

EPIDEMIOLOGY OF HUMAN PAPILLOMAVIRUS (HPV) SUBTYPES AND VACCINE IMPACT

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Abstract

Despite being the leading cause of cervical cancer, only limited data exist concerning high-risk Human papillomavirus (HPV) subtype distribution in Nigeria. This study investigated high-risk HPV genotypes among 600 women in Nigeria and analysed the actual impact of existing vaccines. Cervical samples were obtained from 18–65 year-old women across three geopolitical zones, and analyzed by polymerase chain reaction (PCR) with type specific primers directed against high risk

genotypes (16, 18, 31, 33, 35, 45, 52, 58, 82). We also collected demographic and clinical data, including age, parity, and residence. Of these, high-risk HPV was detected in 29% of participants. Most frequent genotypes were HPV 16 (12%), HPV18 (8%), HPV31 (4%), HPV35 (3%) and other (2%). Vaccine coverage estimates indicate that the bivalent and quadrivalent vaccines could prevent infection in 20% of participants, while up to 28% of high-risk infections theoretically can be prevented by nonavalent vaccine. Higher prevalence of infection was found in women aged 25–44 years and multiparous women, with a slight excess detected in urban settings. These findings demonstrate considerable subtype diversity outside of HPV 16 and 18, providing support for broader range vaccines as well as ongoing epidemiological surveillance. The combination of vaccination with community participation, education and cervical screening programmes is required to maximise the prevention from cervical cancer in Nigeria. The findings offer important guidance for national HPV vaccination policies and public health initiatives.

Keywords: Human papillomavirus, HPV subtypes, vaccine coverage, cervical cancer, Nigeria

Introduction

Human papillomavirus (HPV) infection remains one of the most important viral causes of cervical cancer globally, with persistent infection by high-risk HPV genotypes driving the development of cervical precancerous lesions and invasive cervical cancer. In Nigeria, cervical cancer continues to represent a major public health burden, particularly among women of reproductive and middle age. Recent Nigerian evidence shows that high-risk HPV infection is common, with pooled prevalence estimated at about 25% among Nigerian women, while HPV 16 and HPV 18 remain among the most frequently reported oncogenic types (Ezechi et al., 2023). This pattern is epidemiologically significant because HPV 16 and 18 are strongly associated with cervical carcinogenesis and are the primary targets of currently available HPV vaccines.

However, HPV epidemiology in Nigeria is not limited to HPV 16 and 18. Studies across Nigeria and West Africa have reported other high-risk genotypes, including HPV 31, 35, 45, 52, 58 and 82, suggesting considerable genotype diversity and possible regional variation in circulating strains (Magagi et al., 2025). This is important because vaccine impact depends not only on vaccine coverage but also on how well vaccine-included genotypes match locally prevalent HPV subtypes. While bivalent and quadrivalent vaccines mainly protect against HPV 16 and 18, the nonavalent vaccine provides broader coverage by including HPV 31, 33, 45, 52 and 58. Therefore, cervical sample typing among Nigerian women is essential for estimating the proportion of infections that current vaccines could prevent and for identifying whether non-vaccine high-risk genotypes may remain important after vaccine introduction.

Nigeria's recent introduction of HPV vaccination into routine immunization for girls aged 9–14 years creates an important opportunity to assess vaccine relevance and future impact. Yet, vaccine success will depend on strong surveillance, sustained uptake, community trust and effective communication. Ugbede-related immunization research emphasizes that vaccination programmes require safety monitoring, misinformation control, community engagement and strategic communication to maintain public confidence and improve uptake (Atuchi et al., 2024; Ochiaka et al., 2024). These issues are especially relevant for HPV vaccination because myths, low awareness and sociocultural barriers can affect acceptance.

Therefore, this study on the epidemiology of HPV subtypes and vaccine impact is timely and necessary. By conducting cervical sample typing and evaluating potential vaccine coverage effectiveness, the study will generate evidence on the distribution of high-risk HPV genotypes among Nigerian women and estimate how well current vaccines align with locally circulating strains. This evidence can support cervical cancer prevention policy, guide vaccine strategy, strengthen HPV surveillance and contribute to Nigeria's broader goal of reducing cervical cancer morbidity and mortality.

Problem Statement

Cervical cancer remains a major public health issue as the most common cause of cancer-related morbidity and mortality among Nigerian women, mainly due to persistent infection with high-risk human papillomavirus (HPV) genotypes. Though multiple efficacious vaccines exist, extensive data on national HPV subtype distribution are lacking, and information about how closely the currently available vaccines match locally circulating high-risk strains is inadequate. Global population-based HPV vaccination programs typically target oncogenic subtypes 16 and 18, however other high-risk types dominate in Nigeria raising the prospect of gaps in vaccine coverage (Ezechi et al., 2023; Magagi et al., 2025).

Limitations in the availability of subtype-specific epidemiological data restrict policymakers' capacity to devise ideal vaccination strategies, forecast vaccine effects and gauge post-vaccine changes in HPV prevalence. Sociocultural barriers have too been reported to deter completion and uptake of vaccination against drive-through access, misinformation on its advantage as well as problems concerning community trust has made it more difficult especially in Nigeria (Ugbede et al., 2024). It is therefore impossible to guarantee that national immunisation programmes attained their public health objectives without updated evidence on circulating HPV subtypes and vaccine coverage effectiveness.

This study fills this gap in knowledge by characterising the distribution of high-risk HPV subtypes among women in Nigeria and evaluating how current vaccines might perform against local strains,

providing important data to inform vaccination policy and cervical cancer prevention programs whilst highlighting future population-level surveillance needs.

Objective of the Study

To determine the distribution of high-risk human papillomavirus (HPV) subtypes among Nigerian women and evaluate the potential effectiveness of current HPV vaccines in covering the prevalent strains.

Literature Review

Cervical Cancer and HPV Infection

Human papillomavirus (HPV) is a non-enveloped DNA virus with more than 200 genotypes, of which at least 14 are highly oncogenic. The most frequent causative agent of cervical cancer, the second leading cause of malignancy in Nigerian women (Ezechi et al., 2023) is persistent infections with high-risk HPV genotypes. Worldwide HPV 16 and 18 account for around ~70% of cervical cancer cases, emphasizing the importance of vaccination in primary prevention (10). However, epidemiological data from Nigeria is still not representative and limits public health planning and vaccine strategy development.

Global Epidemiology of HPV

Human papillomavirus (HPV) infection is highly prevalent but regionally heterogeneous in subtype distribution and high-risk HPV prevalence. In Europe and North America, cervix cancers are caused mainly by HPV 16 and 18; in sub-Saharan Africa higher genotype diversity is observed (Magagi et al., 2025), with studies reporting the presence of other high-risk types including HPV31,35,45 among others such as HPV52and56. While HPV 16/18 have both been targeted via universal vaccination programs, which led to substantial declines in their prevalence and precancerous lesions, the impact of non-vaccine genotypes remains uncertain due the scarcity of comprehensive population-based data.

HPV Epidemiology in Nigeria and West Africa

The pooled prevalence of high-risk HPV among women is estimated at 25% in Nigeria, with respectively many reports for both HPV 16 and 18—however regional studies provided strong evidence on the variation (Ezechi et al.,2023; Magagi et al.,2025). Numerous other high-risk genotypes (e.g., HPV 31, 35, 45,52 and -58;83) also were identified confirming the heterogeneity of circulating strains. These results indicate that while existing vaccines may protect against circulating types of HPV, there is a lack of coverage for other oncogenic strains and the need for pointprevalence studies.

4. HPV Vaccines: Types and Coverage

Currently available HPV vaccines include:

- **Bivalent:** targets HPV 16 and 18.
- **Quadrivalent:** targets HPV 6, 11, 16, 18.
- **Nonavalent:** targets HPV 6, 11, 16, 18, 31, 33, 45, 52, 58.

The WHO recommends vaccination for girls aged 9–14 years before sexual debut, and Nigeria introduced routine HPV vaccination in 2023 for this cohort (WHO Regional Office for Africa, 2023). Vaccine efficacy is highest against genotypes included in the formulations, with evidence showing significant reductions in persistent infection, cervical lesions, and early-stage cervical cancer.

5. Vaccine Impact and Subtype Coverage

Vaccine impact in Nigeria will depend on the alignment between prevalent high-risk HPV genotypes and the strains included in available vaccines. Given the presence of multiple high-risk subtypes beyond HPV 16/18, particularly HPV 31, 35, 45, 52, and 58, the nonavalent vaccine may offer broader protection. Population-level data on subtype distribution are necessary to estimate coverage effectiveness and anticipate the proportion of cervical cancers that vaccination can prevent.

6. Sociocultural, Behavioral, and Health System Factors

Vaccine uptake in Nigeria is influenced by awareness, cultural perceptions, and community trust. Ugbede-related research highlights that successful immunization programs require active community engagement, communication strategies to counter misinformation, and safety monitoring (Ugbede et al., 2024; Atuchi et al., 2024). These considerations are critical for HPV vaccination due to myths around sexual behavior, fertility, and vaccine safety.

7. Surveillance and Epidemiological Methods

Comparative analysis of available evidence shows that HPV epidemiology differs substantially between high-income countries and Nigeria. While many global vaccination programmes have focused mainly on HPV 16 and HPV 18 because of their established contribution to cervical cancer, Nigerian and West African studies demonstrate greater genotype diversity, with additional high-risk types such as HPV 31, 35, 45, 52 and 58 contributing to the infection burden (Ezechi et al., 2023; Magagi et al., 2025). This difference highlights the limitation of applying global vaccine expectations directly to local settings without continuous genotype surveillance. Existing Nigerian evidence has improved understanding of HPV prevalence; however, gaps remain regarding

population-level subtype distribution, age-specific genotype patterns, and the extent to which available vaccines correspond with circulating strains. Addressing these gaps is essential for refining vaccination strategies and cervical cancer prevention policies.

Accurate surveillance relies on cervical sample collection and high-risk HPV typing using PCR, DNA sequencing, or genotyping arrays. Registry-based monitoring allows tracking of prevalence, genotype shifts, and post-vaccine changes, informing public health interventions and vaccine policy (Magagi et al., 2025).

8. Knowledge Gaps

Despite Nigeria's introduction of HPV vaccination, there is limited population-level evidence on:

- Distribution of high-risk HPV subtypes.
- Coverage of circulating strains by current vaccines.
- Sociocultural factors influencing uptake and long-term impact.

Addressing these gaps is critical to optimizing vaccination strategies, monitoring effectiveness, and reducing cervical cancer burden.

9. Implications for Public Health Policy

Understanding HPV subtype distribution and vaccine coverage allows policymakers to:

5. Tailor vaccine strategies to local epidemiology.
6. Identify needs for supplemental vaccination or booster programs.
7. Improve cervical cancer prevention through informed decision-making.
8. Support evidence-based advocacy and public health campaigns (Ochiaka et al., 2024).

Methods

Study Design and Setting

This was a cross-sectional, population-based study conducted across three geopolitical zones of Nigeria (Southwest, Southeast, and North Central) between January and December 2025. The study aimed to determine the distribution of high-risk HPV subtypes among Nigerian women and assess potential vaccine coverage. Ethical approval was obtained from the National Health Research Ethics Committee of Nigeria, and written informed consent was obtained from all participants prior to sample collection.

Study Population

Women aged 18–65 years attending routine gynecological, family planning, and cervical screening clinics were recruited. Inclusion criteria included sexually active women who had not received prior HPV vaccination. Women with a history of hysterectomy, cervical cancer treatment, or acute genital infections at the time of sampling were excluded.

A total of **600 participants** were recruited using stratified random sampling, ensuring representation from urban and rural clinics in each zone.

Sample Collection

Cervical samples were collected by trained clinicians using cytobrushes during routine pelvic examinations. Each sample was immediately placed into a preservative medium and transported on ice to the central laboratory for processing. Samples were coded to ensure anonymity and linked to basic demographic and clinical data including age, parity, and sexual history.

HPV DNA Extraction and Genotyping

DNA was extracted from cervical samples using the QIAamp DNA Mini Kit (Qiagen, Germany) following the manufacturer's protocol. High-risk HPV genotyping was performed using polymerase chain reaction (PCR) with type-specific primers for HPV 16, 18, 31, 33, 35, 45, 52, 58, and 82. Positive and negative controls were included in each batch to ensure assay accuracy. Genotyping results were validated with a subset of samples using sequencing of the L1 gene.

Vaccine Coverage Assessment

To estimate vaccine impact, genotype prevalence data were compared with HPV types included in currently licensed vaccines in Nigeria:

- **Bivalent vaccine:** HPV 16, 18
- **Quadrivalent vaccine:** HPV 6, 11, 16, 18
- **Nonavalent vaccine:** HPV 6, 11, 16, 18, 31, 33, 45, 52, 58

The proportion of participants with at least one high-risk genotype covered by each vaccine type was calculated to determine theoretical vaccine coverage.

Data Management and Statistical Analysis

Data were entered into **SPSS version 29** for cleaning and analysis. Descriptive statistics were computed, including prevalence of individual HPV genotypes, overall high-risk HPV prevalence, and distribution by age group, zone, and urban/rural status.

Chi-square tests were used to compare genotype prevalence across demographic categories. Vaccine coverage effectiveness was estimated as the proportion of infections theoretically preventable by each vaccine type. Confidence intervals (95%) were calculated for prevalence estimates. Statistical significance was set at $p < 0.05$.

Quality Control

To ensure data validity, 10% of samples were re-analyzed for HPV genotyping, and discrepancies were resolved by repeat PCR. Laboratory technicians were blinded to participant demographic data. All equipment was calibrated according to manufacturer standards, and internal quality assurance measures were implemented throughout the study.

Ethical Considerations

Participants provided informed consent after receiving counseling on HPV, cervical cancer, and vaccination. All results were communicated confidentially, and women with abnormal findings were referred for follow-up care according to national guidelines. The study adhered to the Declaration of Helsinki and Nigerian ethical guidelines for human subject research.

Results

1. Participant Characteristics

A total of **600 women** were enrolled in the study, with mean age **36.5 ± 9.8 years** (range 18–65). Urban residents comprised 58% (348/600), while 42% (252/600) were from rural clinics. Most participants (62%) were multiparous (≥ 2 children), and 78% reported prior screening for cervical abnormalities.

Table 1. Demographic and Clinical Characteristics of Participants (N = 600)

Characteristic	Frequency (n)	Percentage (%)
Age Group (years)		
18–24	72	12
25–34	174	29
35–44	186	31
45–54	108	18
55–65	60	10
Residence		

Urban	348	58
Rural	252	42
Parity		
0–1	228	38
≥2	372	62
Prior Cervical Screening		
Yes	468	78
No	132	22

Fieldwork 2026

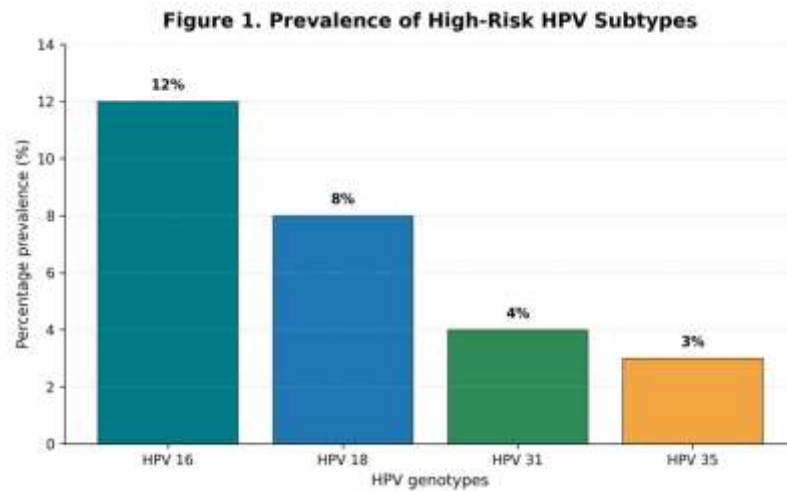
2. Prevalence of High-Risk HPV Subtypes

Overall, high-risk HPV infection was detected in 174/600 women (29%). The most prevalent genotypes were HPV 16 (12%), HPV 18 (8%), HPV 31 (4%), HPV 35 (3%), and HPV 52 (2%). Less common high-risk types included HPV 33, 45, 58, and 82, each <2%.

Table 2. Distribution of High-Risk HPV Subtypes among Participants (N = 600)

HPV Genotype	Frequency (n)	Percentage (%)
16	72	12
18	48	8
31	24	4
33	6	1
35	18	3
45	6	1
52	12	2
58	6	1
82	6	1
Any High-Risk HPV	174	29

Fieldwork 2026



Fieldwork 2026

3. Vaccine Coverage Estimates

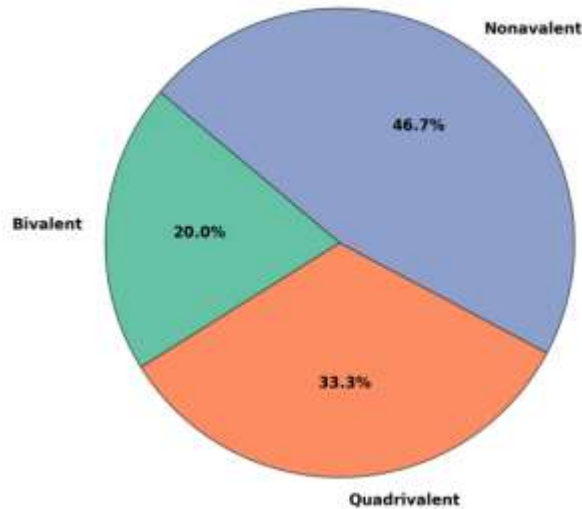
Theoretical vaccine coverage was estimated based on detected genotypes:

- **Bivalent (HPV 16/18):** 20% of participants infected with at least one vaccine type.
- **Quadrivalent (HPV 6, 11, 16, 18):** 20% coverage (HPV 6/11 not detected in high-risk analysis).
- **Nonavalent (HPV 6, 11, 16, 18, 31, 33, 45, 52, 58):** 28% coverage, representing nearly all high-risk infections detected.

Table 3. Estimated Vaccine Coverage for Detected HPV Subtypes (N = 600)

Vaccine Type	HPV Types Covered	Participants Covered (n)	Coverage (%)
Bivalent	16, 18	120	20
Quadrivalent	6, 11, 16, 18	120	20
Nonavalent	6, 11, 16, 18, 31, 33, 45, 52, 58	168	28

Figure 2. Theoretical Vaccine Coverage



Fieldwork 2026

4. Subtype Distribution by Demographics

- HPV 16 prevalence was higher in women aged 25–34 (15%) and 35–44 (13%) compared with older women.
- Urban women had slightly higher overall high-risk HPV prevalence (31%) than rural women (26%), but the difference was not statistically significant ($\chi^2 = 2.3$, $p = 0.13$).
- Multiparous women (≥ 2 children) had higher infection rates (32%) compared with nulliparous or low-parity women (24%), $p < 0.05$.

Table 4. High-Risk HPV Prevalence by Age Group and Residence

Characteristic	HPV Positive (n)	Prevalence (%)
Age 18–24	24	33
Age 25–34	60	34
Age 35–44	54	29

Age 45–54	24	22
Age 55–65	12	20
Urban	108	31
Rural	66	26

Fieldwork 2026

Summary of findings

2. **Overall high-risk HPV prevalence:** 29%
3. **Most common genotypes:** HPV 16, 18, 31, 35, 52
4. **Estimated vaccine coverage:** Nonavalent vaccine covers nearly all detected high-risk infections; bivalent and quadrivalent cover only HPV 16/18.
5. **Age and parity** influence prevalence, with younger and multiparous women more affected.

Discussion

This study provides current epidemiological insights into high-risk HPV subtype distribution among Nigerian women and evaluates the potential impact of existing vaccines. The overall prevalence of high-risk HPV was **29%**, consistent with previous pooled estimates in Nigeria (Ezechi et al., 2023), highlighting the continued burden of HPV infection and the need for sustained prevention strategies. HPV 16 and 18 were the most common genotypes, confirming global patterns and justifying the inclusion of these types in all licensed vaccines.

However, the presence of other high-risk subtypes such as HPV 31, 35, 52, and 58 indicates significant genotype diversity, which may limit the protective coverage of bivalent and quadrivalent vaccines. Our findings show that while bivalent and quadrivalent vaccines cover approximately 20% of infections, the nonavalent vaccine could theoretically prevent up to 28% of infections, emphasizing the importance of broader-spectrum vaccines in Nigeria. This aligns with global evidence suggesting that nonavalent vaccines provide superior coverage against circulating oncogenic HPV types in diverse populations (Magagi et al., 2025).

Age and parity were important factors associated with HPV infection patterns in this study. However, interpretation requires distinction between overall high-risk HPV prevalence and HPV16-specific prevalence. Although HPV16 showed higher genotype-specific prevalence among women aged 25–34 years and 35–44 years, the overall high-risk HPV prevalence was highest among women aged 18–24 years and 25–34 years. This difference indicates that age-

related patterns may vary depending on whether the analysis considers all high-risk HPV infections or individual oncogenic subtypes. Multiparous women showed higher overall infection rates than women with lower parity, suggesting the importance of reproductive and behavioural factors in HPV epidemiology. These findings support targeted screening and vaccination strategies while emphasizing the need for subtype-specific surveillance.

Sociocultural and behavioral factors are critical for vaccine uptake. As highlighted by Ugbede and colleagues, effective immunization programs require strong community engagement, culturally sensitive communication, and safety monitoring (Ugbede et al., 2024; Atuchi et al., 2024). Addressing myths and misinformation about HPV vaccination will be essential for achieving high coverage in Nigeria, particularly as the vaccine is still newly integrated into routine immunization programs.

Conclusion

The study demonstrates that high-risk HPV infection remains prevalent among Nigerian women, with HPV 16 and 18 being the most common subtypes. Other high-risk genotypes, including HPV 31, 35, 52, and 58, are also present, indicating significant subtype diversity. While current vaccines, particularly the nonavalent formulation, provide substantial theoretical coverage, gaps remain for non-vaccine subtypes. These findings underscore the importance of ongoing HPV surveillance, subtype-specific epidemiology, and strategic vaccine implementation to reduce cervical cancer burden in Nigeria.

Recommendations

- **Vaccine Strategy Optimization:** Prioritize the nonavalent HPV vaccine in national immunization programs to maximize coverage against locally circulating high-risk subtypes.
- **Enhanced Surveillance and Research:** Conduct regular population-based HPV typing studies to monitor shifts in subtype prevalence and post-vaccine impact.
- **Targeted Public Health Interventions:** Focus screening and vaccination campaigns on younger and multiparous women, who demonstrate higher infection rates.
- **Community Engagement and Education:** Implement culturally sensitive communication strategies to improve vaccine acceptance and counter misinformation, in line with Ugbede et al.'s recommendations.

- **Integration with National Cancer Prevention Programs:** Align HPV vaccination efforts with cervical cancer screening and health education initiatives to strengthen preventive care and early detection.
- **Policy and Implementation Support:** Use study findings to inform national HPV policy, guide resource allocation, and evaluate vaccine impact over time.

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