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Research Article

Sociodemographic and Risk Factors Associated with Human Papillomavirus Infection among Sperm-Impaired Male Patients Attending Reproductive Clinic at Ahmadu Bello University Teaching Hospital Zaria

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ABSTRACT
Human papillomavirus (HPV) is one of the most common sexually transmitted infections worldwide and has increasingly been implicated in male reproductive dysfunction. However, evidence on the sociodemographic and behavioural determinants of HPV infection among sperm-impaired men in Nigeria remains limited. This hospital-based cross-sectional study investigated the sociodemographic characteristics and risk factors associated with HPV infection among 156 sperm-impaired male patients attending the Reproductive Health Clinic of Ahmadu Bello University Teaching Hospital, Zaria. Semen samples were evaluated for sperm concentration, motility, and morphology using standard laboratory methods, while HPV DNA was detected using the GeneXpert HPV assay. Sociodemographic, behavioural, and clinical information was obtained through structured questionnaires and analysed using IBM SPSS version 23. Chi-square tests and odds ratios were used to determine associations at a significance level of $p < 0.05$. The overall HPV prevalence was 6.7%. Although HPV infection was more frequent among men aged 37–50 years, age was not significantly associated with infection. Single participants had significantly higher HPV prevalence than married men. Lower educational attainment and lack of circumcision were associated with poorer semen quality. History of organ transplantation and presence of genital warts showed significant associations with HPV infection, while dysuria and difficulty with urine flow were significantly related to impaired semen quality. The findings demonstrate that HPV infection among sperm-impaired men is associated with selected sociodemographic and clinical factors. Enhanced HPV awareness, male vaccination, safer sexual practices, and incorporation of HPV screening into infertility evaluation may improve reproductive health outcomes in Nigeria.

Keywords: Human Papillomavirus; Public Health: Risk Factors; Sociodemographic Factors; Sperm Impairment

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INTRODUCTION

Human papillomavirus (HPV) is the most common sexually transmitted viral infection worldwide and remains a major public health concern affecting both men and women (Bruni *et al.,* 2023; Garolla *et al.,* 2024). Although HPV is widely recognized as the primary cause of cervical cancer, growing evidence shows that it also has significant health consequences in men. HPV infection in males is associated with genital warts and cancers of the penis, anus, and oropharynx, while infected men play a crucial role in sustaining viral transmission among sexually active populations (Sung *et al.,* 2021; Bruni *et al.,* 2023). Recent global estimates indicate that approximately

one-third of men aged 15 years and older are infected with at least one genital HPV genotype, with nearly one in five harboring a high-risk HPV (hrHPV) type (Bruni *et al.,* 2023).

Unlike women, whose HPV prevalence generally declines with age following immune clearance, genital HPV infection among men remains relatively stable across adulthood because of continuous exposure and reinfection (Kombe *et al.,* 2021; Bruni *et al.,* 2023). Consequently, men play an important role in sustaining HPV transmission within the population, emphasizing the need to incorporate males into HPV prevention and vaccination programmes (WHO, 2022; Bruni *et al.,* 2023). Despite this growing recognition, HPV prevention strategies in many low- and middle-income countries continue to focus almost exclusively on women, resulting in limited epidemiological data regarding HPV infection among men (Kombe *et al.,* 2021; Garolla *et al.,* 2024).

Beyond its established oncogenic role, HPV has increasingly been implicated in male infertility. Human papillomavirus DNA has been detected in semen, spermatozoa, epididymal tissue and testicular tissue, suggesting that the virus may directly infect the male reproductive tract (Piroozmand *et al.,* 2020; Fedder *et al.,* 2021; Garolla *et al.,* 2024). Experimental studies have demonstrated that HPV binds to the equatorial region of the sperm head, thereby facilitating viral transport during fertilization and potentially impairing normal sperm function and early embryonic development (Pérez-Andino *et al.,* 2009; Zhaffal and Salame, 2023).

Recent systematic reviews and meta-analyses have consistently demonstrated that seminal HPV infection is associated with deterioration of conventional semen parameters. The HPV-positive men frequently exhibit significantly reduced sperm concentration, decreased progressive motility, abnormal sperm morphology, increased sperm DNA fragmentation, oxidative stress, and impaired fertilization potential compared with HPV-negative individuals (Jaworek *et al.,* 2021; Muscianisi *et al.,* 2021; Sucato *et al.,* 2023; Garolla *et al.,* 2024). Furthermore, HPV infection has been associated with poorer outcomes following assisted reproductive technologies and increased risks of unexplained infertility and recurrent pregnancy loss (Capra *et al.,* 2022; Bruno *et al.,* 2023; Garolla *et al.,* 2024).

Several sociodemographic and behavioural characteristics have been identified as important determinants of HPV acquisition among men. Previous studies have consistently reported that multiple lifetime sexual partners, early sexual debut, inconsistent condom use, cigarette smoking, uncircumcised status, previous Sexually transmitted infections, immunosuppression and lower educational attainment significantly increase the likelihood of HPV infection (Rodríguez-Álvarez *et al.,* 2018; Huang *et al.,* 2018; Pan *et al.,* 2018; Kombe *et al.,* 2021; Bruni *et al.,* 2023). These factors may influence both the acquisition and persistence of HPV infection, thereby increasing the risk of reproductive dysfunction among infected men.

In sub-Saharan Africa, HPV infection remains highly prevalent; however, epidemiological evidence among men is still limited compared with women (Kombe *et al.,* 2021; WHO, 2023). Most HPV-related studies in the region have focused primarily on cervical HPV infection and cervical cancer prevention, resulting in inadequate understanding of HPV epidemiology among men, particularly those presenting with infertility or impaired semen quality (Kanmodi *et al.,* 2022; Bruni *et al.,* 2023). In Nigeria, only a few studies have investigated HPV infection among men, leaving substantial knowledge gaps regarding the sociodemographic determinants, behavioural risk factors and relationship between HPV infection and semen abnormalities among infertile male populations (Mohammed *et al.,* 2019; Ashaka *et al.,* 2022).

Male-factor infertility contributes to approximately 40–50% of infertility cases globally, with infectious agents increasingly recognized as important but frequently overlooked causes of impaired reproductive function (Agarwal *et al.,* 2021; Garolla *et al.,* 2024). Identification of modifiable risk factors associated with HPV infection among infertile men could facilitate earlier diagnosis, improve reproductive counselling and support evidence-based implementation of HPV vaccination and sexual health interventions among reproductive-age males (WHO, 2022; Sucato *et al.,* 2023).

Therefore, this study investigated the sociodemographic characteristics and behavioural risk factors associated with HPV infection among sperm-impaired male patients attending the Reproductive Health Clinic of Ahmadu Bello University Teaching Hospital, Zaria, Nigeria. Additionally, the study evaluated the relationship between HPV infection and semen quality to provide evidence that may contribute to improved infertility evaluation, reproductive healthcare, and HPV prevention strategies among Nigerian men.

MATERIALS AND METHODS

Study Design and Setting

This hospital-based cross-sectional study was conducted among sperm-impaired male patients attending the Reproductive Health Clinic of Ahmadu Bello University Teaching Hospital (ABUTH), Shika, Zaria, Kaduna State, Nigeria, a tertiary healthcare facility that receives patients from Kaduna State and neighbouring states. Zaria is located in North-Western Nigeria and serves as a major referral centre for reproductive and fertility services in the region.

Study Population

The study population comprised consenting male patients of reproductive age who attended the Reproductive Health Clinic of ABUTH, for infertility evaluation during the study period.

Inclusion Criteria

The study included consenting males of reproductive age attending the Reproductive Health Clinic of ABUTH for infertility assessment. Participants were enrolled after providing written informed consent and submitting semen samples for laboratory analysis.

Exclusion Criteria

Male patients who declined consent, were unable to provide semen samples, as well as those whose samples were unsuitable for laboratory analysis were excluded from the study. Samples with incomplete laboratory or questionnaire data were also excluded.

Sample Size Determination

The minimum sample size was determined using Fisher's formula for prevalence studies based on an HPV prevalence of 11.5% previously reported among males in Zaria, Kaduna State (Dimie *et al.,* 2013). Using a 95% confidence level and 5% margin of error, the calculated sample size was 156 participants, all of whom were enrolled in the study (Ogbeibu, 2014).

Ethical Considerations

Ethical approval for the study was obtained from the Health Research Ethics Committee of Ahmadu Bello University Teaching Hospital, Shika, Zaria, Nigeria, before commencement of the study. Written informed consent was obtained from all participants before enrolment.

Sampling Technique

Eligible participants were recruited consecutively as they presented at the Reproductive Health Clinic during the study period until the required sample size of 156 participants was attained.

Collection of Data

Data were collected using a structured interviewer-administered questionnaire designed to obtain information on participants' sociodemographic characteristics and potential risk factors for HPV infection. Variables collected included age, marital status, educational level, occupation, alcohol consumption, cigarette smoking, history of hypertension, diabetes mellitus, circumcision status, number of sexual partners, condom use, awareness of sexually-transmitted infections (STIs), previous HPV status, and other behavioural and clinical characteristics considered relevant for HPV acquisition.

Collection of Semen

Participants were instructed to maintain 3 days of sexual abstinence before semen collection. Approximately, 3–4 mL of semen was obtained by masturbation into sterile universal containers. Following liquefaction at room temperature, semen samples were evaluated for semen volume, pH, sperm concentration, total sperm count, progressive motility, and normal morphology according to the World Health Organization (WHO) Laboratory Manual for the Examination and Processing of Human Semen (Cooper *et al.,* 2010). Based on WHO reference criteria, semen samples were classified as either normal or sperm-impaired according to abnormalities in sperm motility, morphology, and sperm count.

Detection of Human Papillomavirus

Following semen analysis, approximately 2 mL of each semen specimen was transferred into tubes containing 2.5 mL of liquid-based cytology preservative (TACAS Amber; MBL Medical & Biological Laboratories Co., Ltd., Tokyo, Japan) and stored at 4°C until molecular analysis. Only semen samples with impaired sperm indices underwent HPV DNA testing.

High-risk HPV DNA detection was performed using the GeneXpert HPV System (Cepheid, Sunnyvale, CA, USA) according to the manufacturer's instructions. The GeneXpert platform is an automated real-time polymerase chain reaction (PCR)-based molecular assay that simultaneously performs DNA extraction, amplification, and detection within a closed cartridge system. The assay detects 14 high-risk HPV genotypes and provides rapid qualitative results with high analytical sensitivity and specificity (Arbyn *et al.,* 2021).

Data Analysis

Data were entered into Microsoft excel sheet and imported into IBM SPSS Statistics version 23.0 (IBM Corp., Armonk, NY, USA) for analysis. Descriptive statistics were used to summarize sociodemographic characteristics and behavioural risk factors. Categorical variables were presented as frequencies

and percentages. Associations between HPV infection and categorical variables were assessed using the Pearson Chi-square test or Fisher's exact test where appropriate. Odds ratios (ORs) with corresponding 95% confidence intervals (95% CI) were calculated to estimate the strength of associations. Statistical significance was established at $P < 0.05$.

RESULTS

Study Population

A total of 156 sperm-impaired male patients attending the Reproductive Health Clinic were enrolled in the study. The participants had a mean age of 37 years. Semen analysis revealed that 41.7% of participants had abnormal sperm motility**,** 38.5% had abnormal sperm morphology, and 41.0% had low sperm count. Among the 60 semen samples subjected to HPV DNA testing, the overall prevalence of HPV infection was 6.7% (4/60)**.**

Sociodemographic Characteristics of Participants

The distribution of semen abnormalities and HPV infection according to participants' sociodemographic characteristics is summarized in Table 1 below:

The highest proportion of abnormal sperm motility **(**43.8%**),** abnormal sperm morphology **(**40.6%**),** and low sperm count **(**43.8%**)** occurred among men aged 37–50 years. However, age was not significantly associated with sperm abnormalities or HPV infection (all $P > 0.05$). HPV infection was slightly more common among men aged 37–50 years (7.7%) than those aged 23–36 years (6.1%), while no HPV-positive case was identified among participants aged 51–64 years.

Marital status showed no statistically significant association with semen quality. Nevertheless, HPV infection was significantly more frequent among unmarried participants than married participants (100.0% vs. 5.1%, $\chi^2 = 14.237$, $P < 0.001$). Because only two participants were unmarried, this finding should be interpreted cautiously.

Although men in polygamous marriages demonstrated relatively higher proportions of abnormal sperm morphology (50.0%), low sperm count (45.0%), and HPV infection (20.0%) compared with men in monogamous unions, these differences did not reach statistical significance.

Educational attainment demonstrated a significant relationship with semen quality. Participants with informal education had the highest prevalence of abnormal sperm motility (83.3%), abnormal sperm morphology (83.3%), and low sperm count (83.3%). Significant associations were observed between educational level and abnormal sperm motility ($P = 0.001$), abnormal sperm morphology ($P = 0.005$), and low sperm count ($P < 0.001$). HPV prevalence was highest among participants with primary education (18.2%), although the association between educational level and HPV infection was not statistically significant ($P = 0.327$).

Behavioural and Clinical Risk Factors Associated with HPV Infection

Behavioural and clinical risk factors for HPV infection and semen abnormalities are presented in Tables 2a and 2b below: Participants who reported previous awareness of reproductive health impairment had slightly higher proportions of abnormal sperm motility (47.8%) and abnormal sperm morphology (43.5%) than those without such awareness; however, these differences were not statistically significant. Importantly, all HPV-positive cases occurred among men who were previously unaware of their reproductive health status, although this association did not achieve statistical significance ($P = 0.355$).

Similarly, all HPV-positive participants had no prior knowledge of their HPV status before enrolment. Knowledge of previous HPV status was not significantly associated with semen abnormalities or HPV infection (all $P > 0.05$).

Uncircumcised men demonstrated higher proportions of abnormal sperm motility (52.8%), abnormal sperm morphology (44.4%), and low sperm count (47.2%) than circumcised men. However, circumcision status was not significantly associated with HPV infection or semen quality (all $P > 0.05$).

Regarding sexual behaviour, men reporting condom use had slightly higher frequencies of abnormal sperm motility (43.8%), abnormal sperm morphology (50.0%), low sperm count (43.8%), and HPV infection (12.5%). However, the calculated odds ratio suggested that men who did not consistently use protection were at greater overall risk of HPV infection (OR = 2.333), although the association was not statistically significant.

Participants who were unaware of their Sexually transmitted infection (STI) status showed higher frequencies of abnormal sperm motility (43.4%), abnormal sperm morphology (39.3%), and low sperm count (42.6%). Likewise, smokers demonstrated higher proportions of abnormal sperm morphology (40.0%) and low sperm count (60.0%) than non-smokers; however, none of these associations reached statistical significance.

The prevalence of HPV infection was highest among participants with two lifetime sexual partners (22.2%), although the association between number of

sexual partners and HPV infection was not statistically significant (*P* = 0.126).

Table 1: Socio-demographic distribution of semen quality and HPV among men attending Reproductive Health Clinics in Ahmadu Bello University Teaching Hospital, Zaria, Nigeria

Socio-demographic factor	N	Abnormal sperm motility Number positive (%)	Abnormal sperm morphology Number positive (%)	Low sperm count Number positive (%)	n	HPV Number positive (%)
Age (years)						
23-36	87	35(40.2)	33(37.9)	34(39.1)	33	2(6.1)
37-50	64	28(43.8)	26(40.6)	28(43.8)	26	2(7.7)
51-64	5	2(40.0)	1(20.0)	2(40.0)	1	0(0.0)
		χ^2=0.194, df =2, P=0.908	χ^2=0.857, df =2, P=0.652	χ^2=0.335, df =2, P=0.846		χ^2=0.135, df =2, P=0.935
Marital status						
Married	154	64(41.6)	59(38.3)	63(40.9)	59	3(5.1)
Single	2	1(50.0)	1(50.0)	1(50.0)	1	1(100.0)
		χ^2=0.058, df =1, P=0.810	χ^2=0.114, df =1, P=0.736	χ^2=0.067, df =1, P=0.795		χ^2=14.237, df =1, P=0.000
Type of marriage						
Monogamy	134	56(41.8)	49(36.6)	54(40.3)	49	1(2.0)
Polygamy	20	8(40.0)	10(50.0)	9(45.0)	10	2(20.0)
Not married	2	1(50.0)	10(50.0)	1(50.0)	1	1(100.0)
		χ^2=0.081, df =2, P=0.960	χ^2=1.441, df =2, P=0.487	χ^2=0.226, df =2, P=0.893		χ^2=18.542, df =2, P=0.000
Number of sex partners						
1	136	57(41.9)	50(36.8)	55(40.4)	50	2(4.0)
2	18	7(38.9)	9(50.0)	8(44.4)	9	2(22.2)
3	2	1(50.0)	1(50.0)	1(50.0)	1	0(0.0)
		χ^2=0.118, df =2, P=0.943	χ^2=1.290, df =2, P=0.525	χ^2=0.173, df =2, P=0.917		χ^2=4.143, df =2, P=0.126
Level of education						
Informal	6	5(83.3)	5(83.3)	5(83.3)	5	0(0.0)
Primary	16	13(81.3)	11(68.8)	13(81.3)	11	2(18.2)
Secondary	26	11(42.3)	10(38.5)	10(38.5)	10	0(0.0)
Tertiary	108	36(33.3)	34(31.5)	36(33.3)	34	2(5.9)
		χ^2=17.690, df =3, P=0.001	χ^2=13.529, df =3, P=0.005	χ^2=17.851, df =3, P=0.000		χ^2=3.449, df =3, P=0.327

n=Number examined
N = (out of 156)
n = (out of 60)

Table 2a.: Risk factors of reproductive health impairments and HPV among male patients presenting at the Reproductive Health Clinics of Ahmadu Bello University Teaching Hospital, Zaria

Risk factors	N	Abnormal sperm motility Number positive (%)	Abnormal sperm morphology Number positive (%)	Low sperm count Number positive (%)	n	HPV Number Positive (%)
Awareness						
[a]**No**	133	54(40.6)	50(37.6)	55(41.4)	50	4(8.0)
[b]**Yes**	23	11(47.8)	10(43.5)	9(39.1)	10	0(0.0)
		χ^2=0.421, df =1, P=0.516, [a]OR =0.746; [b]OR =1.341	χ^2=0.287, df =1, P=0.592, [a]OR =0.783; [b]OR =1.277	χ^2=0.040, df =1, P=0.841, [a]OR =1.097; [b]OR =0.912		χ^2=0.857, df =1, P=0.355 [a]OR =0.920; [b]OR =n.a
Knowledge of Previous HPV Status						
[a]**No**	139	57(41.0)	53(38.1)	58(41.7)	53	4(7.5)
[b]**Yes**	17	8(47.1)	7(41.2)	6(35.3)	7	0(0.0)
		χ^2=0.228, df =1, P=0.633, [a]OR =0.782; [b]OR =1.279	χ^2=0.059, df =1, P=0.807, [a]OR =0.880; [b]OR =1.135	χ^2=0.259, df =1, P=0.611, [a]OR =1.313; [b]OR =0.762		χ^2=0.566, df =1, P=0.452 [a]OR =0.925; [b]OR =n.a
Circumcision						
[a]No	36	19(52.8)	16(44.4)	17(47.2)	16	1(6.3)
[b]Yes	120	46(38.3)	44(36.7)	47(39.2)	44	3(6.8)
		χ^2=2.377, df =1, P=0.123, [a]OR =0.556; [b]OR =1.798	χ^2=0.708, df =1, P=0.400, [a]OR =1.382; [b]OR =0.724	χ^2=0.743, df =1, P=0.389, [a]OR =1.390; [b]OR =0.720		χ^2=0.006, df =1, P=0.938 [a]OR =1.098; [b]OR =0.911

n=Number examined

N = (out of 156) n = (out of 60)

Association between HPV Infection and Sperm Impairment

The relationship between HPV infection and semen quality is presented in Table 3 below: All HPV-positive participants were identified among men with abnormal sperm motility, suggesting an association between HPV infection and impaired sperm motility. However, this relationship was not statistically significant. Similarly, HPV infection showed no statistically significant association with low sperm count (P = 0.057). Interestingly, HPV infection was significantly associated with semen leukocyte count, with all HPV-positive cases occurring among participants with zero semen leukocyte count (P < 0.001).

Overall, the findings indicate that although HPV infection occurred predominantly among men with impaired semen parameters, statistically significant associations were observed only for selected clinical variables, whereas most sociodemographic and behavioural factors showed no significant relationship with HPV infection in this study.

Table 2b: Risk factors of reproductive health impairments and HPV infection among men attending Reproductive Health Clinics in Ahmadu Bello University Teaching Hospital, Zaria (cont'd)

Risk factors	N	Abnormal motility No. positive (%)	Abnormal morphology Number positive (%)	Low sperm count No positive (%)	n	HPV Number positive (%)
Protection during sex						
[a]No	140	58(41.4)	52(37.1)	56(40.0)	52	3(5.8)
[b]Yes	16	7(43.8) χ^2=0.032, df =1, P=0.858, [a]OR =0.909; [b]OR =1.100	8(50.0) χ^2=1.003, df =1, P=0.317, [a]OR =0.591; [b]OR =1.692	6(50.0) χ^2=0.593, df =1, P=0.441, [a]OR =0.667; [b]OR =1.500	8	1(12.5) χ^2=0.505, df =1, P=0.452 [a]OR =2.333; [b]OR =0.429
Knowledge about STIs						
[a]No	122	53(43.4)	48(39.3)	52(42.6)	48	3(6.3)
[b]Yes	34	12(35.5) χ^2=0.726, df =1, P=0.394, [a]OR =1.408; [b]OR =0.710	12(35.3) χ^2=0.184, df =1, P=0.668, [a]OR =1.189; [b]OR =0.841	12(35.3) χ^2=0.590, df =1, P=0.442, [a]OR =1.362; [b]OR =0.734	12	1(8.3) χ^2=0.067, df =1, P=0.452 [a]OR =1.364; [b]OR =0.733
Smoking						
[a]No	151	63(41.7)	58(38.4)	61(40.4)	58	4(6.9)
[b]Yes	5	2(40.0) χ^2=0.006, df =1, P=0.939, [a]OR =1.074; [b]OR =0.931	2(40.0) χ^2=0.005, df =1, P=0.943, [a]OR =0.935; [b]OR =1.069	3(60.0) χ^2=0.769, df =1, P=0.381, [a]OR =0.452; [b]OR =2.213	2	0(0.0) χ^2=0.148, df =1, P=0.701 [a]OR =0.931; [b]OR =n.a
History of organ transplant						
[a]No	154	64(41.6)	58(37.7)	63(40.9)	58	3(5.2)
[b]Yes	2	1(50.0) χ^2=0.058, df =1, P=0.810, [a]OR =0.711; [b]OR =1.406	2(100.0) χ^2=3.242, df =1, P=0.072, [a]OR =0.377; [b]OR =n.a	1(50.0) χ^2=0.067, df =1, P=0.795, [a]OR =0.692; [b]OR =1.444	2	1(50.0) χ^2=6.244, df =1, P=0.012, [a]OR =18.333; [b]OR =0.055

N = (out of 156)
n = (out of 60)

Table 3. Effect of HPV on semen quality among men attending Reproductive Health Clinics in Ahmadu Bello University Teaching Hospital, Zaria, Nigeria.

Semen parameter	n	HPV Number positive (%)	χ^2	df	P-value	Odd Ratio (OR)
Sperm count						
0-37.9	57	3(5.3)	3.609	1	0.057	9.000
38-75.9	3	1(33.3)				0.111
Sperm motility						
Abnormal	53	4(7.5)	0.566	1	0.452	0.925
Normal	7	0(0.0)				n.a
Semen leukocyte count						
0	1	1(100.0)				
1-5	42	2(4.8)	14.262	2	0.001	n.a
6-9	17	1(5.9)				

DISCUSSION

The present study investigated the sociodemographic and behavioural risk factors associated with human papillomavirus (HPV) infection among sperm-impaired male patients attending the Reproductive Health Clinic of Ahmadu Bello University Teaching Hospital (ABUTH), Zaria, Nigeria, and further examined the relationship between HPV infection and semen quality. The findings contribute to the limited body of evidence on HPV infection among infertile men in Nigeria and provide additional insight into factors that may influence HPV acquisition and male reproductive health.

The overall prevalence of HPV infection among sperm-impaired men in this study was 6.7% (4/60). Although lower than prevalence estimates reported in several international studies, the detection of HPV among infertile men remains clinically relevant because of its potential impact on semen quality and reproductive outcomes. Recent global evidence indicates that genital HPV infection affects approximately one-third of men worldwide, with high-risk HPV accounting for nearly one-fifth of infections (Bruni *et al.,* 2023). However, prevalence varies considerably depending on geographical location, study population, specimen type, molecular diagnostic methods, and HPV genotypes investigated (Muscianisi *et al.,* 2023; Garolla *et al.,* 2024).

The relatively low prevalence observed in this study may be attributed to the inclusion of only sperm-impaired men attending a single tertiary hospital, the relatively small number of participants tested for HPV DNA, and differences in molecular diagnostic techniques compared with studies employing broader HPV genotyping platforms. Similar relatively low prevalence rates have been reported among selected male populations in parts of Africa, whereas substantially higher prevalence has been documented in Europe, South America, and Asia, where multiple HPV genotypes are routinely investigated (Kombe *et al.,* 2021; Bruni *et al.,* 2023; Garolla *et al.,* 2024). These observations suggest that regional epidemiological differences and methodological variations should be considered when comparing HPV prevalence across studies.

Age was not significantly associated with HPV infection in the present study, although HPV-positive cases occurred predominantly among participants aged 37–50 years. This finding agrees with previous reports indicating that genital HPV infection in men remains relatively constant throughout adulthood because repeated sexual exposure and reinfection offset the age-related decline commonly observed among women (Bruni *et al.,* 2023; WHO, 2022). Several multinational studies have similarly reported no consistent association between increasing age and HPV positivity among Sexually active men (Nyitray *et al.,* 2021; Bruni *et al.,* 2023). Conversely, some investigators have reported higher HPV prevalence among younger sexually-active males, particularly those with multiple sexual partners (Rodríguez-Álvarez *et al.,* 2018; Kombe *et al.,* 2021). These inconsistencies may reflect differences in sexual behaviour, cultural practices, and population characteristics.

Educational attainment demonstrated a significant association with sperm abnormalities but not with HPV infection. Participants with little or no formal education exhibited the highest proportions of abnormal sperm motility, abnormal morphology, and low sperm count. Although education was not independently associated with HPV positivity, lower educational status may indirectly influence reproductive health through reduced awareness of STIs, delayed healthcare-seeking Behaviour , and poor adoption of preventive practices (WHO, 2022; Kanmodi *et al.,* 2022). Similar observations have been reported in studies from low- and middle-income countries, where educational level is closely linked to health literacy and utilization of reproductive health services (Kombe *et al.,* 2021).

Marital status also showed no significant relationship with semen quality, although HPV infection appeared more frequent among unmarried participants. This observation should be interpreted cautiously because only a very small number of unmarried men were included in the study. The apparent association is therefore likely influenced by the limited sample size rather than reflecting a true epidemiological relationship. Previous studies had likewise shown inconsistent associations between marital status and HPV infection after adjustment for sexual behaviour and number of sexual partners (Bruni *et al.,* 2023; Garolla *et al.,* 2024).

Behavioural factors evaluated in this study, including cigarette smoking, condom use, circumcision status, previous awareness of reproductive impairment, previous HPV knowledge, and STI status, were not significantly associated with HPV infection. Nevertheless, uncircumcised men and smokers tended to exhibit poorer semen quality than circumcised men and non-smokers. These findings are biologically plausible because smoking has been associated with oxidative stress, increased sperm DNA damage, and reduced sperm motility, while male

circumcision has been reported to reduce acquisition and persistence of high-risk HPV infection (Agarwal *et al.,* 2021; WHO, 2022; Muscianisi *et al.,* 2023). The absence of statistically significant associations in the present study is likely attributable to the relatively small number of HPV-positive participants, which limited statistical power.

Although men with two lifetime sexual partners demonstrated the highest HPV prevalence, no statistically significant association was observed between the number of sexual partners and HPV infection. This finding differs from numerous epidemiological studies that consistently identified multiple sexual partnerships as one of the strongest predictors of HPV acquisition among men (Kombe *et al.,* 2021; Bruni *et al.,* 2023). The discrepancy may again be explained by the limited sample size and the low number of HPV-positive cases included in the analysis.

An important finding of this study was the predominance of HPV infection among men with impaired semen quality. All HPV-positive participants had abnormal sperm motility, suggesting that HPV infection may contribute to deterioration of sperm function. Although this association did not reach statistical significance, the observed trend is consistent with recent systematic reviews and meta-analyses demonstrating that HPV-positive men frequently exhibit reduced progressive motility, abnormal morphology, increased sperm DNA fragmentation, oxidative stress, and diminished fertilizing capacity compared with HPV-negative men (Sucato *et al.,* 2023; Muscianisi *et al.,* 2023; Garolla *et al.,* 2024). Experimental studies have further demonstrated that HPV particles bind to spermatozoa and may impair sperm function through inflammatory responses, oxidative damage, and disruption of normal sperm–oocyte interactions (Piroozmand *et al.,* 2020; Zhaffal & Salame, 2023).

Interestingly, a statistically significant association was observed between HPV infection and semen leukocyte count. Although the biological significance of this finding remains uncertain, alterations in seminal inflammatory responses have previously been linked with persistent HPV infection and oxidative stress within the male reproductive tract (Garolla *et al.,* 2024). Additional studies involving larger populations and comprehensive inflammatory biomarkers are required to clarify this relationship.

Overall, the present findings support growing evidence that HPV infection may contribute to impaired male reproductive function even when statistically significant associations are not consistently demonstrated in smaller studies. They also emphasize the importance of incorporating HPV awareness, sexual health education, and preventive strategies into infertility evaluation and reproductive healthcare programmes. Larger multicenter prospective studies using comprehensive HPV genotyping and multivariable statistical modelling are warranted to better define the epidemiology and reproductive consequences of HPV infection among Nigerian men.

CONCLUSION

In conclusion, HPV infection was detected in 6.7% of sperm-impaired men attending the Reproductive Health Clinic of ABUTH, Zaria, demonstrating that HPV is present among men with reproductive impairment in this setting. Educational level was significantly associated with semen quality, while marital status, type of marriage, organ transplantation, and genital warts showed significant associations with HPV infection. Although most behavioural risk factors were not significantly related to HPV infection, HPV-positive participants were more likely to exhibit abnormal semen parameters, particularly impaired sperm motility, suggesting a potential adverse effect of HPV on male reproductive function. These findings support the inclusion of HPV awareness, prevention, and screening strategies in the clinical evaluation of male infertility and provide baseline data for future large-scale studies investigating the role of HPV in male reproductive health in Nigeria.

Human Papilloma Virus screening should be considered for sperm-impaired men with unexplained infertility or persistent abnormal semen parameters where diagnostic facilities are available. Public health programmes should increase awareness of HPV infection, its modes of transmission, potential impact on male fertility, and preventive measures among reproductive-age men. Human Papilloma Virus vaccination strategies should be expanded to include boys and young men to reduce HPV transmission and HPV-related diseases. Healthcare providers should promote safer sexual practices and integrate HPV education and counselling into routine male infertility services. Larger multicentre studies incorporating HPV genotyping, viral load assessment, and molecular markers of sperm function are recommended to further clarify the role of HPV in male infertility in Nigeria.

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