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Human papillomaviruses in Western Africa: prevalences and risk factors in Burkina Faso

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Abstract

Purpose Cervical cancer is the most common cancer in women in low income countries. Certain oncogenic types of human papillomaviruses are causally associated with the cervical cancer. To ensure effective primary prevention through the introduction of a national vaccination program in Burkina Faso, information about the disease burden of HPV infection in the country is of great importance.

Methods In the present work the prevalence of 54 different HPV types and 18 other sexually transmitted infection as well as the predominant risk factors for the development of cervical cancer were investigated in Ouagadougou. A cross-sectional study on two populations without (n=471) and with known cervical dysplasia (n=39) was carried out between October 2013 and March 2014. Retrospectively, data on possible and secured risk factors of the cervical carcinoma were collected. The participants were examined gynecologically and a vaginal lavage was taken, which was molecular genetically examined for 54 different human papillomavirus genotypes and 18 other STIs.

Results The prevalence of human papillomavirus was 42.3% (188/444) in the first study population and 87.2% (34/39) in the second study population. The immunization coverage would be 24.5% of the HPV types and 33.9% of the high-risk HPV types with quadrivalent vaccine Gardasil®. The nonavalent vaccine Gardasil®9 (9vHPV) would cover 37.3% of all HPV types and 57.1% of high-risk HPV types.

Conclusion The prevention of infection with human papillomaviruses by vaccination is expected to result in a drastic reduction in the morbidity and mortality of the cervical cancer in Burkina Faso.

Keywords HPV · Human papillomavirus · Genotyping · STI · Burkina Faso · Africa · Cervical cancer

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Introduction

Cancer of the uterine cervix (cervical cancer) is the most common cancer among women in Burkina Faso [1]. Genital infection with certain high-risk types of human papillomavirus (HPV) has been implicated in the development of cervical cancer [2]. Although HPV type 16 is the most frequently associated with this cancer, less prevalent high-risk HPV types may also be a risk, as well [3]. HPV are epitheliotropic; they infect proliferating epithelial cells of the skin or the mucosa. Initially, the infection results in an inconspicuous intraepithelial lesion of the squamous epithelium, with most of these lesions disappearing 6–12 months after their first appearance [2]. In 5–10% of the patients, however, the infection persists, and in about 3% of infected women, it develops in several stages via high-grade, cervical intraepithelial neoplasia (CIN) to a carcinoma in situ (CIS). This continues without surgical intervention to an invasive

squamous cell carcinoma or adenocarcinoma of the cervix [2, 4]. Both the humoral and the cellular immune systems play an important role in the immunological control of HPV infection and decide whether the infection can be inhibited or not [5]. Heterogeneous risk factors such as high parity, long-term oral contraceptive use, smoking, and co-infection with other sexually transmitted infections favor the persistence of HPV infection which is required for the development of cervical cancer [6].

Both the cervical cancer and the precursor lesions that require surgical intervention can be prevented by effective vaccines against HPV [7]. WHO recommends HPV vaccination for all girls between 9 and 13 years [8]. However, there is currently no HPV vaccination routine immunization program in Burkina Faso. To ensure effective primary prevention through the introduction of a national vaccination program in Burkina Faso, information about the disease burden of HPV infection in the country is of great importance. In recent studies, only the prevalence of high-risk HPV types was investigated [9–12] or the number of investigated genotypes was much lower [13] than in the present study. For optimal planning and implementation of HPV vaccination program, it is important to know the prevalence of HPV types and of cervical dysplasia in each age group.

The aim of this study was to determine which HPV genotypes should be covered by an immunization program in women with and without cervical dysplasia in Ouagadougou. In several studies, some of the STIs have been shown to interact with HPV in the multi-step process of carcinogenesis of the cervical carcinoma [14, 15] Therefore, the study also evaluated whether other sexually transmitted infections (STIs) interacted with HPV infection, the socioeconomic factors influencing on carcinogenesis of cervical, as well as the viral load of the high-risk genotypes.

Materials and methods

Study population and sample collection

A cross-sectional study on two populations in Ouagadougou was performed from October 2013 to March 2014. The first population consisted of $n = 471$ women aged over 18 (mean age 41.3 years, range 19–76) without known cervical neoplasia. Women were selected from a cost-efficient screening examination in six different health centers in Ouagadougou. The second population consisted of $n = 39$ women (mean age 42.8 years; range 24–70) with histologically confirmed cervical neoplasia recruited via a register for cervical dysplasia in the "Centre Hospitalier Universitaire Yalgado Ouedraogo" [CIN 1: 30.8% ($n = 12$); CIN 2: 23.1% ($n = 9$); CIN 3: 5.1% ($n = 2$); cervical cancer: 38.5% ($n = 15$)]. Women which were pregnant or with the previous surgical intervention on the

uterine cervix were not included. The objective of the study was explained in detail to each woman before she signed an informed consent form. Possible and evidenced risk factors for cervical cancer were evaluated retrospectively.

Women underwent a gynecological examination including visual inspection with acetic acid and lugol's iodine. To collect cells from the cervical flora, a vaginal lavage was used via Delphi screener. Vaginal lavages were preserved in tubes with methanol solution to conserve the nucleic acids and kept at a temperature of 4 °C until transportation to the Deutsches Krebsforschungszentrum in Heidelberg, Germany. The study has been approved by the National Ethical Committee of the Ministry of Health, Burkina Faso (reference No 2014-7-090).

HPV detection and genotyping

All laboratory analyses were conducted in the DKFZ (Deutsches Krebsforschungszentrum) in Heidelberg, Germany. DNA was isolated with the MagNA Pure 96 DNA and Viral NA Large Volume Kit (Roche, California, USA) according to the manufacturer's instructions. With the MagNA Pure program "Pathogen Universal 500/50", 50 µl DNA solutions were extracted out of 500 µl clinical probe. 50 µl DNA solutions were then available for the following assays for HPV and STI testing.

The BSGP5+/6+-PCR/MPG assay is made of a broad-spectrum general-primer PCR (BSGP5+/6+-PCR), a Multiplex HPV Genotypization (MPG) and a bead-based hybridization with xMAPLuminex-SAT (suspension array technology). BSGP5+/6+-PCR was performed as described by Schmitt et al. [16]. The used broad-spectrum primers are complementary to conserved regions within the L1 region. An internal beta-globin control allows simultaneous DNA quality control. The generated biotinylated amplicons are type specific polymorph and consist of ~150 bp. Amplification of HPV was performed by Multiplex PCR Kit 1000 (Qiagen, Hilden, Germany).

The PCR mixture consisted of 0.2 µl dNTPs (final concentration 0.2 mM), 12.5 µl PCR buffer (Q solution), 0.5 µl MgCl2 (final concentration 3.5 mM), 0.75 µl BSGP5+/6+-Primer, 0.075 µl β-Globin Primer (Bg3f; Bg3b), 0.1 µl AmpliTaq Gold DNA Polymerase (1 Unit), 5.8 µl ddH2O.100 µM of each BS Patent Primer (C505), and 100 µM of each β-Globin Primer (C502), and 5.0 µl DNA solution or water for negative control was added to the PCR mixture. The QIAGEN Multiplex PCR Kit consists of Hot-StarTaq DNA polymerase, a PCR buffer with the synthetic factor MP, which stabilizes bound primers and of the Q solution, which facilitates the amplification of difficult templates [17]. A 15-min activation step at 90 °C was followed by 40 cycles of amplification with Mastercycler (Eppendorf).

To determine HPV genotype, the generated PCR products were then hybridized with type specific probes with the Luminex bead-based Multiplex HPV Genotyping (MPG) assay. Therefore, 10 µl of each reaction were denatured and hybridized to bead-coupled oligonucleotide probes as described elsewhere [18]. Unhybridized DNA was removed by further washing steps. Each probe was then incubated with 50 µl staining buffer (Streptavidin-R-Phycoerythrin conjugates) and biotinylated, bead-coupled PCR products were marked. Probes were analyzed in the Luminex reader (Luminex Corp). The Luminex system contains two lasers to identify each bead set according to internal bead color and quantify the strep PE reporter fluorescence of the beads. The result was expressed as median fluorescence intensity (MFI). For each sample, the measured MFI values of the reactions without PCR product (hybridization control) were considered as background values. The cut-off value was calculated by adding 5 MFIs to the average background value. For all samples, this cut-off value was above the median background plus three times the standard deviation. The quantification of HPV signals was accomplished by calculating the relative HPV MFI signals for each positive response. For this purpose, the measured MFI values were divided by the maximum MFI value found for the respective HPV type by means of PCR products from colonies. Subsequently, this relative MFI value was divided by the corresponding measured beta-globin MFI value to obtain a value for the viral load. The HPV viral load is a marker that allows an assessment of the relevance of HPV infection. The risk of cytologic pathology increases with the level of the detected viral load. The purely qualitative detection of HPV infection also identifies transient HPV infections with a low viral load that are not clinically relevant. The detection of a high-risk HPV infection with high viral load is associated with a sensitivity and specificity of over 95% to detect a cervical lesion [19].

The following HPV types can be detected by the BSGP5þ/6þ-PCR/MPG assay:

High-risk HPV types: HPV16, 18, 31, 33, 35, 39, 45, 51, 52, 56, 58, 59, 66, 68a, 68b; putative high-risk HPV types: HPV26, 53, 67, 70, 73, and 82.

Low-risk HPV types: HPV6, 7, 11, 13, 30, 32, 34, 40, 42, 43, 44, 54, 55, 57, 61, 62, 64, 69, 71, 72, 74, 81, 83, 84, 85, 86, 87, 89, 90, 91, 97, 102, 106, and 114.

Other sexually transmitted infections (STIs)

Analysis of STIs was performed by the sexually transmitted infection profiling"Assay that detects the following sexually transmitted infections: *Atopobium vaginae*, *Candida albicans*, *Candida glabrata*, *Chlamydia trachomatis*, *Gardnerella vaginalis*, Herpes simplex Virus 1 and 2, *Lactobacillus iners*, *Lactobacillus crispaticus/jensenii*, *Mycoplasma genitalium* (*M. genitalium*), *Mycoplasma spermatophilum*,

Mycoplasma pneumoniae, *Mycoplasma hominis (M. hominis)*, *Neisseria gonorrhoeae*, *Treponema pallidum*, *Trichomonas vaginalis*, *Ureaplasma urealyticum* (*U. urealyticum*), *and Ureaplasma parvum* (*U. parvum*). The STI assay was performed as described by Schmitt et al. [20]. Briefly, DNA extraction was performed as previously described for BSGP5+/6+-PCR/MPG Assay. Two µl of the extracted DNA was used for the Multiplex PCR which was also performed with Mastercycler (Eppendorf). The presence of human DNA was confirmed by the detection of human PolA-sequence. All primers completely matched the selected target sequence. The generated amplicons were biotinylated and had a length of 88–197 base pairs. This DNA products were denatured and hybridized to bead-coupled oligonucleotide probes. Hybridization products were measured in the Luminex® xMAPTMSystem and results were also expressed as Median Fluorescence Intensity (MFI). The bacterial vaginosis score was used for bacterial vaginosis. The calculation of the bacterial vaginosis score was based on DNA detection for *Gardnerella vaginalis* and for *Atopobium vaginae*, which had to be quantitatively above a certain cutoff in relation to lactobacilli. Similar to the Nugent score [21], the bacterial vaginosis score indicates the signs of bacterial vaginosis.

Statistical analysis

Statistical analyses were conducted with Microsoft Excel 2010 and with IBM SPSS version 22 for Microsoft (SPSS Inc., Chicago, IL, USA). Graphics were generated using Sigma Plot 13 (Systat Software Inc., Erkrath, Germany) and GraphPad Prism 6 (GraphPad Software Inc., CA, USA). A Chi-square test was used to determine factors which may influence the development of cervical cancer, such as age, marital status, history of other STIs, number of birth, and number of pregnancy. Fisher's exact test was used to determine two-sided significance. For larger cross tables, connections were made by Pearson's chi-square test. Unless stated differently, all values are denoted for the 5% significance level.

Using the binary logistic regression analysis, the odds ratios and the corresponding 95% confidence intervals were calculated for the probabilities of HPV positivity as a function of various risk factors. In the multivariate regression model, all variables were included, which are potential risk factors for an HPV infection.

Results

Study population characteristics

A total of 471 women without known cervical dysplasia and 39 women with histologically confirmed cervical dysplasia

agreed to participate in the study. In the first-study population, women were between 19 and 76 years old; the average age was 41.3 years. 74.7% of the women were married. The population in the first study had a 38% illiteracy rate. They had, given birth an average of 3.6 times. 81.7% underwent Female genital mutilation (FGM), mostly FGM grade II, which is the partial or total removal of the Clitoris and the labia minora, with or without excision of the labia majora. 166 participants (35.4%) said that they had already received at least once a screening study for the cervical carcinoma; 25.4% had received them within the last 3 years.

The second-study population included 39 patients with a precancerous neoplasia or a cervical carcinoma diagnosed in the Department of Gynecology and Obstetrics of the Center Hospitalier Universitaire Yalgado Ouedraogo (CHU-YO), Ouagadougou, from 2012 to 2014. The age at diagnosis of cervical neoplasia was between 24 and 70 years; on average, 42.3 years. The collective population of this study population was characterized by a very high proportion of illiterate women (48.7%). Patients were, on average, 0.9 years younger (17.8 years) than their first group (18.7 years), and had a history of an average of 4.1 parities.

HPV prevalence and genotyping

HPV–DNA was valid for 444 women in the first population, with 188 (42.3%), resulting in a positive detection. The overall prevalence of HPV–DNA declined to 50 years, after which a slight increase was observed (Fig. 1). Approximately one-fifth of women (20.7%) had multiple infections with several different HPV genotypes, 96 (21.6%) had an infection with only one HPV type, and 127 (28.6%) were infected with high-risk HPV types. Among the high-risk HPV types, 16 (6.5%), 52 (5.9%), 18 (4.1%), and 35 (4.1%)

were the most common. Among the low-risk HPV types, types 42 (4.5%) and 90 (4.1%) were most common, with 2.1% testing positively for the low-risk types HPV6 or HPV11. Those infected with types 16, 18, 6, and 11 were available for vaccination with the vaccine Gardasil®.

Seventy-five participants (16.9%) had an HR-HPV infection with high virus load. These women were, therefore, suspected of having a CIN. 4.1% of the subjects had HPV16 infection with a high viral load, 3.2% HPV52 infection with high viral load, and 2.7% had HPV18 infection with high virus load. In the case of multiple HPV infection, the type with the highest virus load was included in this analysis. Accounting for all 444 women with a valid HPV–DNA test result, the following distribution of high and possible high-risk HPV infections (Table 1 and Fig. 2) was found.

In the second population, HPV was detected in 87.2% of the samples; high-risk HPV prevalence was 76.9%. Almost half (48.7%) of infected patients were positive for HPV16/18 DNA. High-risk HPV with the highest prevalence was HPV

Table 1 Prevalence of HPV–DNA after HPV risk groups (total $n = 444$)

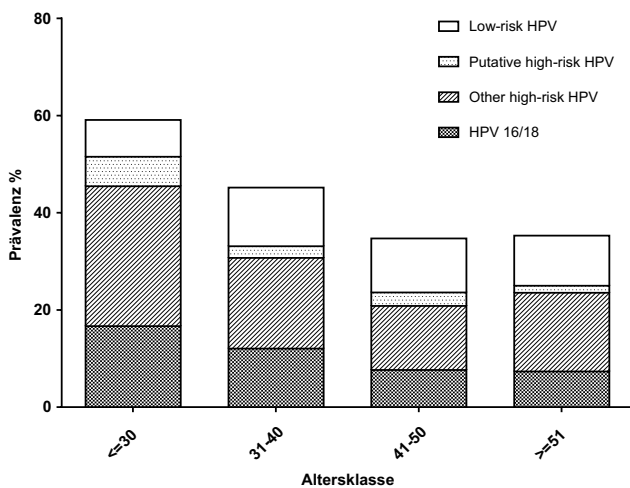|	n	% (95%–KI)
Any HPV positive	188	42.3 (37.7–46.9)
Single	96	21.6 (17.8–25.5)
Multiple	92	20.7 (17–24.5)
High risk	127	28.6 (24.4–32.8)
Probably high risk	13	2.9 (1.4–4.5)
Low risk	108	24.3 (20.3–28.3)
Any HPV with high viral load	128	28.8 (24.6–33)
High-risk with high viral load	75	16.9 (13.4–20.4)
Putative high risk with high viral load	24	5.4 (3.3–7.5)

Fig. 1 Age-specific HPV prevalences in women without known cervical dysplasia
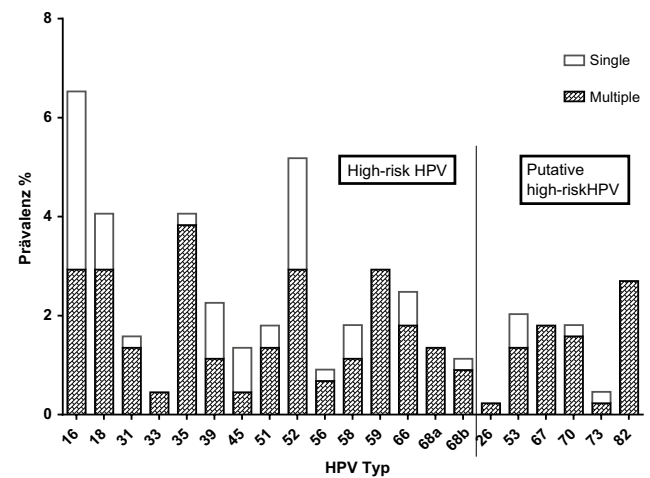

Fig. 2 High-risk and putative high-risk HPV in women without known cervical dysplasia

types 16 (6.5%), 52 (5.9%), 18 (4.1%), and 35 (4.1%) in the first population, and HPV types 16 (30.8%), 18 (17.9%), 35 (15.4%), 52 (17.9%), and 59 (10.3%) in the second population. Patients with cervical neoplasia had significantly more HPV infections with high viral load than women without known cervical neoplasia (74.4 versus 41.1%,). Infection with multiple HPV types was more common in the second population (51.3%) than in the first population (20.7%).

A large difference in prevalence of the high-risk HPV type 18 was found between the first-study population; 4.1% in the first population compared to 17.9% in the second-study population. Among the low-risk HPV types, types 6 (10.3%) and 42 (10.3%) were most frequently present. A total of 10.2% of women with cervical lesions had an exclusive infection with low-risk HPV types, 75% had a CIN 1 lesion, and an invasive carcinoma was detected in a woman with only low-risk HPV infection. For all other women with higher grade lesions (CIN 2, CIN 3, or invasive carcinoma) one or more high-risk HPV types were detected. In comparison to the subjects of the first study, significantly more HPV infections with a high viral load (74.4%, CI 60.7–88.1 versus 41.1%, CI 36.5–45.7) were found such as significantly more infections with high-risk HPV types with high viral load (66.7%, CI 51.9–81.5 versus 15.9%, CI 12.5–19.4).

STI prevalence and co-infection

We detected 43 individuals (10.3%, CI 7.4–13.2) with at least one classical STI. These included *Mycoplasma genitalium, Chlamydia trachomatis, Neisseria gonorrhoea, Treponema pallidum, Trichomonas vaginalis*, *Herpes simplex virus 1, and Herpes simplex virus 2*. A Bacterial vaginosis score higher than or equal to two was calculated for 109 subjects (31.2%, CI 26.4–36.1), which provides conclusive

evidence for the presence of bacterial vaginosis. The most important co-infections were found between DNA detection of HSV 2 and HPV–DNA positivity (CI 1.5–7.6; *p* 0.012) and DNA detection of HSV 2 and HPV high-risk DNA (KI 1.1–8.9; *p* 0.023). There was also a significant association between the detection of one of the classical STIs, and both HPV–DNA positivity (KI 10.4–21.2, *p* 0.001) and high-risk HPV–DNA positivity (KI 10–23.3, *p* 0.007). Also significant was the association between *Gardnerella vaginalis* and *Atopobium vaginae*, and thus, the BV score and HPV (KI 32.4–48.1; *p* 0.005) and high-risk HPV (KI 33.5–53.6; *p* 0.003) DNA positivity.

In the second population, five patients (14.3%, CI 2.7–25.9) were found to be infected with an STI, with no significant difference in the prevalence of the tested infections compared to the subjects of the first-study population. The low incidence of patients led to very high confidence intervals, which made a comparison difficult. There was a high proportion of women with a BV score greater than or equal to 2 (41.4%, CI 23.5–59.3) and the correspondingly high prevalence of *Atopobium vaginae* (40%, CI 23.8–56, 2) and *Gardnerella vaginalis* (45.7, CI 29.2–62.2).

HPV infection and other risk factors

Table 2 shows the associations between the prevalence of HPV–DNA with several selected characteristics of the study participants. HPV prevalence was higher among women born in the city compared to the country (OR 1.9; 95% CI 1.2–2.9; *p* 0.005). Women born in the city were more often single, had a higher number of sexual partners, and had an earlier onset of sexual activity. They were more likely to be nulliparity, were less likely to have polygamous marriages, and had a higher education level than women born

Table 2 Odds ratio (95% confidence interval) for HPV–DNA according to selected characteristics of the study participants in study population 1

Risk factor	No women	HPV–DNA		*p* value
		n positive (%)	OR (95% CI)	
Place of birth				
Rural[a]	225	77 (34.2)	1	
Urban	215	109 (50.7)	1.9 (1.2–2.9)	0.005
Marital status				
Married[a]	328	125 (38.1)	1	
Single	71	46 (64.8)	2 (1.1–3.7)	0.026
Divorced/widowed	41	15 (36.6)	0.7 (0.3–1.7)	0.472
Age at first sexual intercourse				
≥ 21[a]	83	23 (27.7)	1	
16–20	311	143 (46)	2.7 (1.5–4.8)	0.001
≤ 15	46	20 (43.5)	2.8 (1.2–6.6)	0.015

(The reference category, to which the respective odds ratios, confidence intervals, and *p* values refer, is at the top of the respective risk category)

[a]Reference categories

in the country. Single women showed a significantly higher HPV–DNA prevalence than married women (OR 2, 95% CI 1.1–3.7, p 0.026).

No significant association was found between HPV positivity and polygamy, FGM, hormonal contraceptive, multiparity, the level of education, or the number of sexual partners in the past 12 years. However, there was a significant association between the age of women in their first sexual intercourse and HPV–DNA positivity, with a difference between age at the first sexual intercourse ≥ 21 versus age at the first sexual intercourse ≤ 15 (2.8, CI 1.2–6.6; p 0.015).

Discussion

Due to the high mortality and the poor therapeutic possibilities, the prevention of cervical cancer is of great importance, especially in Africa. The primary objective is to generate a comprehensive prevention program. To reduce the incidence and mortality of the cervical carcinoma in Burkina Faso, it is important to follow different approaches. The low use of condoms, the high rate of sexually transmitted infections, and the high HPV rate of infection must be effectively combated. The high proportion of women with a bacterial vaginosis and the associations of different STIs with HPV show the importance of treating the STIs. Perhaps, young women in Burkina Faso benefit from a simultaneous screening of different STIs and HPV. A reduction in the incidence of STIs could lead to a reduction in the incidence of persistent HPV infections. Important aspects in the fight against the cervical cancer are elucidation, the establishment of a national HPV vaccination program, and the implementation of regular preventive examinations.

This work shows that HPV52 is one of the most common high-risk HPV types in Burkina Faso. HPV52 was ranked second after HPV16 among the most common high-risk HPV types, with a prevalence of 5.9% in the general population. This is consistent with a global meta-analysis, in which HPV52 with a prevalence of 2.4% was also second among the most common HPV types in Africa [22]. HPV52 was even more frequently identified as HPV16 in different studies conducted 2003 in Kenya, 2013 in Ouagadougou, and 2016 in Bobo-Dioulasso [9, 11, 23]. Thus, this genotype is of importance in the region.

The data on HPV prevalence in the region vary in the literature. Table 3 provides an overview of the most important studies conducted in the region on HPV prevalence in women with no known cervical neoplasia [12, 13, 24–31]. In the present study, we found a high prevalence of high-risk HPV–DNA of 28.6% in women without known HPV status in Ouagadougou. The high-risk HPV types with the highest prevalence were HPV types 16, 52, 18, 35, and 59 in both study groups in descending order.

Table 3 HPV prevalence in women with normal cytology in West Africa

Study	No women	HPV–DNA test (no of tested types)	Region	HPV +(%)	Selection of specific HR-HPV types (%)						
					16	18	31	35	45	52	58
Present study 2013/14	444	BSGP5+/6+-PCR/MPG Assay (54)	Ouagadougou (Burkina Faso)	42.3	6.5	4.1	1.6	4.1	1.4	5.9	1.8
[24]	6226	GP5+/6+(37)	Overall Africa	22.1	2.7	1.8	1.2	1.0	1.1	1.6	1.6
[25]	725	Biochip array genotyping test (19)	Benin	26.7	4.3	3.1	0.8	4.7	1.6	0.4	3.1
[26]	120	PGMY09/11 (27)	Elfenbeinküste	31.1	nr	nr	nr	nr	nr	nr	nr
[28]	831	GP5+/6+(44)	Guinea	47.9	6.6	3.2	1.3	3.2	4.7	4.0	3.2
[30]	932	GP5+/6+(36)	Nigeria	26.3	3.2	1.9	2.9	3.2	2.0	1.8	2.5
[13]	300	DiatechSTAR HPV Blot (15)	Ouagadougou (Burkina Faso)	24.3	3.0	4.0	nr	nr	1.0	nr	nr
[12]	200	nr but only HR-HPV	Ouagadougou (Burkina Faso)	41.5	nr	nr	nr	nr	nr	nr	nr
[11]	181	HPV Genotypes 14 Real-TM Quant (14)	Bobo-Dioulasso (Burkina Faso)	25.4	0.0	14.8	7.4	13.0	3.7	16.7	3.7
[31]	2065	MY09-MY11 (27)	Senegal	18.0	2.4	1.3	5.8	0.2	0.2	1.0	1.6
[9]	63	HPV HR Typing Real-TM (12)	Ouagadougou (Burkina Faso)	30.2	1.6	6.3	6.3	4.8	4.8	15.9	3.2

nr not reported

In a recently published study conducted in Ouagadougou, an HR-HPV prevalence of 41.5% was found among 200 women (Ouédraogo et al. 2015). However, the average age in this study was 18.7 years, which is clearly below the average age of 41.3 years in the present study. Traore et al. published 2016 data on high-risk HPV prevalence in Bobo-Dioulasso, the second-largest city in Burkina Faso. This was 25.4% [11].

HPV31 is ranked tenth among the high-risk HPV types among women in women without known cervical dysplasia in this study. On the other hand, HPV35 was detected with a prevalence of 4.1% as often as HPV18. In Europe, the second most common high-risk HPV genotype after HPV16 is HPV31 followed by HPV18 in women without cervical dysplasia [32]. The mentioned regional differences in the distribution of high-risk HPV genotypes must be considered when introducing a national screening program.

This study showed that the existing vaccine Gardasil® would cover 24.5% of prevalent HPV types and 33.9% of prevalent high-risk HPV types. In contrast, the second-generation nonavalent vaccine Gardasil®9 (9vHPV) would cover 37.3% of prevalent HPV types and 57.1% of prevalent high-risk HPV types. HPV 52 is very common both in women with and without cervical neoplasia in Burkina Faso; this genotype is covered by Gardasil®9.

Organizing a vaccination program includes many aspects. The target group must be defined and population registers must be used to reach the women. A special focus is given to the design of concrete plans for how women in rural areas in Burkina Faso can be achieved. The self-participation in vaccination should be kept low to make it accessible to a large part of the population. Women's awareness of the development of the cervical carcinoma and that of sexually transmitted diseases is particularly important here, regarding the willingness to vaccinate.

The framework and participation rates in a vaccination program will be decisive for the success. The implementation of a government-sponsored vaccination program in Burkina Faso calls for continuous monitoring to ensure the benefits for women's health in the country. There is the expectation that the implementation of HPV vaccination will reduce the incidence and mortality rates of the cervical carcinoma in Burkina Faso.

Compliance with ethical standards

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