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Epidemiological distribution of HPV genotypes and associated risk factors among HIV Positive and Negative women in Western Kenya

Ivy Akinyi

ivyakinyi44@gmail.com

Odinga University of Science and Technology

Jack Ogony

Jomo Kenyatta University of Science and Technology

Shehu Shagari Awandu

Odinga University of Science and Technology

Juliet Aluoch

Jomo Kenyatta University of Science and Technology

Moses Ochieng

Kenya Medical Research Institute

Naomy Roselyn Ouma

Amrec LTD

Davy Vanden Broeck

AML SONIC HEALTHCARE

Nina Redzic

AML SONIC HEALTHCARE

Ana Rita Pereira

AML SONIC HEALTHCARE

Johannes Bogers

University of Antwerp

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Abstract

Background

Human Papillomavirus infection is documented as the leading cause of cervical cancer globally. In Kenya, the burden of cervical cancer remains high despite cervical cancer preventions strategies. This study explores the epidemiological distribution and risk factors associated with HPV infection among HIV positive and negative women attending Gobei Health Center, Western Kenya.

Methods

We conducted a study between June and August 2024. A total of 308 eligible women aged 17–67 years who sought medical attention at Gobei Health Center and gave written consent were enrolled in the study. Each participant filled a structured questionnaire with the help of a research assistant where their socio-demographic, past reproductive history and sexual behavior characteristics were reported. Participants chose either HPV self-sampling or nurse-assisted cervical specimen collection approach. Riatol assay was used to determine HPV genotypes from each participant.

Results

The overall prevalence of HPV infection among women attending Gobei Health Centre was 37.6%. The most prevalent HPV genotype were HPV 52, 16, 18, 35, 31. HPV 16 was the most common genotype among HIV positive women. Being divorced was associated with HPV infection (AOR = 4.02, CI: 1.20–13.5, P = 0.024) and (AOR = 0.15, CI: 0.04–0.53 P = 0.003) respectively. There was a varied distribution of HPV viral load among HIV positive women compared to HIV negative women.

Conclusion

HPV infection remains common among HIV positive and Negative women attending Gobei Health Centre. Strengthening Cervical cancer prevention program such as comprehensive HPV vaccination and safe sex education in rural settings is important.

1. Introduction

Human Papillomavirus (HPV) is the most common sexually transmitted virus worldwide(1). It is a double stranded DNA virus that is considered the major risk factor for cervical cancer(2). Cervical cancer has been documented as the fourth most common cancer among women with an estimated 604,000 new cases and 342,000 deaths reported globally (3). Among men and women, it is considered as the eighth most common cancer accounting for up to 6.9% of new cancer cases reported in 2020(4). Currently, Sub-Saharan African countries, report the highest burden of cervical cancer with up to 90% attributable

deaths occurring in the region. Low HPV vaccination uptake, limited access to early diagnosis and comprehensive treatment have been noted as the major barriers to successful management of the disease (5). The adoption of cervical cancer screening in Kenya remains optimally low with only 16.8% of women having been screened. The low uptake is attributed to a combination of factors including limited access to screening services, lack of knowledge and cultural barriers among others(6). Further, the full impact of HPV vaccination in Kenya is still unfolding as it takes time to observe reduction in cervical cancer incidence. Kenya implemented the Gardasil-4 vaccine beginning of 2019 by administering it to girls between ages 9 and 14 years(7). Despite disruption attributed to COVID-19 and infrastructural challenges, Kenya is in its 6th year since the roll-out of the vaccine. The program has however faced several challenges including cultural barriers, infrastructural limitations and inadequate funding among others(8)

Past studies have indicated that persistent infection with high-risk HPV contribute to 99% of all cervical cancer(9). The incidence of cervical cancer in Sub-Saharan Africa is primarily driven by the prevalence of high-risk HPV especially HPV-16 and HPV-18(10, 11). Upon exposure, 90% of the viruses often clear and are eliminated within 12–24 months especially among younger women. However, several factors have been found to influence HPV infection. They include age of the woman, age of the woman at sexual debut, number of children, history of cervical cancer in the family, education, number of sex partners, occupation, smoking, alcohol consumption, unprotected sex, non-circumcised sexual partners and human immunodeficiency virus (HIV) status among others (12–14). Fundamentally, studies have shown that HIV is a major risk factor for HPV infection (15). Women living with HIV/AIDS have been reported to be six times likely to get HPV infection compared to HIV negative women(15–17). This is majorly due to the immunosuppressive effects of HIV that impair the immune system's ability to clear HPV infection effectively (18). Specifically, HIV infection is associated with the depletion of HPV E6 and E7 onco-protein which are important in controlling HPV infection and malignancy.

In 2019, according to the Joint United Nations program on HIV/AIDS, the population of people living with HIV in sub-Saharan Africa and Northern Africa was estimated to be 12.9 million(19). In Kenya, as at May 2024, there are an estimated 1.4 million people living with HIV(20). Further, the distribution of HIV in Kenya has been ranked according to the counties. With persistently high HIV prevalence rates positioning Homa-Bay, Siaya, and Kisumu counties as the leading hubs. This study focuses on Gobei, a location within Siaya County, one of these aforementioned endemic areas (21). The aim is to determine the epidemiological distribution of HPV genotypes and its associated risk factors among HIV positive and negative women attending Gobei Health center, Western Kenya.

2. Materials and Methods

We conducted a facility based cross-sectional, descriptive and analytical study at Gobei Health center (level three facility) which is located in the rural settings of Bondo Sub-county, Siaya County, approximately 60 kilometers from Kisumu City, Kenya. We targeted all women of reproductive age who met the eligibility criteria and presented themselves to the facility between June and August 2024. The

HIV sero-status of each woman was confirmed using the hospital's data registry, where results from routine HIV testing for women receiving reproductive health services are recorded in the Ministry of Health's HIV Surveillance registry. All women who were HIV positive were confirmed to have already enrolled in the comprehensive care clinic for HIV which is available Gobei Health Center. Each woman had to consent to take part in the study. Subsequently, each participant was given standardized questionnaires in English or Luo (local language) to fill and those who needed assistance were helped by the research assistants. The structured questionnaires focused on their socio-demographic characteristics, past reproductive health history, sexual behaviors, and other risk factors associated with HPV infection (see supplementary information)

Inclusion Criteria

Women who presented themselves in the outpatient section of the facility or maternal-child health section, for any and every reason including reproductive health appointments were included in the study. The women must have had a sexual intercourse experience in their life to be included.

Exclusion

The study did not include pregnant women or women who were on menstruation as such samples have in the past been linked to unsatisfactory specimen and false negative results. Further, women who were mentally and physically unable to undergo a pelvic examination were excluded from the study.

Ethics statement

The study was approved by the Jaramogi Oginga Odinga Teaching and Referral Hospital Ethical committee (JOOTRH) (ISERC ISERC/JOOTRH/716/23). Participation in the study was voluntary and the participants signed an informed consent form.

Specimen Collection

There were two approaches of cervical sample collection. Women had the opportunity to choose either HPV self-sampling technique or healthcare provider assisted sampling technique. In the self-sampling procedure, the healthcare providers briefed the women on how to do self-sampling using a schematic diagram on the kit. The women were then shown a private room where they would remove the swab, insert it into the cervix and make few rotational brushing movements. The women would then place the swab back into the tube containing 1.6ml of transport medium (liquid amies medium) and handover the collected sample to the healthcare provider. On the other hand, women who opted for healthcare provider sampling collection were directed to the cervical cancer screening room. A sterile speculum was inserted into their vagina. The specimens were obtained using the multicollect kit(Abbot) where the collection swab was rotated twice in the endo and ecto-cervical region of the women. It would then be deposited into 1.2ml of the transport buffer that had guanidine thiocyanate that helps in DNA stabilization. All the samples were stored at 4°C for preservation prior to shipment to Antwerp Belgium for laboratory analysis

DNA Extraction and HPV genotyping

Cervical samples were processed at AML, Sonic Healthcare Benelux (Antwerp, Belgium), an ISO15189 accredited laboratory, for HPV-DNA extraction and genotyping using the RIATOL qPCR assay. This assay was selected for its established clinical accuracy, reproducibility, and ability to quantify viral load. Samples collected using the Abbott multi-Collect Specimen Collection Kit had 300 µL of each sample transferred to 96-well deep plates via a Janus G3 (Perkin Elmer) robot for batch processing. For the HPV self-sampling swabs, the UniVerse instrument from Copan was used. It automatically aliquots 500 µL of media to deep-well blocks. DNA extraction was performed automatically using the Chemagic 360 (Perkin Elmer) system and the viral DNA/RNA 360 H96 extraction kit. Extracted DNA was then stored at 4°C until PCR analysis.

In HPV genotyping, Beta-globin gene amplification served as an internal cellular control to validate PCR run integrity. Standard curves, generated from ten-fold dilutions of synthetic DNA, ensured qPCR efficiency within the acceptable 90–110% range, enabling relative quantification. Using a Janus Liquid handler robot (Perkin Elmer), 384-well PCR plates were prepared by combining 2 µL of extracted DNA or control with 4 µL of specific master mix. Each sample underwent testing with eight distinct master mixes, each containing primers and probes for HPV genotypes 6, 11, 16, 18, 31, 33, 35, 39, 45, 51, 52, 53, 56, 58, 59, 66, 67, 68, and beta-globin. RT-amplification was performed on a Light Cycler 480 (Roche) instrument with a 45-cycle, two-step protocol: 10 seconds at 95°C and 30 seconds at 60°C. Following amplification, data was automatically transferred to the Fast-Finder online AI platform (Velsera) for analysis, where clinical cut-off values were applied to determine sample positivity or negativity. Detailed assay design and validation information have been documented in Micallesi et al(22).

Data Analysis

Data curation and statistical analysis were conducted using R version 4.3.2. We used frequencies and percentages to summarize categorical variables. Prevalence of HPV was calculated as a proportion of study participants. Each independent variable was assessed for its association with HPV infection. We selected variables based on prior literature evidence of association with HPV and included factors such as age, sexual behavior, HIV status, marital status, family history of cervical cancer, contraceptive use, consumption of alcohol and whether the participants had sexually transmitted infection. Specifically, the factors associated with HPV were analyzed using logistic regression (bivariate and multivariate level). Variables that showed statistical significance at the bivariate level or those that had $p < 0.2$ were specifically transferred to the multivariate level. Statistical significance was considered at p-value ≤ 0.05.

3. Results

Description of Socio demographic and Reproductive health characteristics
The median age (years) of women attending Gobei Health center was 32(25–38). Majority of the women were between the age of 30–39 years (36%, 111/308). In this study, majority of the women were HIV positive (61%, 188/308). In addition, about three quarter of the women were married (71%, 22/308) and

had approximately 2–3 number of children (44%, 135/308). About half of the women had used contraceptives for the last 6 months (52%, 161/308) while the other half reported not using contraceptives (48%, 147/308). About one third of the women reported having multiple sex partners in the last one year (33%, 103/308) while the other women (67%, 205/308) reported not having multiple sex partners (See Table 1).

Table 1
Descriptive analysis of sociodemographic, reproductive health history and past sexual history of women attending Gobei Health center.

Variable	Overall	HPV		
	N = 308	No	Yes	p-value
		N = 192	N = 116	
Presence of HPV				
No	192 (62%)			
Yes	116 (38%)			
Self screening or nurse assisted screening				0.595
Nurse-assisted screening	160 (52%)	102 (53%)	58 (50%)	
Self-Screening	148 (48%)	90 (47%)	58 (50%)	
HIV sero status				0.963
Negative	120 (39%)	75 (39%)	45 (39%)	
Positive	188 (61%)	117 (61%)	71 (61%)	
Age				0.647
16–24	69 (22%)	40 (21%)	29 (25%)	
25–29	60 (19%)	39 (20%)	21 (18%)	
30–39	111 (36%)	73 (38%)	38 (33%)	
40+	68 (22%)	40 (21%)	28 (24%)	
Level of Education				0.462
Primary/None	160 (52%)	102 (53%)	58 (50%)	
High School	110 (36%)	64 (33%)	46 (40%)	
College/University	38 (12%)	26 (14%)	12 (10%)	
Marital Status				0.082
Single	51 (17%)	34 (18%)	17 (15%)	
Married	220 (71%)	141 (73%)	79 (68%)	
Divorced/separated	13 (4.2%)	4 (2.1%)	9 (7.8%)	
Widowed	24 (7.8%)	13 (6.8%)	11 (9.5%)	
Number of children				0.358

Variable	Overall	HPV		
	N = 308	No	Yes	p-value
		N = 192	N = 116	
0	14 (4.5%)	10 (5.2%)	4 (3.4%)	
1	69 (22%)	37 (19%)	32 (28%)	
2–3	135 (44%)	88 (46%)	47 (41%)	
4+	90 (29%)	57 (30%)	33 (28%)	
Source of Livelihood				0.415
Unemployed	107 (35%)	66 (34%)	41 (35%)	
Employed	42 (14%)	30 (16%)	12 (10%)	
Self-employed	159 (52%)	96 (50%)	63 (54%)	
Used contraceptives last 6 months				0.700
No	147 (48%)	90 (47%)	57 (49%)	
Yes	161 (52%)	102 (53%)	59 (51%)	
Multiple sex partners last year				0.424
No	205 (67%)	131 (68%)	74 (64%)	
Yes	103 (33%)	61 (32%)	42 (36%)	
Ever had STI				0.191
No	266 (86%)	162 (84%)	104 (90%)	
Yes	42 (14%)	30 (16%)	12 (10%)	
Family member ever had cervical cancer				0.250
No	294 (96%)	185 (97%)	109 (94%)	
Yes	13 (4.2%)	6 (3.1%)	7 (6.0%)	
Use alcohol				0.672
No	264 (86%)	163 (85%)	101 (87%)	
Yes	43 (14%)	28 (15%)	15 (13%)	

Prevalence and Distribution of HPV genotypes by HIV sero status of the women.

The prevalence of HPV infection was 37.6% (116/308). HPV infection was common among HIV positive compared to HIV negative women attending Gobei Health Center. Overall, the most common HPV

genotypes circulating among women in Gobei include HPV 52, 16, 18, 35, 31 in decreasing frequency. However, type specific analysis revealed that the most prevalent HPVs were distinct in both HIV positive and HIV negative women. Among HIV positives women, the circulating genotypes include HPV 16, 52, 18,31,35 while HIV negative women, the genotypes HPV 68,39,52, 18,33 in decreasing frequency. (Table 2). HPV infection pattern was also noted. Most women reported having Single HPV infection compared to multiple infection. Further, HIV positive women reported higher proportion of both single and multiple infection when compared to HIV negative women (Fig. 1).

Table 2
Distribution of HPV Genotypes by HIV.

Variable	**Overall**	**HIV Sero Status**	
	N = 113	**Negative N = 44**	**Positive N = 69**
HPV Genotype			
HPV 16	14 (12%)	2 (14%)	12 (86%)
HPV 18	13 (12%)	4 (31%)	9 (69%)
HPV 31	7 (6.2%)	1 (14%)	6 (86%)
HPV 33	6 (5.3%)	3 (50%)	3 (50%)
HPV 35	8 (7.1%)	2 (25%)	6 (75%)
HPV 39	6 (5.3%)	6 (100%)	0 (0%)
HPV 45	3 (2.7%)	1 (33%)	2 (67%)
HPV 51	6 (5.3%)	1 (17%)	5 (83%)
HPV 52	16 (14%)	5 (31%)	11 (69%)
HPV 53	1 (0.9%)	1 (100%)	0 (0%)
HPV 56	3 (2.7%)	2 (67%)	1 (33%)
HPV 58	6 (5.3%)	2 (33%)	4 (67%)
HPV 59	1 (0.9%)	0 (0%)	1 (100%)
HPV 6	1 (0.9%)	1 (100%)	0 (0%)
HPV 66	3 (2.7%)	3 (100%)	0 (0%)
HPV 67 L1	7 (6.2%)	2 (29%)	5 (71%)
HPV 68	12 (11%)	8 (67%)	4 (33%)

Factors associated with HPV infection

In bivariate analysis, the variables that showed an association with HPV infection ((P value ≤ 0.2) was marital status specifically being married or single (Table 3). On multivariate regression, the independent factor associated with HPV infection was still marital status; married and single (AOR = 0.24, CI: 0.07–0.83, P = 0.024) and (AOR = 0.21, CI: 0.05–0.83 P = 0.026) respectively (see Table 4).

Table 3
The Results of Bivariate analysis for sociodemographic, reproductive health history and past sexual history.

Variable	unadjusted OR[1]	95% CI[1]	p-value
HIV sero status			
Negative	Ref	—	
Positive	1.01	0.63, 1.62	0.96
Age	1.00	0.97, 1.02	0.86
Marital Status			
Divorced/separated	Ref	—	
Married	0.25	0.07, 0.83	**0.024**
Single	0.22	0.06, 0.83	**0.025**
Widowed	0.38	0.09, 1.56	0.18
Number of children	1.02	0.89, 1.16	0.78
Source of Livelihood			
Employed	Ref	—	
Self-employed	1.64	0.78, 3.44	0.19
Unemployed	1.55	0.72, 3.37	0.27
Used contraceptives last 6 months			
No	Ref	—	
Yes	0.91	0.58, 1.45	0.70
Multiple sex partners last year			
No	Ref	—	
Yes	1.22	0.75, 1.98	0.42
Ever had STI			
No	Ref	—	
Yes	0.62	0.31, 1.27	0.19
Family member ever had cervical cancer			
No	Ref	—	

[1]OR = Odds Ratio, CI = Confidence Interval

Variable	unadjusted OR[1]	95% CI[1]	p-value
HIV sero status			
Yes	1.99	0.65, 6.08	0.23
Use alcohol			
No	Ref	—	
Yes	0.86	0.44, 1.70	0.67

[1]OR = Odds Ratio, CI = Confidence Interval

Table 4
The results of Multivariable Logistic Regression of socio-demographics, reproductive health and past sexual history.

Variable	adjusted OR[1]	95% CI[1]	p-value
HIV sero status			
Negative	Ref	—	
Positive	0.81	0.46, 1.42	0.5
Marital Status			
Divorced/separated	Ref	—	
Married	0.24	0.07, 0.83	**0.024**
Single	0.21	0.05, 0.83	**0.026**
Widowed	0.36	0.09, 1.53	0.2
Source of Livelihood			
Employed	Ref	—	
Self-employed	1.69	0.75, 3.79	0.2
Unemployed	1.67	0.75, 3.70	0.2
Ever had STI			
No	Ref	—	
Yes	0.72	0.34, 1.50	0.4
Family member ever had cervical cancer			
No	Ref	—	
Yes	1.87	0.60, 5.86	0.3
[1]OR = Odds Ratio, CI = Confidence Interval.			

Distribution of HPV viral load by HIV status.

The distribution of HPV viral load differed markedly between HIV positive and HIV negative women. In HIV negative individuals, the viral load distribution was characterized by a relatively low variance. In contrast, HIV positive women exhibited a higher variance, with a subset showing substantially elevated viral loads (See Fig. 2)

4. Discussion

The aim of this study was to determine the epidemiological distribution of HPV genotypes and the associated risk factors among HIV positive and negative women attending Gobei Health center, western Kenya. In this study, the HPV prevalence was 37.6%. In the previous study that was conducted by Akinyi et al., in 2023(12), the prevalence of potential HR/HR HPV was 41.4% in the area which is slightly higher compared to the current findings. Nevertheless, the findings reveal the constant presence of HPV infection in the western Kenya population. The high prevalence of HPV infection is a reflection of the increasing burden of cervical cancer in Kenya and sub-Saharan Africa. Kenya is one of the nineteen countries in Sub-Saharan Africa that has a huge burden of cervical cancer. The high burden of the disease in such developing countries have been attributed to inefficient cervical cancer prevention programs(7).

In this study, HPV-52 is the most prevalent genotypes in the population. The high prevalence of HPV-52 in Sub-Saharan Africa and specifically Eastern Africa has been attributed to multifactorial factors including genetics, epidemiological and socio-economic factors, as well as health access and vaccination coverage (10, 23). The heterogeneous distribution of HPV genotypes across different regions majorly influenced by ethnographical variation has been outlined to account for the commonness of HPV 52(23). Again, the high rate of multiple HPV infection and non-vaccine HPV types which are majorly common in African population compared to other regions like Asia could account for the high presence of HPV-52 in this study. This thought is compounded by the high prevalence of HIV in areas such as Gobei (Western Kenya) that increases risk of HPV infection including HPV 52(24). Particularly, the immuno-suppression associated with HIV can often lead to a higher susceptibility to persistent infection hence contributing to the prevalence of a specific HPV type such as HPV 52(24).

This study also reported a high prevalence of HPV-16 among the HIV positive women. The findings are in tandem with those of a systematic review and meta-analysis that was carried out to examine the epidemiology of HPV genotypes among HIV positive women in Kenya(25). In this study, HPV 52 was determined to prevalent among HIV women with normal cytology while HPV-16 was determined to be most common among HIV positive women who had abnormal cytology and those who had invasive cervical cancer(26). HPV-16 is the genotypes of highest clinical significance because it accounts for up to 50% of all cervical cancer cases globally. The tendency of HPV-16 to be detected in HIV positive women has been postulated to emanate from its transmission factors, compromised immunity and its viral properties making it highly carcinogenic(27)

Further, the relationship status of a woman was a significant factor in acquisition of HPV infection in this study. Being divorced was a crucial factor for HPV infection. It is documented that HPV is predominantly transmitted through sexual contact and therefore the sexual behavior of an individual is essential(2). Divorced women have always been considered to have a higher chance of having risky sexual partners or multiple sex partners. In a study that was done in Tehran, Iran to explore HPV infection in women with and without cervical cancer, the results showed that HPV infection was highest among women who had divorced(28). This could be attributed to a combination of several factors including having a number of sexual partners. Further, marital separation tends to change one sexual activity increasing the risk of

contracting HPV. Stable marital status such as a monogamous marriage has often been indicated as a protective factor for HPV infection(29). A study that was done in Nigeria to determine the prevalence of HPV among women in three South geopolitical zones established that women who had unknown marital status had the highest prevalence of HPV(30). On the other hand, women who were married had the lowest HPV prevalence indicating that being married could be a protective factor against HPV infection(30). The findings reveal the need for safe sex education among the divorced women.

The distribution of the HPV viral load by the HIV status of the women was also quite interesting. Overall, HIV negative women exhibited a narrow range of HPV viral loads compared to HIV positive women who exhibited greater variability. The observed difference in HPV viral load variability between HIV positive and HIV negative could be primarily attributed to the impact of HIV on the immune system. Research shows that HIV compromises the immune system by depletion of the CD4 + T cells that are crucial for control of viral infections. The immunosuppression disrupts the ability of the body to effectively regulate HPV replication thereby significant fluctuation of HPV viral load in HIV positive women (15, 31). Moreover, HIV positive women are more likely to have persistent and multiple HPV infection and precancerous lesions leading to greater variability (32). Past studies have indicated that HIV positive women are at a greater risk of acquiring HPV infection and have lower rate of clearance hence higher viral load due to the compromised immune status (33). In a study that carried out among female sex workers in Mombasa Kenya, the median HPV viral load for high-risk HPV was five times more in HIV positive than HIV negative women (34). Finally, it is also postulated that while use of ART among HIV patients can improve their immune functions, the degree of immune reconstitution varies among individuals (35).

The major strength of the study is the use of extended HPV genotyping diagnostic kit that covers more than the 14 high risk-HPV. In essence, the HPV assay used was capable of detecting up to 18HPVs including the probably carcinogenic types. This was a facility based survey hence prone to selection bias. Primarily, such surveys only capture individuals who actually visit the facility and is likely to miss out on those who do not have access to the services due to barriers such as cost, distance or lack of awareness among others. Another limitation is the fact that this was a cross-sectional study and therefore it was not possible to study HPV pathogenesis from the time to infection to its clearance or progression to cervical cancer. Finally, this study did not obtain cervical smear for cytological purpose therefore it was not possible to correlate HPV infection and cytological abnormalities.

Clinical Implication

Given the common occurrence of HPV, reinforcing cervical cancer prevention in resource-constrained regions of Kenya, particularly rural areas, is critical. Although current efforts in these settings focus on education and screening with community health promoters, they are significantly hampered by infrastructural deficits, socio-cultural obstacles, and resource scarcity. This necessitates a national conversation to create and implement effective, context-specific prevention programs.

Consistent with findings from prior research, the alarmingly high prevalence of HPV-52 within the Kenyan population underscores the urgent necessity for the widespread introduction of the nona valent HPV vaccine. This vaccine, offering broader protection against high-risk HPV types, holds the potential to significantly reduce the burden of cervical cancer in Kenya and improve public health outcomes. The observed association between women who are divorced and HPV infection underscores the critical need for comprehensive safe sex education for this group of women. Finally, HIV remains a risk factor that promotes HPV persistence and infection. There is therefore increased need for regular cervical cancer screening with cytological follow up to ensure early detection of precancerous lesions among HIV positive women.

5. Conclusions

The prevalence of HPV among women in Gobei, western Kenya remains high. HPV-52 is most common HPV in the population. Being divorced is associated with prevalence of HPV infection. Cervical cancer prevention program such as introduction of the nona-valent HPV vaccination, routine cervical cancer screening and comprehensive safe sex education needs to be strengthened in rural settings of Kenya.

Declarations

Ethics declarations

Ethical permit and consent to participate

The study was reviewed and approved by research ethics committee of Jaramogi Oginga Odinga Teaching and Referral Hospital JOOTRH ISERC ISERC/JOOTRH/716/23. All participants were provided with written informed consent. The ethical standards for the regulation of research in humans in accordance with Declaration of Helsinki was followed.

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Availability of data and materials

The dataset supporting the conclusions of this article is not publicly available due to privacy and confidentiality requirements, but is available from the corresponding author upon reasonable request.

Consent for Publication

Not Applicable

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Figures

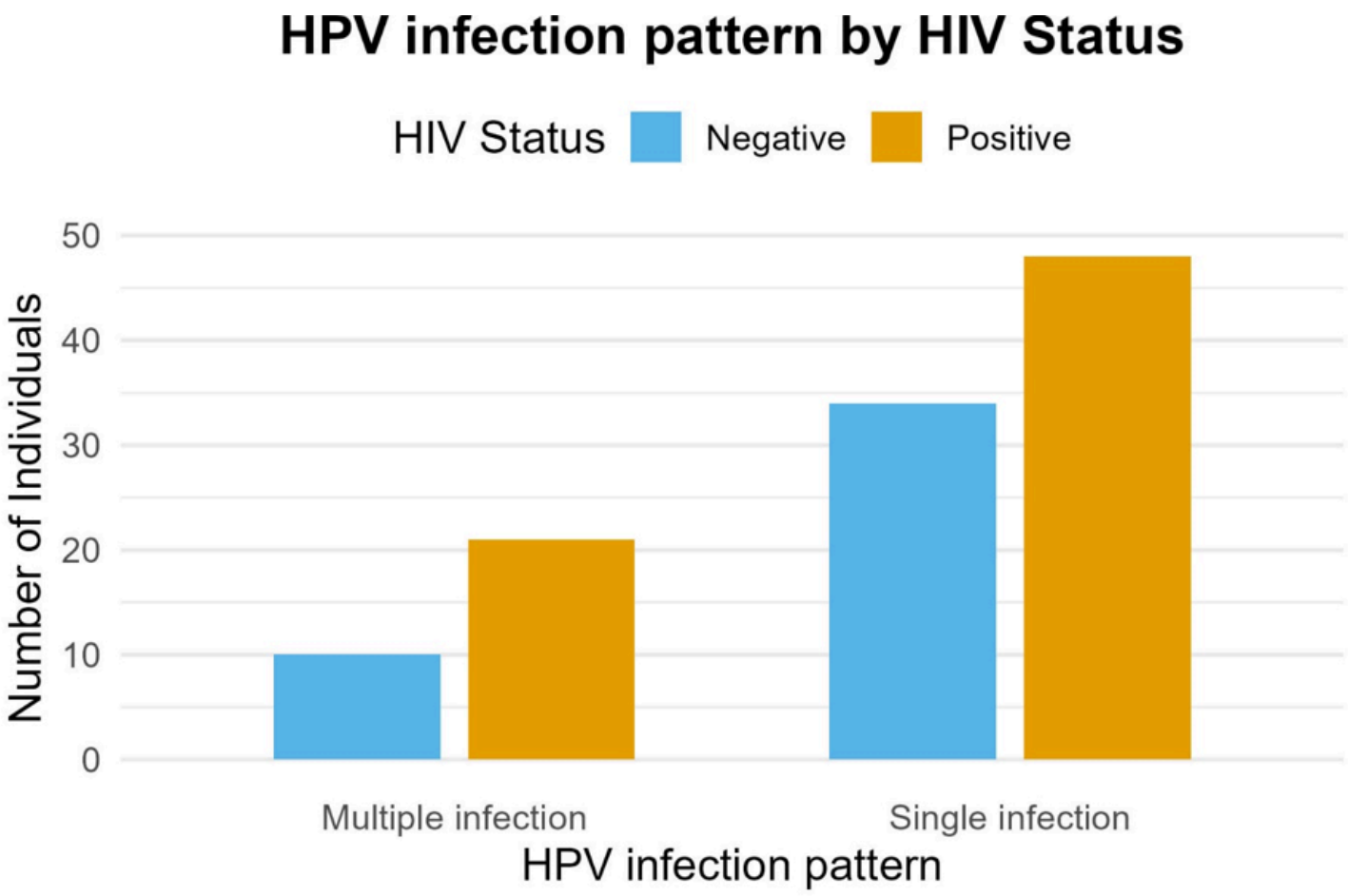


Figure 1

showing HPV infection pattern by HIV status

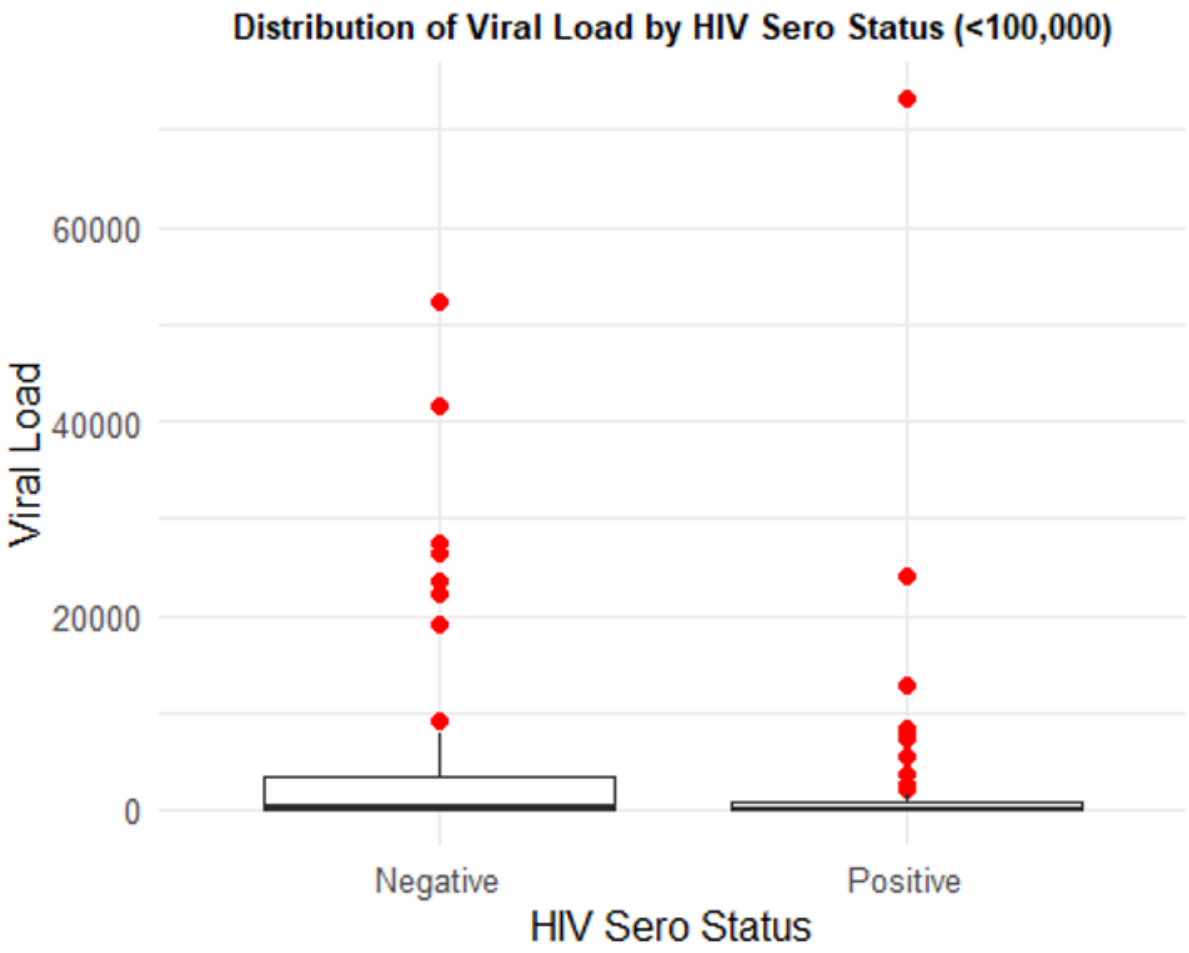


Figure 2

Showing distribution of HPV viral load units (copies/cell) by HIV sero status.

Supplementary Files

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