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Prevalence of Human Papillomavirus Infection and its Association with the Risk of Cervical Cancer among HIV-Positive Women in Plateau State, North-Central Nigeria

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Abstract
Human papillomavirus (HPV) is one of the most common sexually transmitted infections (STI) associated with cervical, uterine, and anogenital cancers. Persistent infection with HPV is associated with abnormal cervical cells, which can develop into cervical cancer if left untreated. Human papillomaviruses are the first viruses to have been acknowledged to prompt carcinogenesis, and they are linked with cancers of the uterine cervix, anogenital tumours, and head and neck malignancies. A hospital-based study of HIV-infected women across the three senatorial zones of Plateau State, Nigeria, was conducted between November 2018 to November 2020. Ethical approval for the study was first obtained from the ethical committee of Plateau State Specialist Hospital Jos, and informed consent to participate in the research was also obtained from each participant. HIV status confirmation was first done through standard rapid test procedures, followed by cytology testing via the Pap smear procedure to detect any precancerous or malignant changes in the cervix. Subsequent detection of HPV utilized the ELISA procedure, while $CD4^+$ cell count and viral load estimations were done using flow cytometry and nucleic acid amplification techniques, respectively. Questionnaires were administered to obtain information on cervical cancer risk factors and clinical presentations. The overall prevalence of HPV was 28% among HIV-infected women. More HPV infection (31.9%) occurred in women with low $CD4^+$ count (0-200 cells/mm^3), and also highest (50.0%) among women with the highest HIV viral load (>100 copies/mL). The possible risk factors identified in this study include multiple sexual partnering, low condom usage, and coinfection with other STIs, among others. In conclusion, this study identified a high HPV prevalence, low $CD4^+$ counts, and coinfection with other STIs among high-risk populations (HIV-infected women). We, therefore, recommend improved sexual behaviours and further research on the impact of low immunity on the rate of progression of cervical abnormality to cervical cancer, not just in HIV-positive women but in the general population.
Keywords: *Cervical cancer, HIV, CD4, Viral load, Pap Smear.*

INTRODUCTION

In impoverished nations like Nigeria, cervical cancer is the most frequent genital tract cancer among women, resulting in over 266,000 deaths yearly (Chinaka and Nwazue, 2013). Over 528,000 new instances of cervical cancer are reported worldwide, with developing nations accounting for 85% of these cases (Sule *et al.*, 2017). Nigeria has a population of 60.9 million women ages 15 years and older who are at risk of cervical cancer. Current estimates indicate that every year, 12,075 women are diagnosed with cervical cancer, and 7,968 die from this disease (ICO/IARC, 2023). Cervical cancer ranks as the 2nd most frequent cancer among women in Nigeria and the 2nd most frequent cancer among women between 15 and 44 years of age.

Human papillomavirus (HPV) infections typically do not cause any symptoms, but persistent genital HPV infection can lead to cervical cancer. Approximately 99% of cervical cancer cases are linked to genital HPV infection with high-risk strains (WHO, 2019). The most prevalent HPV-related illness is cervical cancer, of which 99.7% of cases are brought on by ongoing HPV infection (Okunade, 2020).

Cervical cancer is the primary cause of cancer-related deaths in women in sub-Saharan Africa (Garcia-Espinosa *et al.*, 2009). Beyazit *et al.* (2018) in their study reported the incidence of cervical cancer and the deaths associated with it have decreased dramatically in developed nations as a result of the introduction of efficient screening programs and HPV vaccination, but there is still a notable disparity in mortality and morbidity rates between developing and developed nations.

Since the middle of the 19th century, cervical cancer incidence and death have declined in the United States (US), mostly as a result of screening initiatives. Cervical cancer still counts among the top ten cancers diagnosed in the US among minority communities, which includes Blacks, American Indians, and Hispanics, despite the pap smear test's introduction and widespread use (Blackman *et al.*, 2017).

It is possible to prevent and cure cervical cancer. This is because precancerous lesions often advance slowly through distinguishable and recognized phases before changing into invasive illness, and cervical cancer has a rather long lead time. Therefore, the disease can be considered treatable if discovered before it advances to an advanced state (Beyazit *et al.*, 2018). Worldwide, the most prevalent sexually transmitted infection in both men and women is the human papillomavirus. A growing body of research indicates a significant association between HPV and genital warts as well as cervix, vulva, vaginal, anus, and penile cancer (Krashias *et al.*, 2017).

The first viruses to be recognized as initiating carcinogenesis are human papillomaviruses, which are associated with uterine, cervix, anogenital, and head and neck cancers (Wang *et al.*, 2018). Generally speaking, HPVs are divided into high-risk and low-risk varieties based on their correlation with cancer. Low-risk varieties, like type 6 and 11, are linked to genital warts, whereas high-risk ones, such as type 16 and 18, are linked to various cancers. Worldwide, the human papillomavirus, or HPV, is thought to be one of the viruses linked to cancer and other illnesses (Tulay and Serakinci, 2016). Cervical cancer, anogenital malignancies, and oropharyngeal cancers have all been related to persistent high-risk (HR) human papillomavirus infection, particularly HPV strains 16 and 18 (Blackman *et al.*, 2017).

Genital HPV is highly prevalent among women of reproductive age because they are mostly sexually active. Due to biologic/physiologic differences in their cervical epithelium (having columnar or plastic epithelium as against squamous epithelium) found in older adults, young women are more vulnerable to HPV infection (Silva *et al.*, 2011). Nonetheless, the majority of HPV infections resolve on their own, and only a tiny proportion of infections continue to cause low-grade intraepithelial lesions (LSIL) to advance to high-grade intraepithelial lesions (HSIL) and, in the end, invasive cervical cancer (Silva *et al.*, 2011).

It is now known that high-risk HPV infection over time is a required but not sufficient cause of cervical cancer (Silva *et al.*, 2011). Persistent HPV infection is the main factor contributing to the development of cervical cancer. In this context, persistence means finding the same HPV genotype in the same individual twice or more in six months to a year.

Human papillomavirus is the cause of 90-95% of squamous cell cancers, and HPV type 16 is the most common in invasive cervical cancers (Aminu *et al.*, 2014). Cervical adenocarcinoma has been demonstrated to be more significantly influenced by HPV 18, with a roughly 40% frequency in these tumors. While HPV 18 infection increases the chance of developing adenocarcinoma, HPV 16 infection is still the most common HPV infection in adenocarcinoma. Up to 34% of cervical adenocarcinomas and 35% of cervical adenosquamous carcinomas in younger women have been linked to HPV 18 (WHO, 2011).

Ninety percent of anogenital warts and the majority of oropharyngeal papillomatoses are caused by HPV types 6 and 11. The majority of early HPV infections, particularly those that are low-risk, resolve on their own and frequently do not cause symptoms. The quadrivalent vaccine's HPV strains 16, 18, 6, and 11 are linked to 30% of cervical intraepithelial neoplasia (CIN) 1 cases. HPV 16 and 18 are rare in early CIN, although they are present in 50%–60% of CIN 2 and CIN 3 cases (WHO. 2011).

Human papillomavirus (HPV) infection and HPV-related tumors, such as invasive cervical carcinoma (ICC) and cervical intraepithelial neoplasia grade 2 or 3 (CIN2/3), are more common in women living with HIV. It has been observed that when immunosuppression increases, so does the prevalence of HPV and CIN (Vuyst *et al.*, 2012). The frequency of opportunistic infections, Kaposi's sarcoma, and non-Hodgkin's lymphoma have significantly decreased with combination antiretroviral therapy (cART) for HIV; nevertheless, the incidence of HPV-associated cervical and anal carcinomas has not decreased (Franceschi *et al.*, 2010). Given the lengthy latent phase of HPV-associated carcinomas, this may not come as a surprise.

Certain studies have demonstrated that cART has a positive impact on HPV infection and cervical precancerous lesions, but not all studies on the topic (Paramsothy *et al.*, 2009; Minkoff *et al.*, 2010).

The HPV vaccine Gardasil (which protects against high-risk HPV types 16 and 18 and low-risk types 6 and 11) was authorized by the US Food and Drug Administration (FDA) in 2006 for use in all girls aged 9 to 26. The FDA authorized this vaccine for boys between 9 and 26 in 2009. The FDA authorized Cervarix, a vaccine intended to protect against HR HPV types 16 and 18, in the fall of 2009 for girls ages 10 to 25.

MATERIAL AND METHODS

Study Design and Location

The study was a hospital-based descriptive-analytical study designed among HIV-infected women on ART aged 15-74 years, irrespective of background and socioeconomic status, attending the selected hospitals during the study period. A systematic random sampling technique was used for the selection of study subjects.

Sample Size Determination:

The sample size was determined using the 15.0% prevalence of HPV in Jos, as reported by Musa et al. (2014). The sample size was determined by using the equation described by Naing *et al.* (2006):

$$n = \frac{Z^2 P (1-P)}{d^2}$$

Where n is the sample size;

P is the prevalence from a previous study = 15.0% = 0.150;

Z is the standard normal distribution at 95% confidence interval = 1.96;

d is the absolute desired precision at 5% = 0.05.

Therefore, the calculated sample size was 195.9. However, to minimize errors and remove bias, 10% attrition was added, and 300 samples were collected.

Data Collection

Each participant was administered a structured questionnaire containing both closed and open-ended questions, seeking relevant information on demographic data, socioeconomic status, behavioral and sexual habits, clinical presentations, and risk factors of HIV, HPV infections, and cervical cancer.

Sample Collection and Processing

Blood and cervical samples were collected from each participant from November 2018 to November 2020. Systematic random sampling method was used in collecting blood and cervical samples from HIV-positive women at the various sampling points across the 3 senatorial zones of Plateau state, Nigeria viz: Faith Alive Foundation Hospital and AIDS Prevention Initiative in Nigeria (APIN) Hospital (Jos North L.G.A.); General Hospital and Military Barracks Hospital Bassa (Bassa L.G.A.); General Hospital and Allah Nakowa Hospitals Mangu (Mangu L.G.A.); General Hospital Bokkos (Bokkos L.G.A.); General Hospital and Badikko Health Center Wase (Wase L.G.A.) and General Hospital and Beni Hospital Shendam in Shendam L.G.A.

A total of 300 blood and cervical swab samples were aseptically collected concurrently using syringes and cytobrush with the assistance of professional health workers. The whole blood was allowed to clot for at least 30 minutes and then centrifuged at 1500rpm for 10 minutes; the serum was then carefully removed with a transfer pipette and transferred aseptically into a sterile labeled serum storage screw-lapped container. It was then stored in a refrigerator until further analysis. Cervical swab samples were collected as described by Hayatudeen *et al.* (2021). Briefly, the sample was collected by a consultant pathologist in the presence of other nurses who also served as chaperones. In collecting the sample, the women were placed in a lithotomy position. The cervix was exposed using the bivalve speculum and then inspected. The specimen for the Pap smear was collected using the cytobrush, cut short at the brush end, and inserted into already labeled vial preservative containers containing a preservation fluid. All collected samples with the cytobrush were immediately packed in an ice pack in a container and were sent to the Laboratory for Pap smear analysis. Finally, the collected cells were examined under a microscope to observe abnormalities in the cells.

Detection of HIV using Rapid Diagnosis

Analysis of HIV antibodies in the serum of each participant was conducted using a rapid diagnosis approach aligned with the National HIV testing algorithm (serial algorithm). This encompassed the utilization of a primary test kit (Determine®), confirmation with a secondary test kit (Unigold®), and resolution of any inconsistencies using a tertiary test kit (Stat pak®) if required. The process involved applying 10 microliters of serum to the test pad of the kit, enabling it to flow through the chromatographic pad, and interpreting the result after 10 minutes, all pivotal for validating their HIV status.

Measurement of $CD4^+$ cell count and Viral Load Estimations

Flow cytometry (Sysmex flow counter) was used for $CD4^+$ count, and the results were expressed as cells/mm^3. The viral Load of each HIV-positive patient was estimated using GeneXpert technology, and the results were expressed as copies/mL.

Blood samples were collected in well labelled EDTA sample containers, and 20µl of the blood samples were pipetted and mixed with equal quantities (20µl) of monoclonal antibody and 800µl of buffer solution. After that, the mixtures were inserted into the Cyflow machine chamber, and the results were displayed on the screen within 4 minutes. The results were read and recorded as cells/mm^3 of blood.

The viral Load was estimated using GeneXpert technology, and the results were expressed as copies/mL. First, blood samples collected in EDTA containers were centrifuged for 5 minutes to obtain plasma. 250µl of plasma was added into the Cobas X480, where the sample preparation and extraction occurred. The next step involved extracting RNA from plasma and separating it from inhibitors that can impair amplification. After that, the extracted samples were then transferred from the Cobas X480 inline into a microplate. It then takes roughly 80 minutes to complete the amplification of the products in the PCR setup, and the results would be ready and displayed on the machine's screen and read as copies/mL of blood.

Pap smear screening for the detection of precancerous cells

A Pap smear was performed on all the participating women to assess any cytological change likely associated with HPV infection. The slides were prepared, fixed, and stained using the Papanicolaou (Pap smear) technique. The stained smears were examined and read, and the results were reported accordingly using the Bethesda system of classification by an experienced cytopathologist. Except for patients with a normal report, all others were referred to the gynecology clinic for further evaluation.

Detection of HPV using ELISA

All the cervical specimens collected were analyzed for the presence of human papillomavirus antigens using commercially available enzyme immune assays (Diagnostic Automation/Cortez Diagnostics Inc., USA) ELISA kits. The assay was performed according to the manufacturer's instructions; the reagents and the microtiter ELISA plates were brought to room temperature at 30^0C for 30 minutes before use. A blank well was set without any solution. A micropipette was used to dispense 100µl of the negative and positive control into wells 1 and 2, respectively. One hundred (100) microliter of the sample was added to the appropriate wells, covered with adhesive strip, and incubated for 30 minutes at 37^0C. The wells were then washed vigorously with distilled water, and excess wash buffer was removed after the last washing by slapping the plate on a clean, absorbent tissue. Two (2) drops of reagent 1 (blue solution) were added to each well (except blank) and further incubated at room temperature for 5 minutes. The wells were washed as above, and two (2) drops of reagent 2 (or red solution) were then added to each well (except blank), incubated for 5 minutes, and then washed. Two (2) drops of chromogen were added to each well and incubated for 5 minutes. Finally, 2 drops of stop solution were added to each well and mixed gently by tapping the side of the plate with an index finger.

In determining the optical density of each well at 10 minutes, the blank was set at zero and, using the micro-plate reader, was set at 450nm. However, the results were also read visually. Thus, any sample well that was more yellowish than the positive control was interpreted as positive, and any sample well that appeared colorless or not more yellowish than the negative control was interpreted as negative. Also, any sample well with an absorbance reading of 0.15 and above was regarded as positive, while sample wells with an absorbance reading of less than 0.15 were regarded as negative.

Data analysis and result presentation

Data generated from the questionnaire and the results obtained from the laboratory analysis were subjected to statistical analysis using the Statistical Package for Social Sciences (SPSS) version 26 to test for significant differences between variables using the chi-square test. Statistical significance was determined at ($P<0.05$) at 95% confidence interval, and the results were reduced to frequency tables, ratios, and percentages.

RESULTS

A total of 300 women aged 15 years and older infected with HIV and attending various antiretroviral therapy (ART) and gynecological units in Plateau state were enrolled in this study. The overall prevalence of Human Papillomavirus (HPV) infection among the study population was 28%. Table 1 shows the association between HPV infection and various sociodemographic characteristics of the study population. The highest HPV infection was observed in the age group 55-64 years (42.9%), while the least was observed in the age group of 15-24 years 1(10.0%).

The result further showed the majority of the women having HPV infection were widows (30.4%), while women actively married had the lowest (26.2%), and self-employed women recorded the highest HPV infection (40.0%). There was a statistically significant association between HPV infection and level of education, where a greater proportion of those women infected with HPV were those with only primary education (34.7%: P= 0.03*), as presented in Table 1.

The analysis of results based on risk factors is illustrated in Table 2. Regarding sexual characteristics in relation to HPV infection and cervical cancer risk, no significant statistical association was observed between HPV infection and any sexual character, but the prevalence of HPV infection increases with an increased number of sexual partners. As such, women with over 10 sexual partners have the highest HPV infection (66.7%), while those having less than 5 sex partners have the lowest (26.4%). More so, HPV infection was higher (32.0%) among women who had initiated sex earlier than those who initiated sex at much later age (0.0%). Again, HPV infection was higher among women not using condoms during sex (28.5%) than those using condoms (27.3%), as shown in Table 3. Further analysis of the result for the odds of risk of acquiring HPV infection and cervical abnormality showed the highest odds of risk in women co-infected with other STIs (OR=1.48) and least among women using different contraceptives (OR=0.65), as illustrated in Table 3.

Analysis of HPV infection in relation to contraceptives used among the participants showed that women using oral pills, injections, and implants have higher HPV infections than women combining injections and implants, implants and oral pills, and those using barrier methods. However, the least infection was observed among women combining oral pills with implants as methods of birth control method, as shown in Figure 1.

Analysis of the result based on the participants' immune status in relation to HPV infection shows the highest HPV infection (31.9%) occurring among women with the lowest immune status (0-200 cells/μL), while women having the most robust immune status in this study as reflected by their $CD4^+$ count of ≥ 601 cells/μL had HPV prevalence of 25%. The association between the immune status (as measured by $CD4^+$ count) and HPV infection was not statistically significant (p=0.383), as shown in Table 4.

Upon analyzing HIV viral load regarding HPV infection, it was observed that women with higher viral loads exhibited the highest HPV infection rate at 50.0%. Conversely, HPV infection rates were lower among women with lower HIV viral loads, as depicted in Table 5.

Figure 2 illustrates the relationship between immune status, $CD4^+$ count, and HIV viral load. This result demonstrates that as the immune status improves (i.e., higher $CD4^+$ cell count), HIV viral Load decreases; conversely, as immune status decreases, viral load increases. This indicates an inverse relationship between HIV viral load and $CD4^+$ count: as HIV viral load rises, $CD4^+$ count declines.

Table 1: Some sociodemographic characteristics of the study population and HPV infection

Socio-demographics	No. tested	No. positive (%)	p-value
Marital status			
Single	52	15(28.8)	0.914
Married	126	33(26.2)	
Divorced/separated	30	8(26.7)	
Widow	92	28(30.4)	
Type of family			
Monogamy	189	58(30.7)	0.525
Polygamy	55	11(20.0)	
Others	56	15(26.8)	
Level of education			
Non-formal	10	0(0.0)	0.03*
Primary	72	25(34.7)	
Secondary	109	24(22.0)	
Tertiary	109	35(32.1)	
Occupation			
Working	141	27(19.1)	0.159
Self employed	89	43(48.3)	
Not working	70	14(20.0)	
Age			
15-24	10	1(10.0%)	0.290
25-34	46	11(23.9%)	
35-44	131	33(25.2%)	
45-54	82	26(31.7%)	
55-64	28	12(42.9%)	
65-75	3	1(33.3%)	

Key: x2 = chi square, * = significant at P≤0.05, % = percentage, No. = number, HPV= human papillomavirus, CC=cervical cancer

Table 2: HPV infection in relation to some risk factors among HIV-infected women in Plateau state, Nigeria

Variable	No. examined	No. positive (%)	OR (95% CI)	p-value
Perception about screening for CC?				
Yes	297	84 (28.3)	2.60 (0.09-4.35)	0.278
No	3	0 (0.0)		
Do you smoke cigarette?				
Yes	21	7 (33.3)	1.33 (0.52-3.42)	0.550
No	279	77 (27.5)		
Age at Sexual debut				
11-15	25	8 (32.0)	1.21 (0.62-2.13)	0.001**
16-20	192	56 (29.2)		
21-25	77	19 (24.6)		
26-30	5	1 (20.0)		
31-35	1	0 (0.0)		
Number of Sexual partners				
1 - 5	277	73 (26.4)	0.19 (0.02-2.18)	0.065
6 - 10	20	9 (45.0)		
>10	3	2 (66.7)		
Alcohol Intake				
Yes	70	19 (27.1)	0.95 (0.52-1.72)	0.855
No	230	65 (28.3)		
Duration on alcohol				
1 - 5 years	28	6 (21.4)	0.01 (0.17-2.01)	0.325
6 - 10 years	24	5 (20.8)		
11 - 15 years	4	1 (25.0)		
16 - 20 years	12	6 (50.0)		
21 - 25 years	2	1 (50.0)		
Condom usage?				
Yes	128	35 (27.3)	0.95 (0.57-1.57)	0.827
No	172	49 (28.5)		
History of hysterectomy?				
Yes	1	0 (0.0)	1.74 (1.02-4.16)	0.531
No	299	84 (28.1)		

Key: x2 = chi square, * = significant at P≤0.05, % = percentage, No. = number, HPV= human papillomavirus, CC=cervical cancer

Table 3: Analysis of risk factors for HPV infection and cervical abnormality among HIV-infected women on ART in Plateau State, Nigeria

Risk factors	Odd ratio	95% C.I.	p-value
Contraceptive use	0.65	0.39-1.08	0.095
Using Vaginal herbs	1.23	0.68-2.23	0.491
Parity	1.01	0.23-4.22	0.111
Knowledge of CC	1.18	0.23-5.95	0.844
Vaginal discharge	1.06	0.63-1.78	0.839
Age at sexual debut	1.21	0.62-2.13	0.001**
Coinfection with STIs	1.48	0.81-2.69	0.202
Pap smear test	1.17	0.31-4.45	0.813

Key: x2 = chi square, * = significant at P≤0.05, % = percentage, No. = number, HPV= human papillomavirus, CC=cervical cancer

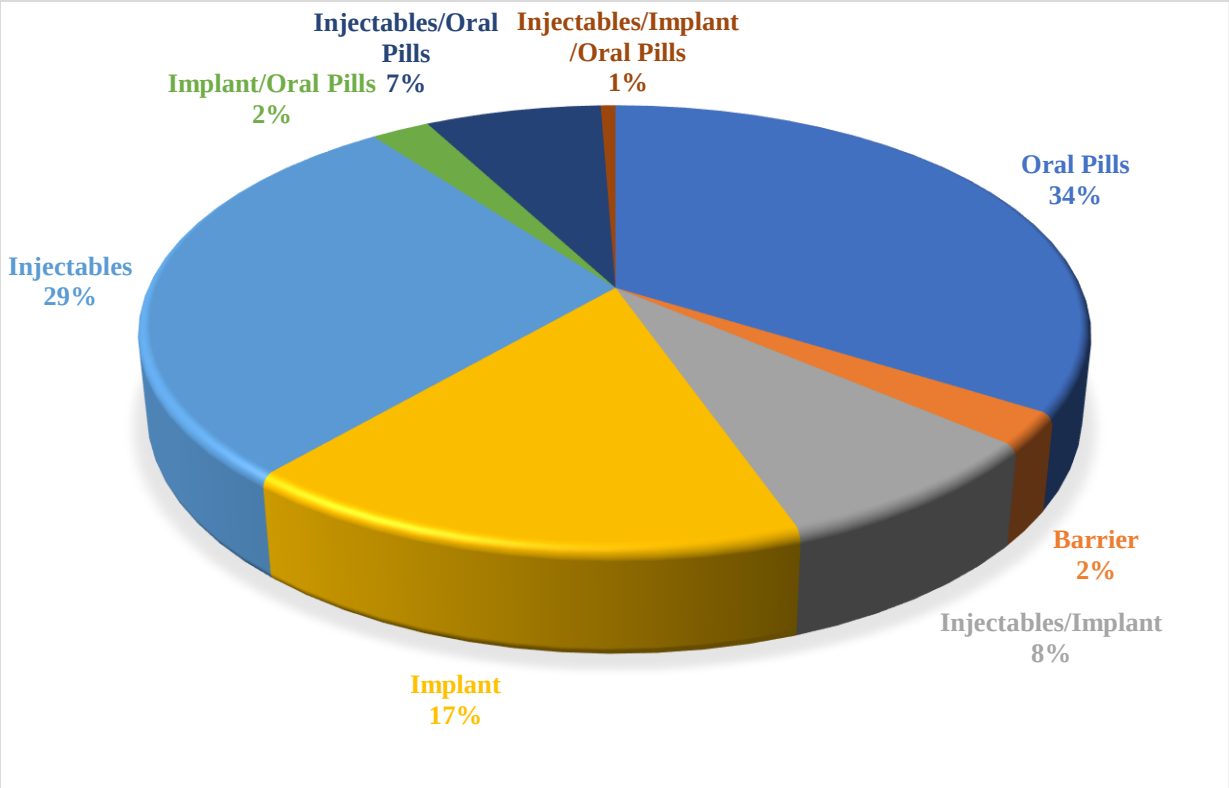

Figure 1: HPV infection in relation to contraceptives used among HIV-infected Women on ART

Table 4: Relationship between HPV infection and immune (CD4⁺) status among HIV-infected women

CD4⁺ Profile (cells/mm³)	Number tested	Positive (%)	p-value
0-200	166	53 (31.9)	0.383
201-400	70	15 (21.4)	
401-600	40	10 25.0)	
≥ 601	24	6 (25.0)	
Total	**300**	**84 (28.0)**	

Key: x2 = chi square, * = significant at P≤0.05, % = percentage, No. = number, HIV=human immunodeficiency virus, ART=antiretroviral therapy, HPV=human papillomavirus, CD= clusters of differentiation

Table 5: Association between HPV infection and viral load profile among HIV-infected women

Viral Load (copies/mL)	Number tested	Positive (%)	p-value
0-20	138	33 (23.9)	0.255
21-40	75	22 (29.3)	
41-60	36	8 (22.2)	
61-80	28	11 (39.3)	
81-100	15	6 (40.0)	
≥ 101	8	4 (50.0%)	
Total	**300**	**84 (28.0)**	

Key: x2 = chi square, * = significant at P≤0.05, % = percentage, No. = number, HIV=human immunodeficiency virus, ART=antiretroviral therapy, HPV=human papillomavirus

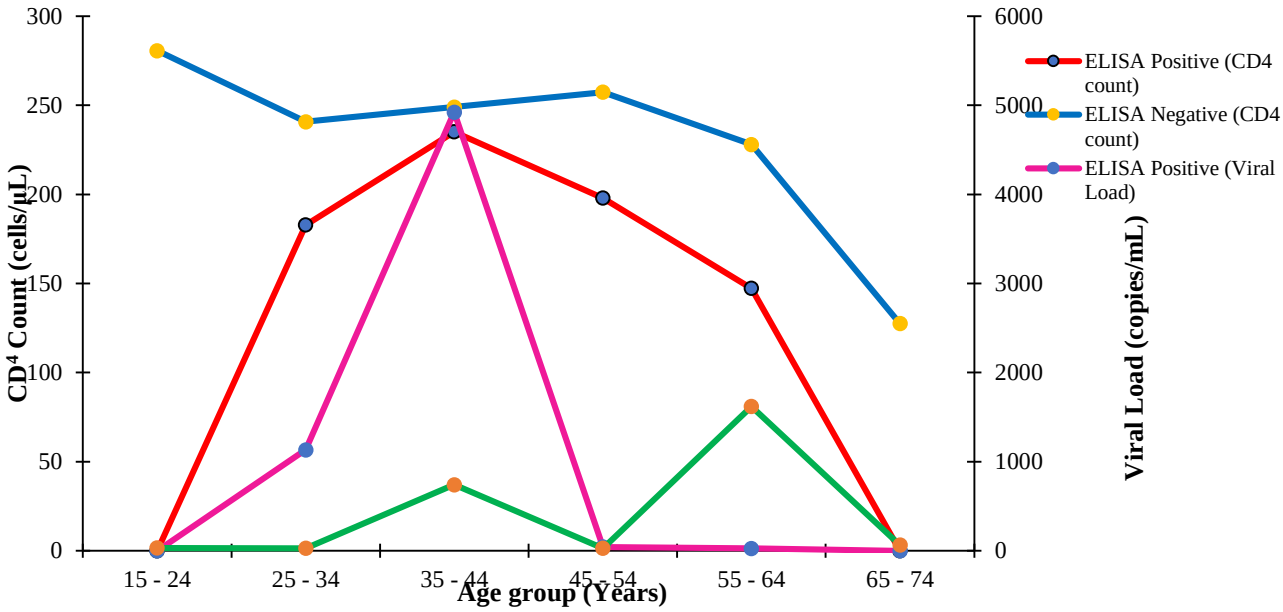

Fig.2: Relationship between CD⁺ count and HIV viral load
KEY: As CD4⁺ count improves, HIV viral load decreases and vice versa

DISCUSSION

This study was designed to determine the prevalence of HPV infection and its association with some risk factors of HPV infection and cervical cancer among HIV-infected women in North-central Nigeria. From this study, the overall prevalence of HPV infection among women 15 years and older attending various ART and gynecological units in Plateau state, Nigeria, was 28%. A high prevalence of HPV infection recorded in this study involving HIV-positive women, who are already placed at high risk in terms of risk of cervical cancer in a developing nation, portrays an important medical concern that requires an important intervention. This result is similar to the 28.5 % prevalence found among HIV-positive women in Eastern Cape, South Africa. The result also agrees with the findings of Sarkar *et al.* (2000) in India, who found the prevalence of HPV among HIV-infected females to be 32.2%. This is also similar to the findings of Seagar et al. (2000), who found a prevalence of 25%. However, our result was much lower than the prevalence of 63.3% found by Monteiro *et al.* (2021) in Brazil. The most probable reason for this level of HPV infection may not be unconnected with the low level of awareness of the connection between sexual behaviours and the risk of cervical cancer. It could also be attributed to some local practices of the use of vaginal herbs and douching, which were common among the study population.

For the risk of HPV infection and cervical cancer considered in this study, poor vaccination against HPV, coinfection with other STIs, early age of sexual initiation, use of vaginal herbs/douching and poor attitude towards cervical cancer screening, and lack of adequate knowledge of cervical cancer risks were found to be important risk factors for acquiring HPV infection and subsequent development of abnormal cervical cytology among these population. This finding is similar to the report of Pinto *et al.* (2011) where they reported several epidemiological and reproductive health factors have been related to the development of cervical cancer, including HPV infection, smoking, genetic predisposition, number of sex partners, age at sexual debut, parity and age at menarche. Separate studies conducted by Temesgan *et al.* (2021) published similar observations in similar studies from other parts of Nigeria and other African countries. This observation is also similar to the findings of Sagay *et al.* (2020) among female sex workers in Nigeria. One of the possible reasons for the observation similarity in our observations may be due to the poor risk perceptions associated with poor knowledge of cervical cancer as well as differences in risk perception of cervical cancer, among others. However, a different observation about risk factors was recorded in similar studies among the general population in Gombe and Niger states, as shown by Leonard *et al.* (2022). These differences may be observed due to the differences in the risk of the populations studied. This is so because, unlike our research that focused on a high-risk group (HIV-positive), those studies were conducted among women without any perceived risk.

Our findings showed that most of the population studied had very low CD4+ cells while only a few had robust $CD4^+$ cells. Generally, a person's immune status is measured by the level of their $CD4^+$ cells. Therefore, the level of immunity measured by $CD4^+$ status shows how effectively one can resist or minimize its impact after infection. Nowak *et al.* (2017) also found the prevalence of HPV to be higher in HIV-infected women with lower immune status than HIV-negative women in Nigeria. This is similar to the findings that the lower the immunity, the higher the chances of HPV infection leading to cervical intraepithelial neoplasia (CIN) and invasive cancer, as reported by Alex *et al.* (2003). Similar studies by Song *et al.* (2015) and Davies *et al.* (2001) also showed that the prevalence of abnormal cytology in HIV-positive women with robust immunity was much lower than in women with low immunity. This is so because women with low $CD4^+$ count and high viral Load have elevated risk of HPV acquisition, and low $CD4^+$ count was also associated with decreased HPV clearance. More so, a compromised immune response is a prerequisite for disease progression. One unique feature of HPV infection is that it can affect the immune system in such a way that it presents a much more tolerant state, which facilitates persistent high-risk HPV infection and cervical lesion progression to cervical cancer.

The present findings showed different levels of HIV viral Load across the population, but one important observation was that the higher the HIV viral load, the higher the prevalence of HPV infection. That is, HPV prevalence increases steadily as HIV viral load increases. While HPV clearance is common among HIV-infected individuals on ART, continued acquisition and persistence of HPV infections are common. This may be expected for a high-risk population, judged by their self-reported sexual and other risky behaviours. A similar study conducted in Romania also showed a strong correlation between HPV and HIV coinfection (Cambrea *et al.*, 2022). More so, Gautam (2018) also showed in their study a strong correlation between HIV viral load and HPV infection. The implication of high HIV viral load on the progression of cervical dysplasia to cervical cancer may be due to increased HPV persistence. This is so because the immunosuppressive effects of HIV can impair the body's ability to clear HPV infections. The similarities in findings here may be a reflection of similar poor healthcare facilities and access. Most developing countries, irrespective of region, usually face similar healthcare challenges from illiteracy, poverty and poor hygienic practices.

Conclusively, this study has shown that HIV-infected women, though on ART, still have not achieved immune reconstitution, mostly due to poor adherence to the drugs. We equally found poor sexual habits, use of some local vaginal herbs, and douching for prevention of unplanned pregnancies and STIs, among others, as key risk factors for acquiring HPV infection and cervical dysplasia.

We, therefore, recommend routine cervical cancer screening, improved knowledge of risky sexual behaviours among HIV-infected women, and better monitoring of ART regimens to improve the immune status of HIV-infected women. Further research is recommended to establish the role or otherwise of ART on cervical dysplasia progression to cervical cancer.

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