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Research Report

Increased proportion of "other hrHPV" genotypes other than 16 and 18/45 among women attending ART clinic in Northern Uganda☆

Frank Ssedyabane [a,*], Lugemwa Yvonne [a], Kamama Fahima [a], Komakech Simon [a], Ojosia Lawrence [a], Ebong James [a], Kadhumbula Silvester [b], Wasswa Hassan [b]

[a] Department of Medical Laboratory Science, Faculty of Medicine, Mbarara University of Science and Technology, P.O. Box 1410, Mbarara, Uganda
[b] Department of Pathology and Laboratory Medicine, Uganda Cancer Institute, P.O. Box 3935, Kampala, Uganda

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ABSTRACT

Introduction: Cervical cancer, caused by persistent infection with High-Risk Human Papillomavirus (hrHPV) disproportionately affects women living with HIV, moreover with low HPV vaccination coverage and inadequate screening. We conducted this study to determine the prevalence, genotype distribution, and associated factors for hrHPV among women living with HIV, receiving antiretroviral therapy at Gulu Regional Referral Hospital (GRRH).

Methods: From August to October of 2024, a cross-sectional descriptive analytical study was carried out at GRRH. We enrolled 346 women living with HIV through convenient sampling. Cervical swab specimens were collected and analyzed for hrHPV genotypes using the CEPHIED GeneXpert HPV assay Model type GX XVI 16 serial number 846215. STATA version 14 was used to analyze quantitative data, and associations were tested using logistic regression considering p values of <0.05 as statistically significant.

Findings: Overall, 29.5 % (95 % CI: 24–34 %) of participants had hrHPV. The most prevalent category of HPV genotype was "Other hrHPV" (31, 33, 35, 39, 51, 52, 56, 58, 59, 66, and 68) (75.2 %) while HPV 18/45 and HPV 16 had prevalence of 15.7 % and 9.1 % respectively. Being professionally employed was significantly associated with reduced odds of hrHPV infection (aOR = 0.293, $p = 0.037$). Although not statistically significant, individuals who were unemployed showed higher odds of hrHPV infection (aOR = 1.779, $p = 0.086$). Also longer ART duration (61 $\leq$ months) was associated with reduced odds of hrHPV infection (aOR = 0.512, $p = 0.074$). Infrequent alcohol consumption appeared associated with increased odds of hrHPV infection, particularly among non-drinkers (aOR = 5.193, $p = 0.059$) and rare drinkers (aOR = 5.321, $p = 0.058$).

Conclusion: Women on ART at Gulu RRH, Gulu district, had an elevated prevalence of hrHPV especially those HPV genotypes categorized as "Other hrHPV". Unemployment was associated with increased odds of hrHPV among the study participants. This calls for extended HPV genotyping during screening and customization of HPV vaccination to cover all HPV genotypes.

1. Introduction

Persistent hrHPV infections are a major factor in the development of cervical lesions and their progression to cervical cancer (Bosch et al., 2002). These viruses are categorized based on their virulence as either Low-Risk HPV (types 6, 11, 40, 42, 43, 44, 54, 61, 70, 72, and 81) or High-Risk HPV (types 16, 18, 31, 33, 35, 39, 45, 51, 52, 56, 58, 59, 66, and 68). Cervical cancer is the most common cancer among women living with HIV (Nang et al., 2023) implying an increased risk of HPV infection among women living with HIV (Dreyer, 2018; Nakisige et al.,

Abbreviations: HPV, Human Papilloma Virus; hrHPV, High- Risk Human Papilloma Virus; lrHPV, Low- Risk Human Papilloma Virus; ICC, Invasive Cervical Cancer; HIV, Human Immunodeficiency Virus; WHO, World Health Organization; STIs, Sexually Transmitted Infections; DNA, Deoxyribonucleic acid; ART, Antiretroviral therapy; LSIL, Low grade squamous intraepithelial lesion; HSIL, High grade squamous intraepithelial lesion; E6 and E7, are viral genes produced by High-Risk HPV strains; mRNA, messenger Ribonucleic Acid; GRRH, Gulu Regional Referral hospital; TLRL, Tenofovir-Lamivudine-Ritonavir-Lopinavir.

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* Corresponding author.
E-mail address: fssedyabane@must.ac.ug (F. Ssedyabane).

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2017; Nakisige et al., 2020; Temesgen et al., 2021).

There are over 570,000 new cervical cancer cases worldwide and corresponding 311,000 deaths (Zhao et al., 2021). The incidence and mortality rates due to cervical cancer are estimated to be 117,316 and 76,745 respectively (Sharma et al., 2022). The cervical cancer incidence in East Africa stands at 43/100,000 (Sankaranarayanan, 2014), and in Uganda, the age-standardized cervical cancer incidence is higher than the global average at 56.2/100,000 (WHO, 2018). Notably, a dot density map analysis for spatial distribution of cervical cancer cases in Gulu district in the northern region of Uganda reported about 6,000 cervical cancer cases per 100,000 women (Bingi et al., 2018).

Genital HPV infections are disproportionately distributed in many regions of the world, owing largely to many factors including socio-economic status (Sung et al., 2021). Significant ethno-geographic diversity has been found in Sub-Saharan African countries. Multiple hrHPV genotypes, such as HPV-16, 18, 35, and 52, are found in Africa and are responsible for the ongoing increase in cervical cancer rates (Mandiriri et al., 2020). In the Ugandan general population, the prevalence of hrHPV infection has been reported to range from 17 % (Asiimwe et al., 2008) to 39.1 % (Nakigozi et al., 2024). A systematic review and *meta*-analysis across sub-Saharan Africa reported the prevalence of hrHPV infection in the general population to be 55.1 % (Tchouaket et al., 2023).

With Uganda's HIV prevalence said to be approximately 6 % (MoH U, 2019) and mostly affecting women (Bray et al., 2018; Ouma et al., 2021), there is a high cervical cancer burden as evidenced by increasing rates of hrHPV genotypes in several Ugandan regions (Nakisige et al., 2017; Banura et al., 2011). Therefore, understanding the distribution and prevalence of HPV genotypes in women living with HIV is crucial for guiding targeted vaccination strategies, screening programs, and clinical management. This study aimed to investigate the genotype specific prevalence of HPV and associated factors among women living with HIV in Uganda.

2. Materials and methods

2.1. Study design

We conducted a cross-sectional study from August to October of 2024.

2.2. Study setting

The study was carried out at Gulu Regional Referral Hospital (GRRH) in Gulu, the largest city in the Northern Region of Uganda with roughly 27,000 HIV-positive individuals. The hospital is located approximately 332 km (206 miles) north of Kampala, Uganda's capital and largest city. The geographical coordinates of GRRH are 02.777778 latitude and 32.297778 longitude.

It provides essential specialized healthcare services to the community in its catchment area which includes the districts of Amuru, Gulu, Kitgum, Lamwo, and Pader. The hospital runs a functional antiretroviral therapy (ART) clinic which routinely open Monday through Friday. The services offered at the clinic include laboratory services as well as cervical cancer screening services.

2.3. Study population

We studied all HIV-positive women at the ART who met the eligibility criteria and gave their written informed consent to participate in the study.

2.4. Sampling procedure

A convenient sampling procedure was used to obtain study participants working alongside a physician who identified the women at the ART who met the criteria. This was a non-probability sampling method where we consecutively recruited participants as they attended the clinic. This continued until a final sample size was obtained.

2.5. Inclusion criteria

All women who attended the ART clinic at GRRH during the study period, aged 18 years and above and provided written informed consent were included in the study.

2.6. Exclusion criteria

We excluded all those women who reported to be undergoing their menstruation periods, those who were too ill to provide information as well as those who had undergone total hysterectomy.

2.7. Sample size estimation

We included a total of 346 participants. This was calculated using the Kish and Leslie (1965) formula using a 5 % margin of error, the prevalence of hrHPV among women living with HIV of 34.3 % (Nakigozi et al., 2024), and a z value of 1.96.

2.8. Demographic data collection

Demographic data were collected using a pretested questionnaire, and administered by a research assistant who was a qualified and experienced midwife stationed at the ART clinic. The data included variables such as age, residential region, religion, family planning practices and methods, educational attainment, marital status, history of blood pressure, history of diabetes, most recent Pap smear results, HIV viral load, duration on ART, occupation, tribe, age at sexual debut, knowledge on HPV among others. This data collection process followed the standard care procedures at the ART clinic and provision of written informed consent.

2.9. Collecting of cervical specimens

A well trained and experienced midwife collected the cervical specimens following standard operating procedures. The speculum was inserted into the vagina to expose the cervix and an endocervical brush was inserted, and rotated 360 degrees, after which it was withdrawn and inserted into a PreservCyt solution. This specimen was left to stand at room temperature until several specimens were transported to the laboratory and processed together as a batch.

2.10. HPV DNA testing

HPV DNA testing was performed using the GeneXpert HPV Assay, a qualitative in-vitro test for specific HPV genotypes. This test is based on the principle of real time polymerase chain reaction and detects the E6/E7 region of the viral DNA genome from 14 hrHPV types in a single analysis. The Cepheid GeneXpert instrument is a closed system, with automated sample processing, cell lysis, purification, nucleic acid amplification, and target sequence detection in clinical samples. This system uses real-time monitoring to ensure the specimen contains an adequate number of human cells for a qualitative assessment of HPV status. Probe Check Control (PCC) verifies reagent rehydration, PCR tube filling in the cartridge, probe integrity, and dye stability. Primers and probes for the detection of particular genotypes or pooled results are found in six color channels: "SAC primary" for sample adequacy control, "HPV 16 primary," "HPV 18/45 primary" for pooled results, "P3 primary" for pooled results of HPV types 31, 33, 35, 52, or 58, "P4 primary" for pooled results of HPV types 51 or 59, and "P5 primary" for pooled results of HPV types 39, 56, 66, or 68.

Table 1
The Socio-demographic characteristics of the study participants.

Variable	Category	Proportion n(%) N = 346
Age (years)		37.12 (10.21)
Age group (years)	18–20	4 (1.2 %)
	21–30	95 (27.5 %)
	31–40	143 (41.3 %)
	41–50	72 (20.8 %)
	51–60	20 (5.8 %)
	61-max	12 (3.5 %)
Religious affiliation	Born again	47 (13.6 %)
	Catholic	184 (53.2 %)
	Muslim	8 (2.3 %)
	Others	2 (0.6 %)
	Protestant	105 (30.3 %)
Ethnic tribe	Acholi	295 (85.3 %)
	Alur	3 (0.9 %)
	Dinka	2 (0.6 %)
	Langi	34 (9.8 %)
	Muganda	3 (0.9 %)
	Mugisu	1 (0.3 %)
	Munyankole	1 (0.3 %)
	Others	7 (2.0 %)
Highest level of education	None	3 (0.9 %)
	Primary	146 (42.2 %)
	Secondary	129 (37.3 %)
	Certificate/Diploma	62 (17.9 %)
	Bachelors	6 (1.7 %)
Occupation	Peasant Farmer	192 (55.5 %)
	Professional	78 (22.5 %)
	Unemployed	76 (22.0 %)
Marital status	Divorced	45 (13.0 %)
	Married	210 (60.7 %)
	Single	67 (19.4 %)
	Widow	24 (6.9 %)
Current ART regimen	TLD	346 (100.0 %)
Ever tested for HPV	No	183 (52.9 %)
	Yes	163 (47.1 %)
History of cervical cancer	No	345 (99.7 %)
	Yes	1 (0.3 %)
History of other STIs	No	175 (50.6 %)
	Yes	171 (49.4 %)
Smoking	No	340 (98.3 %)
	Yes	6 (1.7 %)
Alcohol consumption	Daily	20 (5.8 %)
	Monthly	33 (9.5 %)
	Never	177 (51.2 %)
	Rarely	81 (23.4 %)
	Weekly	35 (10.1 %)
Ever received HPV vaccine	No	340 (98.3 %)
	Yes	6 (1.7 %)
Family history of cervical cancer	No	339 (98.0 %)
	Yes	7 (2.0 %)
Number of lifetime sexual partners	0 to 1	122 (35.3 %)
	2 to 3	205 (59.2 %)
	4 to 6	19 (5.5 %)

2.11. Results Interpretation

For a hrHPV positive result, the designated hrHPV DNA shows a Ct (Cycle Threshold) within the accepted range, the fluorescence endpoint is above the predetermined threshold, the SAC is not applicable. Since HPV target amplification may impede this control, SAC is ignored and PCC has to pass. All probe check outcomes must pass.

For a HPV 16 positive result, the specific HPV 16 DNA exhibits a Ct value within the permissible range and the fluorescence endpoint surpasses the threshold setting. And the SAC is not applicable. The SAC is disregarded due to the possibility of interference from HPV target amplification and the PCC has to pass. Every probe check result has to be satisfactory.

For a HPV 18/45 positive result, the Ct value of HPV 18/45 DNA has to be within the permissible range, and the fluorescence endpoint is higher than the threshold. The SAC is not applicable. Because of possible interference from HPV target amplification, the SAC is ignored and the PCC has to pass. All probe check results must be successful.

For a positive result for "Other hrHPV", the particular DNA of HPV 31, 33, 35, 39, 51, 52, 56, 58, 59, 66 or 68 exhibits a Ct value that falls within the acceptable range and a fluorescence endpoint that surpasses the specified threshold and the SAC is not applicable. Since HPV target amplification can occur without this control, the SAC is ignored. PCC has to pass and all probe check results must be within the acceptable criteria.

For a negative result, the Ct value of the targeted hrHPV DNA is outside the acceptable range, and the fluorescence endpoint is below the designated threshold. The SAC has to pass. When the SAC target is amplified using PCR, the fluorescent endpoint surpasses the threshold and the Ct value falls within the permissible range. The PCC also has to pass and every probe check results has to meet the necessary standards.

2.12. Data management and analysis

Following initial entry into Microsoft Excel (Microsoft Office Professional Plus 2013, version 15.0.4675.1003, Microsoft Inc, USA) we imported the data into STATA 17 software (StataCorp LLC, College Station, Texas, United States). We used descriptive statistical measurements to describe the population using frequencies, means ± standard deviations (SDs) or median values for continuous variables. We also used frequencies and proportions to describe categorical variables. We used chi-square or t-tests to evaluate the relationships between variables. We also employed logistic regression (bivariate and multivariate) to derive associations between different variables and HPV positivity. The findings were displayed in tables as frequencies and percentages. The prevalence was presented as a percentage with the respective confidence interval. Associations between variables were presented as odds ratios and 95 % confidence intervals and P-values of <0.05 were considered to be statistically significant.

Table 1 (*continued*)

Variable	Category	Proportion n(%) N = 346
Age at sexual debut (years)	10 to 15	55 (15.9 %)
	16 to 19	257 (74.3 %)
	20 to 25	34 (9.8 %)
Duration of ART (months)	0–12	56 (16.2 %)
	13–24	17 (4.9 %)
	25–36	14 (4.0 %)
	37–48	11 (3.2 %)
	49–60	16 (4.6 %)
	>=61	232 (67.1 %)

Age was presented as a continuous variable and reported as mean (standard deviation); ART- Antiretroviral Therapy; TLD- Tenofovir disoproxil fumarate, Lamivudine and Dolutegravir.

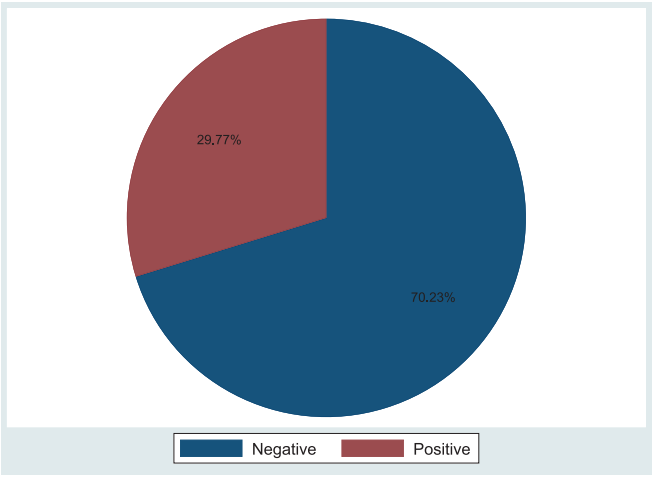


Fig. 1. A pie chart showing the prevalence of Human Papilloma Virus among HIV-positive women at the ART clinic of Gulu Regional Referral Hospital.

3. Results

3.1. Population characteristics

We recruited 346 participants with a mean age of 37.1 years and most were aged 31–40 years (41.3 %). Majority belonged to the catholic religious denomination (53.2 %), were Acholi (85.3 %) by tribe, and had attained primary (42.2 %) or secondary education (37.3 %). Over half of the study participants were peasant farmers (55.5 %), and 60.7 % were married. All the participants were on the TLD (Tenofovir disoproxil fumarate, Lamivudine and Dolutegravir) ART regimen while 67.1 % had been on ART for over 61 months. About 47.1 % reported to have ever been tested for HPV and 49.4 % reported a history of other STIs. HPV vaccination was reported in very few (1.7 %) participants. Most participants report to have had 2–3 lifetime sexual partners (59.2 %) while 74.3 % reported to have had their sexual debut between 16–19 years as detailed in Table 1.

3.2. Overall prevalence of HPV

Out of the 346 participant, 103 participants tested positive. This gave an overall HPV prevalence of 29.77 % as shown in Fig. 1.

3.3. Distribution of different HPV genotypes

Among all HPV test results, "other hrHPV" types was the most common category, accounting for 20.81 %. The category of HPV 18/45 was detected in 2.31 %, while HPV 16 was found in 1.73 % of study participants as shown in Fig. 2.

HPV16-single infection with HPV genotype 16; HPV18/45-mixed infection with HPV genotypes 18 and 45; HPV16 + HPV18/45-mixed infection with HPV genotypes 16, 18 and 45; Other hrHPV- infection with any hrHPV genotypes (HPV 31, HPV 33, HPV 35, HPV 39, HPV 51, HPV 52, HPV 56, HPV 58, HPV 59, HPV 66 and HPV 68); Other hrHPV + HPV16-mixed infection with Other HPV and HPV16; Other hrHPV + HPV18/45-mixed infection with Other hrHPV and HPV18/45.

3.4. Prevalence of HPV across different participant demographics

HPV prevalence did not significantly vary by age, education, religion, tribe, sexual behavior, or HPV vaccination status. However, occupation showed a significant distribution **($p = 0.016$)**, with unemployed individuals having a higher HPV positivity **(30/103, 39.5 %)**. Additionally, unmarried participants and those with a shorter duration on ART showed higher HPV prevalence, though not significantly differing. A slightly higher proportion of HPV-positive individuals reported a history of other STIs and early sexual debut, but these distributions did not significant differ as shown in Table 2.

3.5. Prevalence and distribution of HPV16

HPV 16 prevalence was 3.2 % (11/346), with a significant distribution observed only in age group. Most cases of HPV16 were observed among individuals aged 21–30 years as shown in Table 3.

3.6. Prevalence and distribution of HPV18/45

The HPV 18/45 prevalence was 5.2 % (18/346), with significant distributions observed across age groups (p = 0.004) and ART duration (p = 0.001). The highest positivity was seen in individuals aged 21–30 and those on ART for ≤12 months as shown in Table 4.

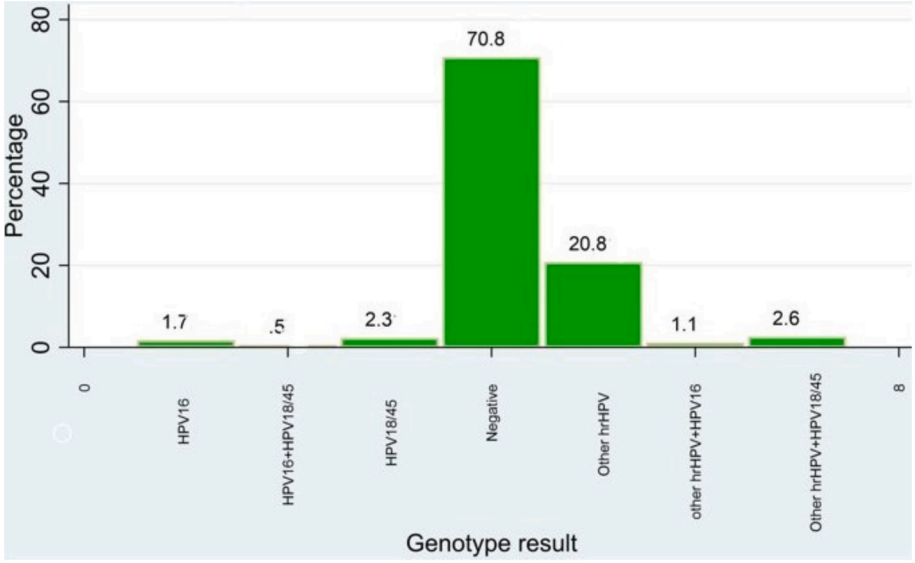


Fig. 2. A bar graph showing the distribution of Human Papilloma Virus among HIV-positive women at the ART clinic of Gulu Regional Referral Hospital.

Table 2
General distribution of HPV across participant demographics.

Variable	Category	HPV TEST RESULT		Test	p-value
		Negative N = 243	Positive N = 103		
Age (years)		37.27 (9.89)	36.79 (10.94)	Ind. *t* test	0.7
Age group	18–20	2 (0.8 %)	2 (1.9 %)	Fisher's exact	0.57
	21–30	64 (26.1 %)	31 (30.5 %)		
	31–40	101 (41.5 %)	42 (41.0 %)		
	41–50	55 (22.8 %)	17 (16.2 %)		
	51–60	14 (5.8 %)	6 (5.7 %)		
	61-max	7 (2.9 %)	5 (4.8 %)		
Religious affiliation	Born again	34 (14.1 %)	13 (12.6 %)	Fisher's exact	0.93
	Catholic	126 (52.3 %)	58 (56.3 %)		
	Muslim	8 (2.5 %)	0 (0.0 %)		
	Others	1 (0.4 %)	1 (1.0 %)		
	Protestant	74 (30.7 %)	31 (30.1 %)		
Ethnic tribe	Acholi	208 (86.3 %)	87 (82.9 %)	Fisher's exact	0.28
	Alur	3 (1.2 %)	0 (0.0 %)		
	Dinka	1 (0.4 %)	1 (1.0 %)		
	Langi	22 (9.1 %)	12 (11.4 %)		
	Muganda	3 (1.2 %)	0 (0.0 %)		
	Mugisu	0 (0.0 %)	1 (1.0 %)		
	Munyankole	0 (0.0 %)	1 (1.0 %)		
	Others	6 (1.7 %)	1 (2.9 %)		
Highest level of education	None	2 (0.8 %)	1 (1.0 %)	Fisher's exact	0.97
	Primary	102 (42.3 %)	44 (41.9 %)		
	Secondary	88 (36.5 %)	41 (39.0 %)		
	Certificate/ Diploma	47 (18.7 %)	15 (16.2 %)		
	Bachelors	4 (1.7 %)	2 (1.9 %)		
Occupation	Farmer	135 (56.0 %)	57 (54.3 %)	Fisher's exact	0.016
	Professional	62 (25.7 %)	16 (15.2 %)		
	Unemployed	46 (18.3 %)	30 (30.5 %)		
Marital status	Divorced	35 (13.7 %)	10 (11.5 %)	Fisher's exact	0.053
	Married	152 (63.1 %)	58 (55.2 %)		
	Single	38 (15.8 %)	29 (27.6 %)		
	Widow	18 (7.5 %)	6 (5.7 %)		
Current ART regimen	TLD	243 (100.0 %)	102 (100.0 %)		
Ever tested for HPV	No	130 (53.9 %)	53 (50.5 %)	Chi-square	0.55
	Yes	113 (46.1 %)	50 (49.5 %)		
History of genital warts or cervical cancer	No	243 (100.0 %)	102 (99.0 %)	Fisher's exact	0.3
	Yes	0 (0.0 %)	1 (1.0 %)		
History of other STI	No	129 (52.7 %)	46 (45.7 %)	Chi-square	0.23
	Yes	114 (47.3 %)	57 (54.3 %)		
Smoking	No	239 (98.3 %)	101 (98.1 %)	Fisher's exact	1
	Yes	4 (1.7 %)	2 (1.9 %)		
Alcohol consumption	Daily	18 (7.5 %)	2 (1.9 %)	Fisher's exact	0.24
	Monthly	25 (10.4 %)	8 (7.6 %)		
	Never	120 (49.0 %)	57 (56.2 %)		
	Rarely	55 (22.8 %)	26 (24.8 %)		
	Weekly	25 (10.4 %)	10 (9.5 %)		
HPV vaccination	No	238 (97.9 %)	102 (99.0 %)	Fisher's exact	0.67
	Yes	5 (2.1 %)	1 (1.0 %)		
Family history of cervical cancer	No	237 (98.3 %)	102 (97.1 %)	Fisher's exact	0.44
	Yes	6 (1.7 %)	1 (2.9 %)		
Number of lifetime sexual partners	0 to 1	92 (37.3 %)	30 (30.5 %)	Chi-square	0.16
	2 to 3	141 (58.5 %)	64 (61.0 %)		
	4 to 6	10 (4.1 %)	9 (8.6 %)		
Age at sexual debut (years)	10 to 15	34 (14.1 %)	21 (20.0 %)	Chi-square	0.37
	16 to 19	182 (75.5 %)	75 (71.4 %)		
	20 to 25	27 (10.4 %)	7 (8.6 %)		
Duration of ART (months)	0–12	32 (13.3 %)	24 (22.9 %)	Fisher's exact	0.096

(*continued on next page*)

Table 2 (*continued*)

Variable	Category	HPV TEST RESULT		Test	p-value
		Negative N = 243	Positive N = 103		
	13–24	13 (5.4 %)	4 (3.8 %)		
	25–36	7 (2.9 %)	7 (6.7 %)		
	37–48	7 (2.9 %)	4 (3.8 %)		
	49–60	13 (5.4 %)	3 (2.9 %)		
	>= 61	171 (70.1 %)	61 (60.0 %)		

Age was presented as a continuous variable and reported as mean (standard deviation); ART- Antiretroviral Therapy; TLD- Tenofovir disoproxil fumarate, Lamivudine and Dolutegravir.

3.7. Prevalence and distribution of "other hrHPV"

The prevalence of "other hrHPV" was 26.6 % (92/346), with the highest proportion observed in the 31–40 age group (44.6 %). No statistically significant distributions were observed except for marital status (p = 0.014), where a higher proportion of married women tested positive as shown in Table 5.

3.8. Factors associated with HPV

In multivariate analysis, being professionally employed was significantly associated with reduced odds of hrHPV infection (aOR = 0.293, 95 % CI: 0.092–0.931, $p = 0.037$). Although not statistically significant, individuals who were unemployed showed higher odds of hrHPV infection (aOR = 1.779, $p = 0.086$). Also longer ART duration (61 ≤ months) was associated with reduced odds (aOR = 0.512, $p = 0.074$) of hrHPV infection.

Infrequent alcohol consumption appeared associated with increased odds of hrHPV infection, particularly among non-drinkers (aOR = 5.193, $p = 0.059$) and rare drinkers (aOR = 5.321, $p = 0.058$), though these associations were borderline. Other variables, including age at sexual debut, number of sexual partners, HPV vaccination, STI history, and marital status, were not significantly associated with hrHPV infection as shown in Table 6.

4. Discussion

In this study, we aimed to determine the prevalence of hrHPV genotypes and associated factors among women living with HIV at an ART clinic in Northern Uganda. We observed an overall prevalence of hrHPV to be 29.5 %. This prevalence was comparably high as seen in a similar study carried out in another HIV population by Nakigozi et al (Nakigozi et al., 2024) where the prevalence was 34.3 %. However, another study in another population in Mukono district, central Uganda, among women aged 25–49 years and receiving ART, the prevalence was as high as 39.8 % (Nantale et al., 2023). There was also a lower prevalence of hrHPV (16.67 %) among women of reproductive age at a rural teaching hospital in Western Uganda (Nang et al., 2023). It is important to note that this study was conducted among HIV positive population, and that HIV itself is a risk factor for HPV infection and its persistence (Bowden et al., 2023). This difference could be attributed to differences to the number life time sexual partners as reported in our study. A good fraction of our study population reported to have had 2–3 life time sexual partners which increases their chances of acquisition of hrHPV infection.

We observed increased proportions of HPV16 and HPV 18/45 among individuals below 30 years, those who had not received HPV vaccine and those who reported 2 to 3 lifetime sexual partners. The same observation was made among those who were married, those who had

Table 3
Distribution of HPV16 across participant demographics.

Variable	Category	HPV16		Test	p-value
		Negative N = 335	Positive N = 11		
Age(yrs)		37.2 (10.1)	35.6 (14.4)	Ind. *t* test	0.6
Age group	18–20	4 (1.2 %)	0 (0.0 %)	Fisher's exact	0.01
	21–30	88 (26.3 %)	7 (63.6 %)		
	31–40	143 (42.7 %)	0 (0.0 %)		
	41–50	69 (20.6 %)	3 (27.3 %)		
	51–60	20 (6.0 %)	0 (0.0 %)		
	61-max	11 (3.3 %)	1 (9.1 %)		
Religious affiliation	Born again	46 (13.7 %)	1 (9.1 %)	Fisher's exact	0.47
	Catholic	178 (53.1 %)	6 (54.5 %)		
	Muslim	7 (2.1 %)	1 (9.1 %)		
	Others	2 (0.6 %)	0 (0.0 %)		
	Protestant	102 (30.4 %)	3 (27.3 %)		
Ethnic tribe	Acholi	285 (85.1 %)	10 (90.9 %)	Fisher's exact	1
	Alur	3 (0.9 %)	0 (0.0 %)		
	Dinka	2 (0.6 %)	0 (0.0 %)		
	Langi	33 (9.9 %)	1 (9.1 %)		
	Muganda	3 (0.9 %)	0 (0.0 %)		
	Mugisu	1 (0.3 %)	0 (0.0 %)		
	Munyankole	1 (0.3 %)	0 (0.0 %)		
	Others	7 (2.1 %)	0 (0.0 %)		
Highest level of education	None	3 (0.9 %)	0 (0.0 %)	Fisher's exact	0.64
	Primary	143 (42.7 %)	3 (27.3 %)		
	Secondary	123 (36.7 %)	6 (54.5 %)		
	Certificate/ Diploma	60 (17.9 %)	2 (18.2 %)		
	Bachelors	6 (1.8 %)	0 (0.0 %)		
Occupation	Farmer	188 (56.1 %)	4 (36.4 %)	Fisher's exact	0.33
	Professional	75 (22.4 %)	3 (27.3 %)		
	Unemployed	72 (21.5 %)	4 (36.4 %)		
Marital status	Divorced	41 (12.2 %)	3 (27.3 %)	Fisher's exact	0.064
	Married	207 (61.8 %)	3 (27.3 %)		
	Single	64 (19.1 %)	3 (27.3 %)		
	Widow	23 (6.9 %)	2 (18.2 %)		

(*continued on next page*)

Table 3 (*continued*)

Variable	Category	HPV16		Test	p-value
		Negative N = 335	Positive N = 11		
Current ART regimen	TLD	335 (100.0 %)	11 (100.0 %)		
Ever tested for HPV	No	175 (52.2 %)	8 (72.7 %)	Chi-square	0.18
	Yes	160 (47.8 %)	3 (27.3 %)		
History of genital warts or cervical cancer	No	334 (99.7 %)	11 (100.0 %)	Fisher's exact	1
	Yes	1 (0.3 %)	0 (0.0 %)		
History of other STI	No	170 (50.7 %)	5 (45.5 %)	Chi-square	0.73
	Yes	165 (49.3 %)	6 (54.5 %)		
Smoking	No	329 (98.2 %)	11 (100.0 %)	Fisher's exact	1
	Yes	6 (1.8 %)	0 (0.0 %)		
Alcohol consumption	Daily	20 (6.0 %)	0 (0.0 %)	Fisher's exact	0.17
	Monthly	31 (9.3 %)	2 (18.2 %)		
	Never	169 (50.4 %)	8 (72.7 %)		
	Rarely	81 (24.2 %)	0 (0.0 %)		
	Weekly	34 (10.1 %)	1 (9.1 %)		
HPV vaccination	No	329 (98.2 %)	11 (100.0 %)	Fisher's exact	1
	Yes	6 (1.8 %)	0 (0.0 %)		
Family history of cervical cancer	No	328 (97.9 %)	11 (100.0 %)	Fisher's exact	1
	Yes	7 (2.1 %)	0 (0.0 %)		
Number of lifetime sexual partners	0 to 1	120 (35.8 %)	2 (18.2 %)	Chi-square	0.46
	2 to 3	197 (58.8 %)	8 (72.7 %)		
	4 to 6	18 (5.4 %)	1 (9.1 %)		
Age at sexual debut (years)	10 to 15	54 (16.1 %)	1 (9.1 %)	Chi-square	0.39
	16 to 19	247 (73.7 %)	10 (90.9 %)		
	20 to 25	34 (10.1 %)	0 (0.0 %)		
Duration of ART (months)	0–12	52 (15.5 %)	4 (36.4 %)	Fisher's exact	0.44
	13–24	16 (4.8 %)	1 (9.1 %)		
	25–36	14 (4.2 %)	0 (0.0 %)		
	37–48	11 (3.3 %)	0 (0.0 %)		
	49–60	16 (4.8 %)	0 (0.0 %)		
	>= 61	226 (67.5 %)	6 (54.5 %)		

Age was presented as a continuous variable and reported as mean (standard deviation); ART- Antiretroviral Therapy; TLD- Tenofovir disoproxil fumarate, Lamivudine and Dolutegravir.

attained a maximum of secondary education as well as who had spent 0–12 months and 61 $\leq$ months on ART. There have been other observations in disagreement with ours concerning proportions of HPV16 and HPV 18/45. For instance, Liang et al (Liang et al., 2024) reported a population based prevalence of hrHPV of 9.8 % in the age group of 30–34 years and a prevalence of 3.6 % among those aged 60 years and above. However, there have also been previous studies that reported increased proportions of HPV16 and HPV 18/45 in individuals above 30 years of age (Klug et al., 2007; Luyten et al., 2009; Cuzick et al., 1999; Dareng et al., 2019; Torres-Poveda et al., 2019).

Generally, we present results of an increased proportion of "other hrHPV" genotypes among the study population. This reflects the fact that none of these genotypes are covered under the current HPV vaccination programs with the available vaccines. Also, the fact that the study population was generally young and moreover HIV positive, several HPV genotypes have a high likelihood to persist. In addition, the GeneXpert assay, as used in this study, groups eleven (Bingi et al., 2018) hrHPV genotypes under the 'other hrHPV' category, which potentially inflates their relative contribution.

We also report an increased prevalence of "other hrHPV" genotypes among participants aged 31–40 years, those who reported early sexual debut and those with history of other STIs. Studies from several European countries equally reported increased prevalence of hrHPV genotypes in this category (Luyten et al., 2009; Kjær et al., 2008; Coupé et al., 2008; Forslund et al., 2002). However, there are studies in Africa that have shown increased prevalence of HPV in women that are as young as 20 years and below (Cosmas et al., 2022). Earlier global estimates also indicated that the HPV infection prevalence was highest among women below 25 years of age (Smith et al., 2008) which reflects the average age of sexual debut (Weaver et al., 2011; Wellings et al., 2006). Studies in South Africa and Tanzania have reported much higher prevalence estimates among girls aged 16 to 22 years (66.7 % and 32.5 % respectively) (Mbulawa et al., 2018; Baisley et al., 2020). Several other studies have reported lower HPV prevalence estimates among virgin girls in Tanzania (Houlihan et al., 2016), young girls in India with varying socio-sexual lifestyles (Sharma et al., 2015) as well as young women in Burkina Faso (Traore et al., 2016). These differences may be attributed to differences in the prevalence of HIV and sexual behavior of the participants which increases their exposure to HPV (Peltzer and Pengpid, 2016).

We take note of the fact that almost all participants in this study were unvaccinated against hrHPV. Moreover, current vaccination efforts target young girls of 10 years and below (WHO, 2013). Also, early sexual debut has already been fronted as a factor that increases chances of acquiring the HPV infection (Weaver et al., 2011; Peltzer and Pengpid, 2016). A good number of participants in this study were observed to have a history of other sexually transmitted diseases, which could be responsible for increased prevalence of hrHPV. Some of these, including chlamydia have been shown to increase ones chances of HPV infection (Ssedyabane et al., 2019).

The observation of an increased prevalence of hrHPV among young

Table 4
Distribution of HPV18/45 across participant demographics.

Variable	Category	HPV18/45		Test	p-value
		Negative N = 328	Positive N = 18		
Age(years)		37.17 (9.83)	36.39 (15.93)	Ind. *t* test	0.75
Age group	18–20	2 (0.6 %)	2 (11.1 %)	Fisher's exact	0.004
	21–30	89 (27.1 %)	6 (33.3 %)		
	31–40	138 (42.1 %)	5 (27.8 %)		
	41–50	71 (21.6 %)	1 (0.6%)		
	51–60	18 (5.5 %)	2 (11.1 %)		
	61-max	10 (3.0 %)	2 (11.1 %)		
Religious affiliation	Born again	45 (13.7 %)	2 (11.1 %)	Fisher's exact	0.19
	Catholic	178 (54.3 %)	6 (33.3 %)		
	Muslim	7 (2.1 %)	1 (5.6 %)		
	Others	2 (0.6 %)	0 (0.0 %)		
	Protestant	96 (29.3 %)	9 (50.0 %)		
Ethnic tribe	Acholi	281 (85.7 %)	14 (77.8 %)	Fisher's exact	0.52
	Alur	3 (0.9 %)	0 (0.0 %)		
	Dinka	2 (0.6 %)	0 (0.0 %)		
	Langi	31 (9.5 %)	3 (16.7 %)		
	Muganda	3 (0.9 %)	0 (0.0 %)		
	Mugisu	1 (0.3 %)	0 (0.0 %)		
	Munyankole	1 (0.3 %)	0 (0.0 %)		
	Others	6 (1.8 %)	1 (5.6 %)		
Highest level of education	None	3 (0.9 %)	0 (0.0 %)	Fisher's exact	0.6
	Primary	139 (42.4 %)	7 (38.9 %)		
	Secondary	122 (37.2 %)	7 (38.9 %)		
	Certificate/ Diploma	59 (18.0 %)	3 (16.7 %)		
	Bachelors	5 (1.5 %)	1 (5.6 %)		
Occupation	Farmer	182 (55.5 %)	10 (55.6 %)	Fisher's exact	0.73
	Professional	75 (22.9 %)	3 (16.7 %)		
	Unemployed	71 (21.6 %)	5 (27.8 %)		
Marital status	Divorced	41 (12.5 %)	3 (16.7 %)	Fisher's exact	0.55
	Married	200 (61.0 %)	10 (55.6 %)		
	Single	62 (18.9 %)	5 (27.8 %)		
	Widow	25 (7.6 %)	0 (0.0 %)		
Current ART regimen	TLD	328 (100.0 %)	18 (100.0 %)		
Ever tested for HPV	No	171 (52.1 %)	12 (66.7 %)	Chi-square	0.23
	Yes	157 (47.9 %)	6 (33.3 %)		
Family history of cervical cancer	No	327 (99.7 %)	18 (100.0 %)	Fisher's exact	1
	Yes	1 (0.3 %)	0 (0.0 %)		
History of other STI	No	164 (50.0 %)	11 (61.1 %)	Chi-square	0.36
	Yes	164 (50.0 %)	7 (38.9 %)		
Smoking	No	322 (98.2 %)	18 (100.0 %)	Fisher's exact	1
	Yes	6 (1.8 %)	0 (0.0 %)		
Alcohol consumption	Daily	20 (6.1 %)	0 (0.0 %)	Fisher's exact	0.77
	Monthly	31 (9.5 %)	2 (11.1 %)		
	Never	165 (50.3 %)	12 (66.7 %)		
	Rarely	78 (23.8 %)	3 (16.7 %)		
	Weekly	34 (10.4 %)	1 (5.6 %)		
HPV vaccination	No	322 (98.2 %)	18 (100.0 %)	Fisher's exact	1
	Yes	6 (1.8 %)	0 (0.0 %)		
Family history of cervical cancer	No	321 (97.9 %)	18 (100.0 %)	Fisher's exact	1
	Yes	7 (2.1 %)	0 (0.0 %)		
Number of lifetime sexual partners	0 to 1	116 (35.4 %)	6 (33.3 %)	Fisher's exact	0.98
	2 to 3	194 (59.1 %)	11 (61.1 %)		
	4 to 6	18 (5.5 %)	1 (5.6 %)		
Age at sexual debut (years)	10 to 15	49 (14.9 %)	6 (33.3 %)	Fisher's exact	0.1
	16 to 19	247 (75.3 %)	10 (55.6 %)		
	20 to 25	32 (9.8 %)	2 (11.1 %)		
Duration of ART (months)	0–12	47 (14.3 %)	9 (50.0 %)	Fisher's exact	0.001
	13–24	17 (5.2 %)	0 (0.0 %)		
	25–36	13 (4.0 %)	1 (5.6 %)		
	37–48	9 (2.7 %)	2 (11.1 %)		
	49–60	16 (4.9 %)	0 (0.0 %)		
	>= 61	226 (68.9 %)	6 (33.3 %)		

Age was presented as a continuous variable and reported as mean (standard deviation); ART- Antiretroviral Therapy; TLD- Tenofovir disoproxil fumarate, Lamivudine and Dolutegravir.

Table 5
Distribution of "other hrHPV" across participant demographics.

Variable	Category	Other hrHPV		Test	p-value
		Negative N = 254	Positive N = 92		
Age(years)		37.41 (10.13)	36.33 (10.43)	Ind. *t* test	0.38
Age group	18–20	2 (0.8 %)	2 (2.2 %)	Fisher's exact	0.47
	21–30	68 (26.8 %)	27 (29.3 %)		
	31–40	102 (40.2 %)	41 (44.6 %)		
	41–50	58 (22.8 %)	14 (15.2 %)		
	51–60	16 (6.3 %)	4 (4.3 %)		
	61-max	8 (3.1 %)	4 (4.3 %)		
Religious affiliation	Born again	34 (13.4 %)	13 (14.1 %)	Fisher's exact	0.4
	Catholic	133 (52.4 %)	51 (55.4 %)		
	Muslim	8 (3.1 %)	0 (0.0 %)		
	Others	1 (0.4 %)	1 (1.1 %)		
	Protestant	78 (30.7 %)	27 (29.3 %)		
Ethnic tribe	Acholi	219 (86.2 %)	76 (82.6 %)	Fisher's exact	0.27
	Alur	3 (1.2 %)	0 (0.0 %)		
	Dinka	1 (0.4 %)	1 (1.1 %)		
	Langi	23 (9.1 %)	11 (12.0 %)		
	Muganda	3 (1.2 %)	0 (0.0 %)		
	Mugisu	0 (0.0 %)	1 (1.1 %)		
	Munyankole	0 (0.0 %)	1 (1.1 %)		
	Others	5 (2.0 %)	2 (2.2 %)		
Highest level of education	None	2 (0.8 %)	1 (1.1 %)	Fisher's exact	0.98
	Primary	108 (42.5 %)	38 (41.3 %)		
	Secondary	94 (37.0 %)	35 (38.0 %)		
	Certificate/ Diploma	46 (18.1 %)	16 (17.4 %)		
	Bachelors	4 (1.6 %)	2 (2.2 %)		
Occupation	Farmer	142 (55.9 %)	50 (54.3 %)	Fisher's exact	0.095
	Professional	63 (24.8 %)	15 (16.3 %)		
	Unemployed	50 (19.3 %)	27 (29.3 %)		
Marital status	Divorced	37 (14.6 %)	8 (8.8 %)	Fisher's exact	0.014
	Married	158 (62.2 %)	52 (56.5 %)		
	Single	40 (15.7 %)	27 (29.3 %)		
	Widow	19 (7.5 %)	5 (5.4 %)		
Current ART regimen	TLD	254 (100.0 %)	92 (100.0 %)		
Ever tested for HPV	No	139 (54.7 %)	44 (47.8 %)	Chi-square	0.26
	Yes	115 (45.3 %)	48 (52.2 %)		
History of genital warts or cervical cancer	No	254 (100.0 %)	91 (98.9 %)	Fisher's exact	0.27
	Yes	0 (0.0 %)	1 (1.1 %)		
History of other STI	No	134 (52.8 %)	41 (44.6 %)	Chi-square	0.18
	Yes	120 (47.2 %)	51 (55.4 %)		
Smoking	No	250 (98.4 %)	90 (97.8 %)	Fisher's exact	0.66
	Yes	4 (1.6 %)	2 (2.2 %)		
Alcohol consumption	Daily	18 (7.1 %)	2 (2.2 %)	Fisher's exact	0.16
	Monthly	28 (11.0 %)	5 (5.4 %)		
	Never	127 (50.0 %)	50 (54.3 %)		
	Rarely	55 (21.7 %)	26 (28.3 %)		
	Weekly	26 (10.2 %)	9 (9.8 %)		
HPV vaccination	No	249 (98.0 %)	91 (98.9 %)	Fisher's exact	1
	Yes	5 (2.0 %)	1 (1.1 %)		
Family history of cervical cancer	No	250 (98.4 %)	89 (96.7 %)	Fisher's exact	0.39
	Yes	4 (1.6 %)	3 (3.3 %)		
Number of lifetime sexual partners	0 to 1	95 (37.4 %)	27 (29.3 %)	Chi-square	0.064
	2 to 3	149 (58.7 %)	56 (60.9 %)		
	4 to 6	10 (3.9 %)	9 (9.8 %)		
Age at sexual debut (years)	10 to 15	37 (14.6 %)	18 (19.6 %)	Chi-square	0.51
	16 to 19	191 (75.2 %)	66 (71.7 %)		
	20 to 25	26 (10.2 %)	8 (8.7 %)		
Duration of ART (months)	0–12	37 (14.6 %)	19 (20.7 %)	Fisher's exact	0.23
	13–24	14 (5.5 %)	3 (3.3 %)		

(*continued on next page*)

Table 5 (*continued*)

Variable	Category	Other hrHPV		Test	p-value
		Negative N = 254	Positive N = 92		
	25–36	7 (2.8 %)	7 (7.6 %)		
	37–48	9 (3.5 %)	2 (2.2 %)		
	49–60	13 (5.1 %)	3 (3.3 %)		
	>= 61	174 (68.5 %)	58 (63.0 %)		

Age was presented as a continuous variable and reported as mean (standard deviation); ART- Antiretroviral Therapy; TLD- Tenofovir disoproxil fumarate, Lamivudine and Dolutegravir.

participants unlike the old could be explained by higher rates of new sexual partnerships, greater biological susceptibility of the cervical epithelium in younger individuals and lack of prior immunity. It has been suggested earlier that early sexual debut exposes women to hrHPV (Bosch et al., 2002; Weaver et al., 2011; Peltzer and Pengpid, 2016; Winer et al., 2003; Durowade et al., 2017; Krüger-Kjær et al., 1998), moreover when their immune systems are immature hence increasing the chances of hrHPV infections and persistence (Baisley et al., 2020). Moreover, young people in Africa tend to engage in risky sexual behavior including multiple high risk sexual partners, and young age at sexual debut (Tchouaket et al., 2023; Delam et al., 2020).

The observation of a reduced prevalence as age advances is consistent with previous studies (Coupé et al., 2008; Bruni et al., 2010; De Vuyst et al., 2009; Jacobs et al., 2000). The possible explanation for this observation could be a likely reduction in the number of sexual partners

Table 6
Association between participant demographic factors and HPV infection.

Variable	Category	Bivariate			Multivariate		
		cOR	p-value	95 % CI	aOR	p-value	95 % CI
Age at sexual debut	10 to 15	1	1		1	1	
	16 to 19	0.67	0.19	0.36–1.22	0.78	0.49	0.39–1.59
	20 to 25	0.58	0.26	0.23–1.49	0.53	0.26	0.18–1.60
Number of lifetime sexual partners	0 to 1						
	2 to 3	1.27	0.34	0.78–2.11	1.42	0.24	0.79–2.55
	4 to 6	2.53	0.07	0.94–6.79	2.81	0.11	0.78–10.08
Age group	18–20	1	1		1	1	
	21–30	0.51	0.51	0.07–3.78	0.61	0.67	0.07–5.69
	31–40	0.43	0.41	0.06–3.15	0.74	0.79	0.08–6.84
	41–50	0.31	0.26	0.04–2.36	0.49	0.54	0.05–4.82
	51–60	0.43	0.45	0.05–3.79	0.77	0.83	0.07–9.04
	61-max	0.71	0.77	0.07–6.92	1.58	0.73	0.12–20.07
Duration on ART (months)	0–12	1	1		1	1	
	13–24	0.41	0.16	0.12–1.42	0.36	0.13	0.09–1.37
	25–36	1.33	0.63	0.41–4.31	1.33	0.67	0.35–5.03
	37–48	0.76	0.69	0.19–2.91	0.71	0.64	0.16–3.06
	49–60	0.31	0.09	0.0–81.21	0.41	0.24	0.09–1.78
	>= 61	0.49	0.02	0.27–0.91	0.51	0.07	0.25–1.07
Family history of cervical cancer	No	1	1		1	1	
	Yes	1.74	0.47	0.05–3.93	1.72	0.55	0.29–9.92
HPV vaccination status	No	1	1		1	1	
	Yes	0.45	0.47	0.05–3.93	0.88	0.92	0.09–9.08
Alcohol consumption frequency	Daily	1	1		1	1	
	Never	4.56	0.05	1.01–20.05	5.19	0.06	0.94–28.71
	Rarely	4.25	0.06	0.92–19.72	5.32	0.06	0.95–29.86
	Weekly	3.64	0.15	0.71–18-46	4.17	0.13	0.66–26.38
	Monthly	2.88	0.21	0.55–15.21	3.59	0.18	0.55–23.63
Smoking status	No	1	1		1	1	
	Yes	1.15	0.87	0.21–6.38	2.43	0.39	0.32–18.38
History of other STIs	No	1	1		1	1	
	Yes	1.32	0.23	0.84–2.09	1.22	0.48	0.71–2.12
Marital status	Divorced	1	1		1	1	
	Married	1.15	0.72	0.53–2.42	1.26	0.59	0.53–2.99
	Single	2.29	0.05	0.99–5.28	1.74	0.29	0.63–4.85
	Widow	1	1				
Occupation	Peasant Farmer	1	1		1	1	
	Professional	0.61	0.13	0.33–1.15	0.29	**0.04****	0.09–0.93
	Unemployed	1.76	0.04	1.01–3.06	1.78	0.09	0.92–3.44

** -Statistically significant; ART- Antiretroviral Therapy.

and general sexual activity (Haversath et al., 2017; Hansen et al., 2020) as age increases, which reduces chances of HPV infection regardless of their vaccination status.

Unlike a shorter duration on ART, this study revealed that a longer ART duration (>= 61), as well as having a professional employment decreased study participants' risk of hrHPV infection. Studies conducted in Botswana and Kenya concurred that longer ART duration was linked to a lower chance of HPV infection in HIV-positive women (Kelly et al., 2017; Ermel et al., 2021). During HIV infection, and prior to ART initiation, or even early stages on ART, there is persistent chronic inflammation, antiretroviral toxicity and general cellular dysregulation and active HIV viral replication (Deeks et al., 2013) which increases chances of HPV infections. ART initiation and continued use over a long time can indeed reduce the likelihood of HPV infection since it boosts immune function and may aid the body to more efficiently clear HPV infection (de Vries and Steenbergen, 2018; Rositch et al., 2013). In fact several authors have gone ahead to recommend ART for immune reconstitution and viral suppression (Liu et al., 2018). Moreover, HPV clearance, as one advances on ART, is favored by an improved immunological and virological status, which further underscores the importance of ART in fighting infections including HPV (Beachler et al., 2012).

There was also an observed increase in hrHPV infection risk among infrequent alcohol consumers and those who reported to be unemployed, though not statistically significant. This has been equally reported by previous studies (Bowden et al., 2023; Schabath et al., 2015). Alcohol consumption has long been reported in previous studies as risk factor of HPV infection, which precedes cervical cancer (Ho et al., 1998; Goodman et al., 2008). In other populations in other parts of the world, alcohol consumption has been demonstrated to be associated with having multiple HPV genotypes not only in men (Nielsen et al., 2013) but also young women (Ho et al., 1998; Burkett et al., 1992; Bairati et al., 1994). There have also been previous studies that demonstrated no associations between alcohol consumption and HPV infection (Sikström et al., 1995; Tolstrup et al., 2006). Alcohol could be increasing one's chances of HPV infection through other mechanisms. For instance, alcohol has been said to be a non-independent factor for HPV infection, since it is believed to be associated with risky sexual behavior in many populations (Olusanya et al., 2020).

Alcohol consumption is a very common practice among people of lower socioeconomic status and those who are unemployed (Crum et al., 1992; Thun et al., 1997). Alcohol is known to induce iron deficiency, hence blocking it's would be protective contribution towards cervical cancer (Sanjoaquin et al., 2005). Therefore, through several mechanisms, iron deficiency can cause DNA hypomethylation (Baraona et al., 2001), an increase in which has been demonstrated to facilitate HPV-related cervical carcinogenesis (Powers, 2005; Ferguson et al., 1998). In addition, alcohol can activate cytochrome P450 2E1 leading to production of reactive oxygen species (ROS) (Pöschl et al., 2004) which themselves are associated with carcinogenesis (De Marco, 2013).

Alcohol, no matter the consumption level, is further considered to have a modulator effect on the functioning of one's immune system, which often results in immune deficiencies, which eventually lead to increased susceptibility to infectious diseases (Dunne, 1989; Szabo, 1997; Cook, 1998; Diaz et al., 2002; Molina et al., 2010; Nelson and Kolls, 2002). Also, alcohol interferes with inflammatory and other specific immune responses to pathogens (Szabo, 1997).

Some of the limitations of this study include the fact that cross sectional design does not provide concrete evidence on statistical associations. We relied on logistic regression after controlling for other confounders to derive the associations provided in this study. Therefore, the associations presented here are not easily extrapolatable to the general population. We also did not explore statistical significance in differences between women positive for HPV 16/18/45 and those positive for other high-risk HPV genotypes. However, one of the strengths of this study is statistical power, which we considered while computing the sample size. We also employed standard collection, processing, analysis, and reporting methods for HPV DNA from cervical specimens.

5. Conclusion

Women on ART at Gulu RRH, Gulu district, had an elevated prevalence of hrHPV especially those HPV genotypes categorized as "Other hrHPV". Unemployment was significantly associated with increased odds of hrHPV among the study participants. Given the slowly growing number of vaccinated women and the fact that screening recommendations are changing towards hrHPV testing, it is important to note that a considerable fraction of existing HPV genotypes are not covered by the existing vaccines. This calls for extended HPV genotyping during screening and customization of HPV vaccination to cover all HPV genotypes. Prospective studies are recommended to further unpack the category of "other hrHPV" and describe individual HPV genotypes and their distribution.

CRediT authorship contribution statement

Frank Ssedyabane: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Lugemwa Yvonne:** Writing – review & editing, Visualization, Validation, Resources, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. **Kamama Fahima:** Writing – review & editing, Visualization, Validation, Resources, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. **Komakech Simon:** Writing – review & editing, Visualization, Validation, Resources, Methodology, Investigation, Funding acquisition, Conceptualization. **Ojosia Lawrence:** Writing – review & editing, Visualization, Validation, Resources, Project administration, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization. **Ebong James:** Writing – review & editing, Visualization, Validation, Resources, Project administration, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization. **Kadhumbula Silvester:** Writing – review & editing, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization. **Wasswa Hassan:** Writing – review & editing, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Informed Consent Statement

Prior to participation in the study, we obtained written informed consent from each and every participant. Additionally, we used research numbers rather than names on all specimens and documents. We dissociated all participant identifiable information during data analysis.

Institutional Review Board Statement

Mbarara University of Science and Technology provided clearance for this study, through the Faculty of Medicine Research Committee

(MUST/MLS/24-11U) and the department of Medical Laboratory Science. The Gulu Regional Referral Hospital also provided administrative clearance before commencement of the study. At the ART clinic, all women who were diagnosed with hrPHV were given the routine standard package of care, while adhering to national recommendations.

Consent for publication

Not applicable.

Support

The bigger portion of the study was funded by the research team. Gulu Regional Referral Hospital generously provided the infrastructure and some consumables for HPV DNA testing.

Data availability of data and materials

All data used to prepare this paper is available from the corresponding author upon reasonable request.

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