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Human Papillomavirus Infection and Cervical Cancer Risk Modelling Among Women in Niamey, Niger Republic

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Abstract

Background: The impact of human papillomavirus (HPV) infection diagnosis aims to use a cervical cancer screening method in public health programs in West Africa. This study aims to determine the prevalence of HPV infection in women in Niger Republic.

Methods: A prospective cross-sectional study, we randomly selected 598 women, aged 15–75 years, between January 2024 and April 2025 in four healthcare facilities providing gynecological and routine cervical cancer screening in Niamey the capital cities of Niger Republic. We collected informed consent and assent, collected data, and trained participants, to self-collect vaginal or assisted endocervical samples using FloqSwabs. HPV

DNA was extracted and amplified using Genotyping Real-time PCR Kit on a Real-time PCR thermocycler (STC-48PLUS). Data were organized using Excel software, and descriptive analyses were performed using IBM SPSS Statistics 29 (IBM Corp., Armonk, NY, USA) and modelling had been performed using R.

Results: The overall prevalence of total HPV and HR-HPV infections in the study population was 12.20% (73/598) and 11.03% (66/598) respectively. HPV infections were confirmed among women from aged group 20–29 years. The commonest HR-HPV types detected were 16 and 66 by followed HPV 35, 53, 31, 45, 52, 68, 58, 26, 51, 59, 18, 33, 39, 73, 82 and 56. The most frequently LR-HPV types were 6 by followed HPV 81 and 11. We also examined factors associated with HPV infection and cervical cancer using multivariate logistic regression models. While no independent predictors of HPV infection were identified, HPV positivity was significantly associated with an increased risk of cervical cancer. Indeed, women who tested positive for HPV had a nearly three times higher risk of diagnosis than women who tested negative.

Conclusion: The prevalence of HPV infection was assessed among women in Niamey, the capital of Niger. Therefore, HPV DNA genotyping and HPV vaccination are necessary for the prevention of cervical cancer in Niger and the rest of West Africa.

Keywords: Human Papillomavirus, Women, cervical cancer, Niger Republic

Introduction

Genital human papillomavirus (HPV) is the most common sexually transmitted infection in the world. It is associated with cancers of the cervix, anus, vagina, oropharynx, vulva, oral cavity, penis and larynx (Saraiya et al., 2015). Globally, 662,301 new cervical cancer cases and 348,874 deaths occurred were an estimated in 2022 World (Li et al., 2025). The highest prevalence of HPV infection was observed among women under the age of 25 years because sexually active, however to persistent infections or reactivation can be of than older women, often linked to higher-risk HPV types (García-Gil et al., 2025). Almost 80% of sexually active men and women can become infected at least once in their lifetime, as infection can occur not only through sexual intercourse but also through rubbing or touching the skin surfaces and mucous membranes (Das et al., 2023; Kombe Kombe et al., 2020). In addition, HPV can induced cervical cancer among older women , emphasizing continued screening (Grieco et al., 2025). However few data reported the earliest age of HPV infection among women (Joura et al., 2015).

The impact of HPV vaccination, cervical screening and cancer treatment play out over different timeframes (Ginsburg et al., 2023). HPV vaccination has been shown to be efficacious for prevention of infection and associated diseases (Clifford et al. 2003). However, in order to prevent HPV infection and reduce the risk of associated diseases, the WHO recommends single-dose HPV vaccination for girls aged 9 to 14 years in the first year, then twice during their lifetime, as well as HPV screening at 35 and 45 years, before the start of their sexual life (Jean et al.; 2018; *OMS 2020*).

In Niger republic, 624 new cases of cervical cancer were reported in 2023, resulting in an age-standardized incidence rate of 9.3 per 100,000 women (*WHO 2017*). Moreover, an estimated standardized mortality rate of 440 women died from cervical cancer (Ferlay et al. 2019). This data, cleaning supported that if the countries achieves the WHO's proposed '90-70-90' targets by 2030, cervical cancer could be eliminated as a public health problem by 2060 , and 400 620 lives could be saved by 2120 (Brisson et al., 2020; Ferlay et al., 2019). In addition, few epidemiological studies on HPV infection in women that could contribute. This study aims to determine the prevalence of HPV infection in women in Niger Republic.

Methods

Participants enrolment and sample collection

A prospective cross-sectional study was conducted between January 2024 and April 2025 in four healthcare facilities providing gynecological and routine cervical cancer screening in Niamey the capital cities of Niger Republic. We randomly selected two groups of women, with the first group undergoing assisted endocervical sampling, while the second group practice self-sampling. For both groups, a nursing assistant and multi-skilled health workers were charged to sensitize women on sampling procedure, all samples were collected using FloqSwabs, Copan, Brescia, Italy following the manufacturer procedure. The self-sampling consists of inserting the flexible swab at a depth of 5 to 6 cm into the vagina, rotated it five times and then placed into the container. The assisted endocervical sampling were carried out by a physician before the visualization of the cervix with acetic acid (VIA) and with lygol (VIL). All woman with a history of hysterectomy or menstruating were not included.

Virological analysis

Sample preparation

All samples were transported to the Centre de Recherche Médicale et Sanitaire (CERMES) de Niamey for testing. First, the samples were suspended in 2 ml sterile phosphate-buffered saline (PBS) and vortexing three times for 15 s before discarding the swab. Aliquots were then stored at

-20 °C prior to DNA extraction using Nucleic Acid Extraction Rapid Kit ® 48T/plate® from Bioperfectus Technologies Co., Ltd, China on an Automated extraction System Bioperfectus SSNP-3000A according to the manufacturer's instructions. This kit purified the DNA by removing blood, inflammatory cells, necrotic debris, HPV virions, and mucus.

HPV detection and genotyping

HPV DNA was amplified using Genotyping Real-time PCR Kit from Bioperfectus Technologies, which simultaneously detects 18 High-risk HPV types 16, 18, 31, 33, 35, 39, 45, 51, 52, 53, 56, 58, 59, 66, 68, 26, 73, 82 and 3 Low-risk HPV types (6, 11, 81). Analysis was carried out on a Real-time PCR thermocycler (STC-48PLUS) from Bioperfectus Technologies. Briefly, eight reactions per sample were prepared to detect and differentiate HPV genotypes using three fluorescent channels FAM, VIC, HEX or ROX. Internal control (IC) consisting with the housekeeping gene was added for each reaction to identify possible PCR inhibition and the reagents' reliability. At the end of the reaction, specimens with cycle threshold (Ct) value of ≤ 38 less than were considered as positive for each HPV genotype.

Statistical analysis

Descriptive analyses were performed using IBM SPSS Statistics 29 (IBM Corp., Armonk, NY, USA). Categorical variables were summarized using frequencies and percentage Wile continuous variables were grouped into intervals in order to create categories. Furthermore, p-values were determined using either the chi-square test or Fisher's exact test. For inferential analyses, multivariable logistic regression models were fitted using the R statistical environment (R Foundation for Statistical Computing, Vienna, Austria). Prior to modeling, the dataset was cleaned and prepared. Categorical variables were converted into factors and continuous variables were treated as numeric variables. Two binary outcomes were considered: HPV infection status and cervical cancer diagnosis. HPV infection was defined based on molecular detection and coded as a binary variable (positive vs negative), with HPV-negative women used as the reference category. Independent variables included education level, contraceptive use, sampling type (self-sampling vs assisted sampling), family type (monogamous vs polygamous household), age, age at first sexual intercourse, gravidity, and number of abortions. Education level was treated as a categorical variable with primary education as the reference category.

Modeling analysis

Two multivariable logistic regression models were constructed. The first model assessed factors associated with HPV infection, with PCR-

confirmed HPV status as the dependent variable. The second model evaluated factors associated with cervical cancer diagnosis, including HPV infection status as an additional explanatory variable. Adjusted odds ratios (ORs) and their 95% confidence intervals (95% CI) were estimated. Statistical significance was assessed using Wald tests, and a p-value < 0.05 was considered statistically significant. Model estimates were exponentiated to obtain odds ratios, and regression outputs were formatted into publication-ready tables using packages available in the R environment.

Ethical approval and informed consent

The study protocol was approved by the National Ethics Committee for Scientific Research of the Republic of Niger (CNERS) under number 02/2024/CNERS dated January 4, 2024.Written informed consent was obtained from each participant who were supposed to be screened for cervical cancer. For participants who were of childbearing age, they provided written informed consent prior to enrolment.

Results

Sociodemographic, sexual and behavioral characteristics

A total of 598 women were included in this study, with median age of 31.06 years (15-75 years). Among the enrolled women, 581 (97.15%) were married and 313 (52%) living a monogamous regime. Women with no educational background represent 254 (42.47%) and 468 (78.26%) were unemployed. 336 (56.18%) had their first sexual intercourse between the ages of 15 and 19, with an average age of 17.9 years. Majority of women 595 (99.49%) had only one sexual partner. Only 1(0.16%) among women reported Anti-HPV vaccine history. There was no difference in type of education levels, occupation, first sexual intercourse, sexual partner, marital status and family type of HPV positive compared with HPV negative women, p >0.05. In addition, 548 (91.63%) women had never benefited from cervical cancer screening. However, there is significant differences between HPV detection and cervical cancer screening (p=0.014). Importantly, 387 (64.71%) of the women benefited for an assisted sample collection by a health professional, while 211 (35.28%) carried self-sample collection p >0.05 (Table 1).

Table 1: Sociodemographic, sexual and behavioral characteristics of the women studied HPV prevalence

Characteristics		PCR-HPV				HPV type				
		Negative	Positive	Total	p-value	High risk	Low risk	N/A	Total	p-value
HPV		525 (87.80)	73 (12.20)	598 (100)	0.000	66 (11.03)	7 (1.17)	525 (87.80)	73 (12.20)	0.234
Age	< 20	34 (5.68)	6 (1)	40 (6.68)	0.606	6 (1)	0 (0)	34 (5.68)	40 (6.68)	0.791
	20 – 29	229 (38.29)	31 (5.18)	260 (43.47)		27 (4.51)	4 (0.66)	229 (38.29)	260 (43.47)	
	30 – 39	160 (26.75)	26 (4.34)	186 (31.1)		24 (4.01)	2 (0.33)	160 (26.75)	186 (31.1)	
	40 – 49	76 (12.7)	6 (1)	82 (13.71)		5 (0.83)	1 (0.16)	76 (12.7)	82 (13.71)	
	≥ 50	26 (4.34)	4 (0.66)	30 (5.01)		4 (0.66)	0 (0)	26 (4.34)	30 (5.01)	
First sex age	< 15	86 (14.38)	14 (2.34)	100 (16.72)	0.871	12 (2)	2 (0.33)	86 (14.38)	100 (16.72)	0.94
	15 – 19	296 (49.49)	40 (6.68)	336 (56.18)		37 (6.18)	3 (0.5)	296 (49.49)	336 (56.18)	
	20 – 24	107 (17.89)	13 (2.17)	120 (20.06)		12 (2)	1 (0.16)	107 (17.89)	120 (20.06)	
	≥ 25	36 (6.02)	6 (1)	42 (7.02)		5 (0.83)	1 (0.16)	36 (6.02)	42 (7.02)	
Number of sex partner	1	523 (87.45)	72 (12.04)	595 (99.49)	0.102	65 (10.86)	7 (1.17)	523 (87.45)	595 (99.49)	0.212
	2	1 (0.16)	1 (0.16)	2 (0.33)		1 (0.16)	0 (0)	1 (0.16)	2 (0.33)	
Education level	Other	224 (37.45)	30 (5.01)	254 (42.47)	0.881	29 (4.84)	1 (0.16)	224 (37.45)	254 (42.47)	0.341
	Primary	85 (14.21)	10 (1.67)	95 (15.88)		9 (1.5)	1 (0.16)	85 (14.21)	95 (15.88)	
	Secondary	163 (27.25)	24 (4.01)	187 (31.27)		19 (3.17)	5 (0.83)	163 (27.25)	187 (31.27)	
	Tertiary	53 (8.86)	9 (1.5)	62 (10.36)		9 (1.5)	0 (0)	53 (8.86)	62 (10.36)	
Marital status	Divorced	10 (1.67)	2 (0.33)	12 (2)	0.345	1 (0.16)	1 (0.16)	10 (1.67)	12 (2)	0.175
	Married	511 (85.45)	70 (11.7)	581 (97.15)		64 (10.7)	6 (1)	511 (85.45)	581 (97.15)	
	Single	1 (0.16)	1 (0.16)	2 (0.33)		1 (0.16)	0 (0)	1 (0.16)	2 (0.33)	
	Widow	3 (0.5)	0 (0)	3 (0.5)		0 (0)	0 (0)	3 (0.5)	3 (0.5)	
family type	Other	14 (2.34)	3 (0.5)	17 (2.84)	0.744	2 (0.33)	1 (0.16)	14 (2.34)	17 (2.84)	0.466
	Monogamy	274 (45.81)	39 (6.52)	313 (52.34)		36 (6.02)	3 (0.5)	274 (45.81)	313 (52.34)	
	Polygamy	237 (39.63)	31 (5.18)	268 (44.81)		28 (4.68)	3 (0.5)	237 (39.63)	268 (44.81)	
Occupation	Formal employment	61 (10.2)	7 (1.17)	68 (11.37)	0.433	6 (1)	1 (0.16)	61 (10.2)	68 (11.37)	0.576
	Other	22 (3.67)	8 (0,0133)	28 (4.68)		6 (1)	0 (0)	22 (3.67)	28 (4.68)	
	Student	29 (4.84)	5 (0.83)	34 (5.68)		5 (0.83)	0 (0)	29 (4.84)	34 (5.68)	
	Unemployed	413 (69.06)	55 (9.19)	468 (78.26)		49 (8.19)	6 (1)	413 (69.06)	468 (78.26)	
Cancer diagnostic	No	487 (81.43)	61 (10.2)	548 (91.63)	0.008	56 (9.36)	5 (0.83)	487 (81.43)	548 (91.63)	0.014
	Yes	38 (6.35)	12 (2)	50 (8.36)		10 (1.67)	2 (0.33)	38 (6.35)	50 (8.36)	
Anti-HPV vaccin history ?	No	524 (87.62)	73 (12.2)	597 (99.83)	0.709	66 (11.03)	7 (1.17)	524 (87.62)	597 (99.83)	0.933
	Yes	1 (0.16)	0 (0)	1 (0.16)		0 (0)	0 (0)	1 (0.16)	1 (0.16)	
Sampling type	Assisted	340 (56.86)	47 (7.85)	387 (64.71)	0.949	44 (7.35)	3 (0.5)	340 (56.85)	387 (64.71)	0.455
	Self	185 (30.93)	26 (4.34)	211 (35.28)		22 (3.67)	4 (0.66)	185 (30.93)	211 (35.28)	

HPV prevalence and genotype

HPV has been confirmed among 73 (12.20%), with 66 (11.03%) belonging to the high-risk group and 7 (1.17%) being low-risk genotypes (Table 1). No statistically significant association was found between the type of sample and HPV detection (p >0.05). HPV infections were confirmed among women from aged group 20–29 years. However, this was not statistically significant (p>0.05). The distribution of HPV genotypes allows the detection of 21 different genotypes with 18 high risk HR and 3 low risk. Among the high risk HPV16 and HPV 66 were respectively detected in 1.83%. The other high-risk HPV genotypes were detected in low proportion (Fig 1). The most frequently identified low-risk HPV genotype was HPV 6 (1.67%), followed by HPV 81 (1.03%) and HPV 11 (0.16%).

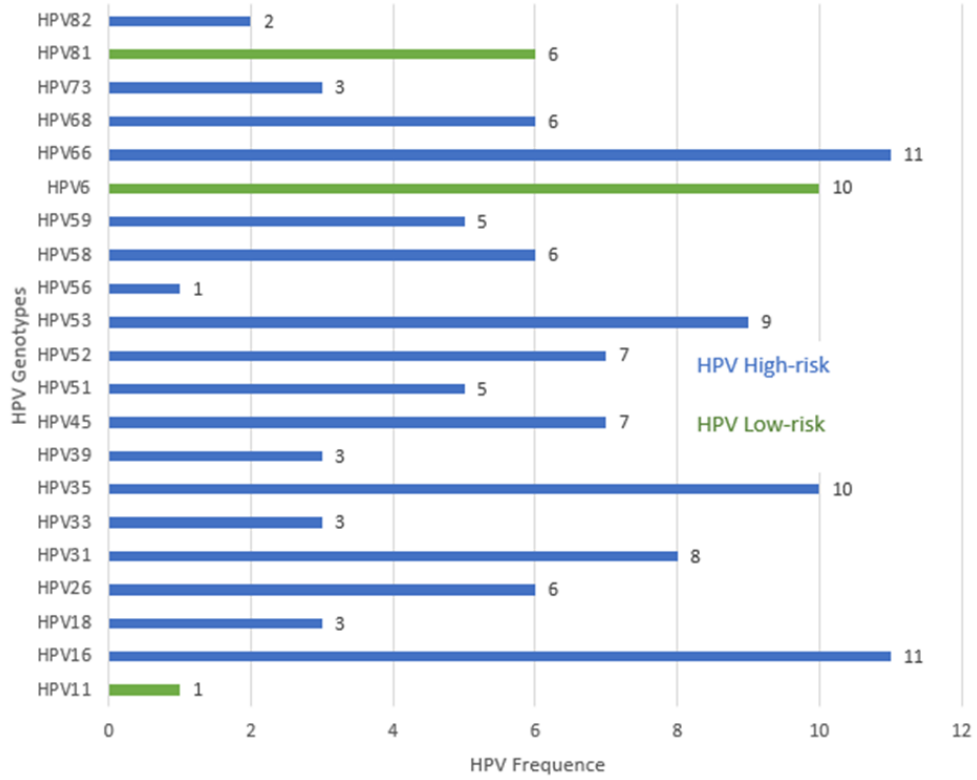

Fig 1: Distribution of genotypes in the general population

HPV infection risk modelling

Multivariable logistic regression analysis was conducted to identify factors independently associated with HPV infection. After adjustment for all covariates, none of the variables examined reached statistical significance (Table 2). Contraceptive use showed a non-significant trend towards a protective effect (adjusted odds ratio [OR] = 0.72; 95% confidence interval [CI]: 0.41 - 1.24; p= 0.245), while self-sampling was not significantly

associated with HPV detection compared to clinician-assisted sampling (OR = 1.10; 95% CI: 0.59–2.02; p = 0.765). Educational level, family type (polygamy versus monogamy), age, age at first sexual intercourse, gravidity, and number of abortions were also not significantly associated with HPV infection (all p > 0.05).

Table 2: Multivariable analysis of factors associated with HPV infection

Variable	Odds ratio	IC 2.5%	IC 97.5%	p
Sociodemographics characteristics				
Age	0.989	0.947	1.029	0.588
First sex age	1.043	0.964	1.125	0.285
Gravidity	1.043	0.889	1.225	0.609
`Number of Abortion`	0.936	0.658	1.295	0.703
Education level with Primary as reference				
Secondary	1.159	0.530	2.695	0.719
Tertiary	1.005	0.326	2.967	0.992
Other	1.099	0.524	2.482	0.810
Use of contraceptive with No as reference				
Yes	0.721	0.408	1.236	0.245
Sampling type with Assisted as reference				
Self	1.098	0.593	2.020	0.765
family type with Monogamy as reference				
Polygamy	0.943	0.557	1.588	0.825

Cervical cancer risk modelling

Multivariable logistic regression analysis identified three factors independently associated with cervical cancer diagnosis (Table 3). Human papillomavirus (HPV) infection was the principal risk factor, with HPV-positive women having a nearly threefold higher likelihood of diagnosis compared to HPV-negative women (adjusted odds ratio [OR] = 2.84; 95% confidence interval [CI]: 1.24 - 6.18; p = 0.010). Contraceptive use was also associated with increased odds of cervical cancer (OR = 2.72; 95% CI: 1.41 - 5.37; p = 0.003). In contrast, self-sampling was associated with a lower probability of diagnosis compared to clinician-assisted sampling (OR = 0.20; 95% CI: 0.045 - 0.59; p = 0.010). No significant associations were observed with educational level, family type, age at first sexual intercourse, gravidity, or number of abortions (all p > 0.05). Age showed a non-significant trend (p = 0.052).

Table 3: Multivariable analysis of factors associated with cervical cancer diagnosis

Variable	Odds ratio	IC 2.5%	IC 97.5%	P
Sociodemographics characteristics				
Age	1.042	0.999	1.085	0.052
`First sex age`	1.066	0.983	1.154	0.118
Gravidity	1.077	0.896	1.294	0.428
`Number of Abortion`	0.906	0.618	1.291	0.598
Education level with Primary as reference				
Secondary	2.029	0.740	6.586	0.196

Tertiary	1.676	0.429	6.811	0.455
Other	1.574	0.562	5.170	0.414
Use of contraceptive with No as reference				
Yes	2.719	1.413	5.369	0.003
Sampling type with Assisted as reference				
Self	0.195	0.045	0.593	0.010
Family type with Monogamy as reference				
Polygamy	1.226	0.638	2.363	0.540
PCR-HPV with Negative as reference				
Positive	2.840	1.239	6.184	0.010

Discussion

HPV screening represents a primary screening method for cervical cancer, particularly in a resource-limited settings where advance laboratory testing are challenging (Adebamowo et al., 2025). In this study, the prevalence of HPV in Niger was found to be 12.20%. This rate is higher than those reported among West African countries included Nigeria (1.7%) (Modibbo et al., 2017), Ivory Coste (9%) (Abdoulaye et al., 2017), but lower in Ethiopia (14%) (Jede et al., 2020) and Kenya (19%) (Swanson et al., 2018). Importantly, other studies have reported elevated HPV prevalence rates ranging from 45% in Brazil (Rodrigues et al., 2018) to 92.7% in Gabon (Muwonga Tukisadila et al., 2025). These differences of HPV infection rates could be attributed to sociodemographic factors such as population age, countries economic levels, education levels and level of implementation of cervical cancer prevention and control including vaccination (Modibbo et al., 2017; Swanson et al., 2018).

In this study, HPV infections were mostly confirmed among women age 20–29 years. This is similar to the findings reported by studies conducted in China (W. Wei et al., 2025) and Ghana(Adams et al., 2019). In contrast, our findings differ from result of studies conducted in Nigeria which reported a high prevalence of HPV among women aged 30 years and more (Adejo et al., 2024; Akarolo-Anthony et al., 2014; Kolawole et al., 2016). For instance, this age group is characterized by intense sexual activity, promoting new infections, early detection and the transient nature of HPV infection (Akarolo-Anthony et al., 2014).

Importantly, the prevalence of high-risk HPV genotypes found in this study was higher than that of low-risk. These findings aligned with those reported in Burkina Faso (30.2%) (Zohoncon et al., 2013), Nigeria (46.2%), (Emeribe et al., 2021), and Mali (43%) (Konaté et al., 2019). In contrast to our results, a study from Tunisia reported a high prevalence of the low-risk HPV genotype (Ardhaoui et al., 2016). This is mainly supported by the methodology used and samples type (Konaté et al., 2019; Zohoncon et al., 2013).

The distribution of HPV genotypes in this study, showed that HPV16 and 66 were the predominating strains circulating in Niger. These results are similar to those observed from studies conducted in Chilean (Vergara et al., 2017), in Polish couples (Kiwerska et al., 2019). In contrast to studies conducted in Burkina Faso and Nigeria (Modibbo et al., 2017; Zohoncon et al., 2013, p. 35), where HPV-35 was the most frequently detected genotype. The presence of non-vaccine HPV type does not mean that cancer is present, but it does indicate the need for medical follow-up to monitor for any persistence or the appearance of lesions (Zohoncon et al., 2013). However, the fact that all high-risk HPV types detected in this study and in several other studies conducted among women are not vaccine types means that cervical cancer screening will continue to play an important role in cervical cancer prevention efforts in the country, even after the implementation of a national vaccination policy (Awua et al., 2016; Tounkara et al., 2021).

The most frequently identified low-risk HPV types were HPV 6 (1.67%), 81 (1.03%), and 11 (0.16%). Similarly, a study on urban girls in Nigeria revealed that HPV 6 was the most frequently detected genotypes (Cosmas et al., 2022; Emeribe et al., 2021). Furthermore, two systematic reviews and meta-analysis conducted among West African populations showed that low-risk genotypes, HPV-81 and 11 were the most commonly reported (Kabuga et al., 2020; Larwanou et al., 2025).

In this study, HPV was significantly associated with an increased risk of cervical cancer, with HPV-positive women exhibiting nearly a threefold higher odd of diagnosis compared to HPV-negative women. This finding is consistent with the well-established causal role of persistent high-risk HPV infection in cervical carcinogenesis and aligns with global evidence demonstrating that a limited number of oncogenic HPV genotypes are responsible for the majority of invasive cervical cancer cases, with regional variations in genotype distribution, including a higher contribution of certain genotypes such as HPV35 in African settings (Clifford et al., 2003; F. Wei et al., 2024). Contraceptive use was the most significantly associated factors with cervical cancer, supporting evidence that hormonal contraceptives may act as cofactors in HPV-mediated carcinogenesis (Iversen et al., 2021; Lessa & Podlasek, 2025). In contrast to the existing literature, we did not observe significant associations between HPV infection and sociodemographic or behavioral factors. Similar findings have been reported in some population-based studies where no significant association was found between high-risk HPV infection and sociodemographic characteristics (*RSU* 2024).

An additional important finding was the association between self-sampling and a lower probability of cervical cancer diagnosis compared to clinician-based sampling. This result should be interpreted with caution, as it may reflect differences in diagnostic performance rather than a true

biological effect. While HPV self-sampling has been shown to improve screening uptake, its sensitivity for detecting high-grade lesions may be lower in certain contexts, potentially leading to underdiagnosis (Arbyn et al., 2020). Alternatively, this finding may be explained by selection bias, as women opting for self-sampling may differ systematically from those undergoing clinician-based sampling in terms of healthcare access, symptomatology, or risk perception.

This study has few limitations that warrant the discussions. First, the study was a hospital-based in Niamey, therefore, does not cover the whole female population in Niger, so it cannot represent the general population of Niger. Second. it lacks cellular or pathological data from positive cases, making comparative statistics infeasible. Third, the failure to perform both cervical and vaginal swabs on each women included, does not allowed to fully assess the sampling methods. Despite these limitations, our findings reinforce the central role of HPV in cervical cancer and highlight the importance of strengthening HPV-based screening strategies, while emphasizing the need to optimize self-sampling approaches and to further investigate the complex relationship between contraceptive use and cervical cancer risk in diverse epidemiological settings.

Conclusion

Our results reveal variable HPV genotypes circulating in Niger. These data demonstrate the need for the implementation of screening strategies and appropriate prevention measures including vaccination. Importantly, the HPV genotypes 16 and 6 which are respectively predominating HR and LR genotypes contribute to the HPV vaccine composition. These findings would allow for the development of more targeted screening tests for the most prevalent genotypes in Niger.

Authors' contributions:

- Study Design, Sample Collection, Data Extraction, Manuscript writing and review, LHM;
- Study Design, Manuscript writing and review, AL;
- Data Extraction, Manuscript writing and review, WH;
- Data Extraction, Manuscript writing and review, FH;
- Data Extraction, Manuscript writing and review, MI;
- Data Extraction, Manuscript writing and review, AE;
- Study Design, Manuscript writing and review, AMZ.

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Declaration for Human Participants: The study protocol was approved by the National Ethics Committee for Scientific Research of the Republic of Niger (CNERS) under number 02/2024/CNERS dated January 4, 2024.

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