/130). Written informed consent was obtained from all participants.

Consent for publication. Not applicable; no identifiable individual data is reported.

Availability of data and materials. Available from the corresponding author on reasonable request.

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Authors' contributions. Osayanmo conceived the study idea. Daniel Oseji designed the questionnaire. Moses Luke collected the data, performed the statistical analyses, and drafted the manuscript. Samuel Chika Ugwu carried out grammatical revisions. All authors reviewed the

manuscript and approved the final version for publication.

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