



## hrHPV prevalence and type distribution in rural Zimbabwe: A community-based self-collection study using near-point-of-care GeneXpert HPV testing



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### ABSTRACT

**Objectives:** High-risk human papilloma viruses (hrHPV) are the causative agents of cervical cancer, the leading cause of cancer deaths among Zimbabwean women. The objective of this study was to describe the hrHPV types found in Zimbabwe for consideration in cervical cancer screening and vaccination efforts.

**Design and methods:** To determine hrHPV prevalence and type distribution in Zimbabwe we implemented a community-based cross-sectional study of self-collected cervicovaginal samples with hrHPV screening using near-point-of-care Cepheid GeneXpert HPV.

**Results:** The hrHPV prevalence was 17% (112/643); 33% (41/123) vs. 14% (71/520) among HIV-1-positive and -negative participants, respectively ( $p = 2.3E-07$ ). Typing via Xpert HPV showed very good overall agreement (77.2%, kappa = 0.698) with the Seegene Anyplex II HPV HR Detection kit. The most common types were HPV16, HPV18, HPV35, HPV52, HPV58, HPV68, HPV18, and HPV51, each of which appeared in 14–20% of infections. 37% (28/76) of women with positive cytology results (ASCUS+) had a type not included in the basic vaccine and 25% (19/76) had a type not currently in the nine-valent vaccine.

**Conclusions:** hrHPV type distribution includes less common high-risk types in rural Zimbabwe. The distribution and carcinogenicity of hrHPV type distribution should be considered during screening assay design, program development, as well as vaccine distribution and design.

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### Introduction

Cervical cancer is common among women in low- and middle-income countries (LMIC), particularly in Sub Saharan Africa (SSA). High-risk human papillomavirus (hrHPV) is the causative agent of >99% of cervical cancers and hrHPV infection is more common among HIV-positive women (Walboomers et al., 1999; Grulich et al., 2007). Zimbabwe has a high HIV prevalence (15–18%), and ranks fifth

in the world for cervical cancer prevalence (UNAIDS, 2017; Ferlay et al., 2015). While cervical cancer is preventable through screening and early treatment, only 5.2% of rural Zimbabwean women are screened in their lifetime (Chin'ombe et al., 2014).

In this study, we investigate the hrHPV prevalence and type distribution in HIV-positive and HIV-negative women in rural Zimbabwe. Initial hrHPV screening from self-collected cervicovaginal specimens was performed by the Xpert HPV test (Cepheid, Sunnyvale, CA), on the GeneXpert instrument and further typed using the Seegene Anyplex II HPV HR Detection kit (Seegene, Seoul, South Korea) (Einstein et al., 2014; Mbulawa et al., 2016; Cornall et al., 2017; Hesselink et al., 2016; Ostrbenk et al., 2018). Prior studies have demonstrated comparable sensitivity, specificity, and positive

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predictive value for detection of hrHPV and Cervical Intraepithelial Neoplasia (CIN) 2+ when Xpert HPV is compared to other platforms (Einstein et al., 2014; Cuschieri et al., 2016). Comparison of self- versus clinician-collected cervical cytobrush specimens in low-resource settings has demonstrated good overall agreement when screened with Xpert HPV (Petignat et al., 2007; Arbyn et al., 2014).

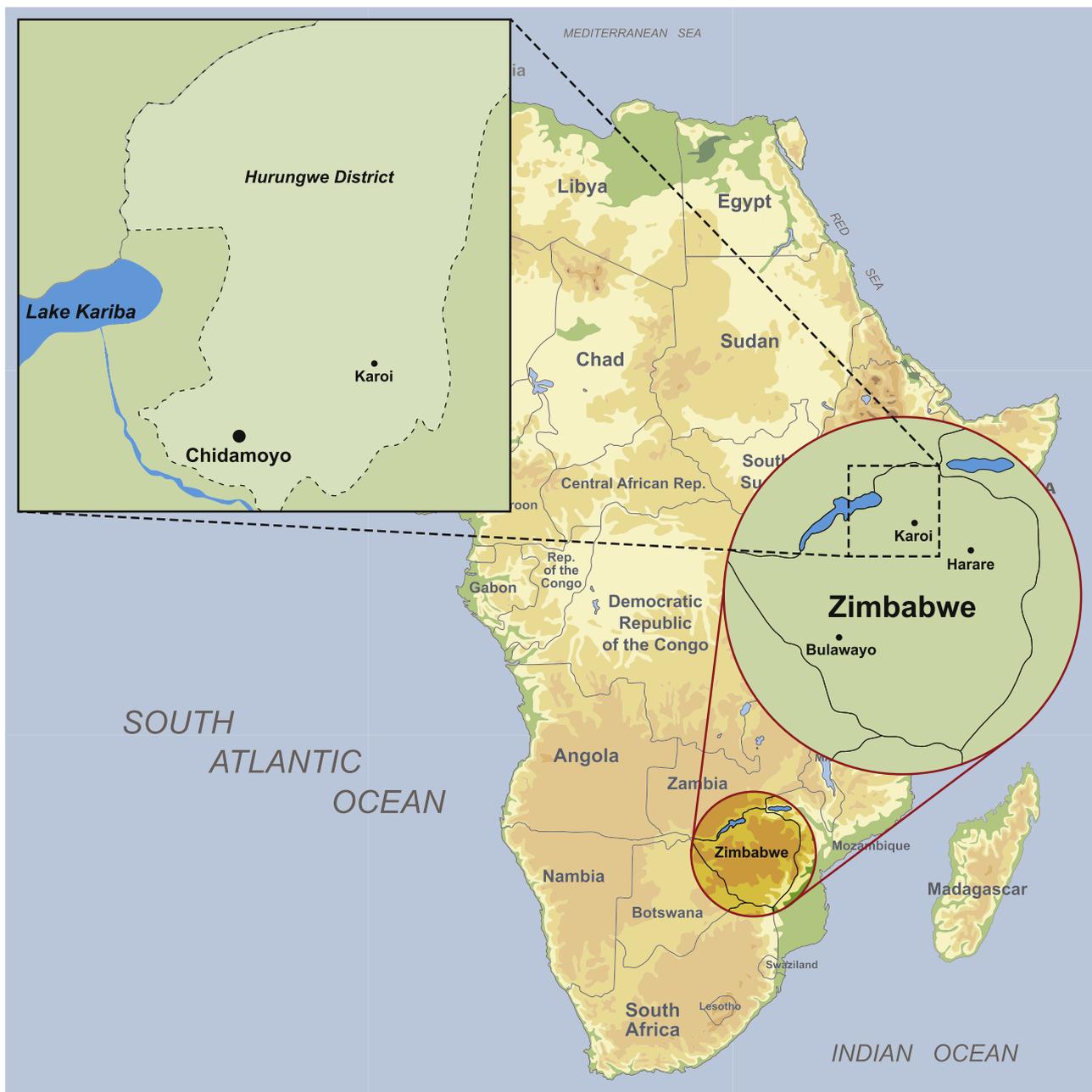
The current HPV vaccines include the quadrivalent vaccine (Merck, Whitehouse Station, NJ USA), directed at HPV types 6, 11, 16, and 18, and a bivalent vaccine which includes HPV16 and 18 only (GlaxoSmithKline, Rixensart, Belgium) (Crosbie et al., 2013; Allan et al., 2008). In addition, a nine-valent vaccine (Merck) is available which includes HPV16 and 18, as well as 5 additional high-risk types: 31, 33, 45, 52, and 58 (Crosbie et al., 2013). Despite the disproportionate burden of hrHPV infections and cervical cancer in LMIC, high income countries account for more than 70% of vaccinated women worldwide (Crosbie et al.,

2013; Black and Richmond, 2018; Bruni et al., 2016). An estimated 33.6% of women in high-income countries have received at least one dose of an HPV vaccine, compared to only 2.7% of women in less developed regions (Bruni et al., 2016). Additionally, most vaccine coverage and efficacy data are from high-income settings (de Sanjose et al., 2007; Jemal et al., 2013). In this study, we describe the hrHPV types found in rural Zimbabwe for consideration in cervical cancer screening and vaccination efforts.

## Materials and methods

### Study design and subject recruitment

The study was conducted from January 2017 to May 2017 in rural northwestern Zimbabwe (Hurungwe district in Mashonaland West)



**Figure 1.** A Community-based HPV Self-collection study in Rural Zimbabwe. Zimbabwe is a landlocked country in southern Africa bordered by Mozambique in the East, South Africa in the South, Botswana in the West, and Zambia in the North. This study took place in rural northwestern Zimbabwe, Hurungwe district in Mashonaland West. The study area was defined as Ward 13/15 and comprised 12 rural village center locations served by the Chidamoyo Christian Hospital.

with the study area defined as Ward 13/15 and comprised of 12 rural village center locations served by the Chidamoyo Christian Hospital (Figure 1). Three months prior to sample collection (October 2016), community health workers were provided training on cervical cancer and community screening methodologies and asked to submit complete lists of all women from 30 to 65 in their villages. Otherwise healthy, sexually active, non-pregnant women between the ages of 30–65 years-old with an intact uterus and no history of cervical neoplasia were eligible to participate in the study. No women were vaccinated for HPV. Women were recruited during community outreach days, which were conducted in parallel with scheduled Expanded Program for Immunization (EPI) campaigns and Antiretroviral (ART) medication outreach. Women were instructed on cervicovaginal self-collection in group sessions and individually with the aid of an illustrated guide. These sessions were conducted in Shona, the predominant language and ethnicity in this region of Zimbabwe. The samples were then transported daily to Chidamoyo Christian Hospital for hrHPV testing. 654 women provided self-collected cervicovaginal swabs in liquid-based cytology media.

#### Ethical consent

Ethical approval was granted by Stanford University (#37975), University of Zimbabwe (JREC 221/16), the Medical Research Council of Zimbabwe (MRCZ/A/2128), and the Research Council of Zimbabwe (No. 02921). In addition, the Provincial and District Medical Officers were notified, as well as headmen and villages during community meetings, after sensitization via training of community health workers prior to data collection. Women were informed that their participation was voluntary, they could withdraw at any time, that testing for HIV was available, but they could refuse this testing or refuse to be notified of their result, and that all information regarding their HIV and HPV status would be kept confidential. Inclusion took place after individual informed consent was signed electronically with a paper copy given to the participant. Informed consent (signature or witnessed thumbprint) was obtained from all participants prior to enrollment. Eligible women were interviewed by trained research data collectors on the research team using an electronic questionnaire to collect information on sociodemographic and reproductive information.

#### hrHPV nomenclature

Individual hrHPVs are referred to as types throughout, as described by de Villiers, (2013) and Bzhalava et al. (2015). The process of type determination is referred to as typing.

#### hrHPV screening

Self-collected, cervicovaginal cytobrush specimens were obtained using Cervex brushes collected in ThinPrep PreservCyt (Hologic, Marlborough, MA). Xpert HPV testing was conducted on a clinic-based GeneXpert in accordance with manufacturer's instructions. Invalid results (due to a negative sample adequacy control or sample processing control as defined in the manufacturer's manual) were rerun. If the sample failed twice, the participant was contacted for specimen recollection at a village outreach or Chidamoyo Christian Hospital.

The Xpert HPV test is a sample-to-answer, real-time PCR assay that simultaneously detects thirteen hrHPV types (HPV 16, 18, 31, 33, 35, 39, 45, 51, 52, 56, 58, 59, 68), and one possible hrHPV type (HPV 66). Each test also detects a human reference gene (hydroxymehtylbilane synthase, HMBS) to ensure sufficient cellularity of the specimen collection, and an internal Probe Check control that verifies reagent rehydration, reaction tube filling, probe integrity and dye stability. The 14 HPV types are detected in five fluorescent channels, each with individual parameters

for target detection and validity; channel 1: HPV16, channel 2: HPV18/45, channel 3: HPV31/33/35/52/58, channel 4: HPV51/59, channel 5: HPV 39/56/66/68. For channels in which more than one type is detected, the Xpert HPV test does not distinguish between types.

#### hrHPV typing

DNA was extracted from ThinPrep PreservCyt using the QIAgen DNA mini elute kit (Qiagen, Germantown, MD) per the manufacturer's instructions. hrHPV typing was performed using the Anyplex II HPV HR Detection kit on the BioRad CFX-96 thermocycler, per the manufacturer's instructions. This real-time PCR kit detects and distinguishes between the 14 HPV types detected by Xpert HPV (HPV16, 18, 31, 33, 35, 39, 45, 51, 52, 56, 58, 59, 66, 68).

#### Cytology

Liquid-based cytology specimens were collected by trained nurses and/or doctors with a Cervex brush at the time of Visual Inspection with Acetic Acid, prior to application of acetic acid, and stored in PreservCyt solution. The samples were then processed and ThinPrep slides were prepared. All slides were reviewed by two cytotechnologists (Stanford and Cimas Pathology Group, Zimbabwe) and a pathologist (Stanford) and the consensus diagnosis was used for analysis. Bethesda classification was used to classify lesions as atypical squamous cells of undetermined significance (ASCUS), atypical squamous cells – cannot rule out high-grade (ASCH), low-grade intraepithelial lesion (LSIL), high-grade intraepithelial lesion (HSIL), squamous cell carcinoma (SCC), atypical glandular cells (AGC), adenocarcinoma in situ (AIS), or adenocarcinoma (Solomon and Nayar, 2004). These lesions were then grouped into “Negative”, “Low-grade” (ASCUS, LSIL), and “High-grade” (HSIL, squamous cell carcinoma, adenocarcinoma or adenocarcinoma in situ).

#### HIV testing

HIV serologic testing was performed with the Zimbabwe Ministry of Health-provided 3rd generation Alere Determine HIV-1/2 test (Alere/Abbott, Lake Bluff, Illinois), a qualitative immunoassay for the detection of antibodies to HIV-1 and HIV-2. Reactive specimens were confirmed with the First Response, Rapid HIV 1–2 card test (Premier Medical Corporation Ltd., Kachigam, India), which is a second qualitative immuno-chromatographic test for the detection of antibodies to HIV-1 and HIV-2. The results were interpreted per manufacturer's instructions by Ministry of Health-trained HIV counselors.

#### Statistical analysis

Statistical analyses were performed using STATA, v. 14 (College Station, TX) and R software. A sample size of 700 women was calculated as sufficient to determine a difference for hrHPV infection/type with a power of 0.80, effect size of .25 and an alpha of 0.05 with proportionate sampling of villages of differing sizes to provide a population representative sample. Type-specific HPV prevalence was calculated with a 95% confidence interval (CI) among women enrolled in the study, determined by Clopper-Pearson analysis. A kappa statistic was used to compare the analytic agreement between Xpert HPV and Anyplex II HPV HR Detection on samples found to be positive initially by Xpert HPV testing.

## Results

### Characteristics of the study population

957 women ages 30–65 from rural Zimbabwe (Hurungwe district, Ward 13/15) were invited to participate in the study (Table 1).

Sociodemographic and reproductive information was collected via questionnaires administered by trained data collectors in Shona. The structured questionnaires were modeled on existing questionnaires used in other epidemiologic and local HPV studies in Zimbabwe (Dube Mandishora et al., 2017). Nineteen percent (123/643) of the study population was HIV-positive; 73% (90/123) of the HIV-positive women were on anti-retroviral treatment at the time of the study. The mean age of the 643 women was 43.8 (SD:±10.2), age of sexual debut was 18.0 (SD:±3.8). Mean parity was 4.0 (SD: ±3.0). Most women (47%) had O-level education. The majority of women use contraception (69.6%).

#### hrHPV screening

Valid hrHPV results were obtained from 99.1% (648/654) of self-collected samples on the near-point-of-care Cepheid Xpert HPV test. Among women with complete survey and hrHPV data, the hrHPV prevalence was 17.4% (112/643); 33% (41/123) vs. 13.7% (71/520) among HIV-1-positive and –negative participants, respectively ( $p \leq 0.001$ ). Among women with age data (N=599), the prevalence of hrHPV was 19% (51/265) among women <40-years-old, 18% (30/167) among 40–50-year-old women, and 13% (22/167) among women over 50. These results were not statistically significant, nor was there a statistical difference between HIV-positive and negative women.

#### Effect of HIV treatment on HPV status

Among HIV positive women, 72% (89/123) had been on anti-retroviral treatment (ART) for a known length of time, and 25.8% (23/89) of women on ART had hrHPV infections. There were also 9.7% (12/123) women that had not been on ART at the time of the study, and

**Table 1**  
Sociodemographic data.

Age in years, mean (SD)	43.8 (10.2)
Sexual debut, mean (SD)	18.0 (3.8)
Parity, median (IQR)	4.0 (3.0)
Education level, n (%)	
Did not attend school	142 (22.1%)
Primary school	159 (24.4%)
O level	303 (47.1%)
A level	2 (0.3%)
Unknown	39 (6.1%)
Partner circumcised, n (%)	
No	514 (88.5%)
Yes	32 (5.5%)
Don't know/not applicable	35 (6.0%)
Contraception, n (%)	
No	162 (26.0%)
Yes	434 (69.6%)
No answer	25 (4.0%)
HIV-1, n (%)	
Negative	520 (80.9%)
Positive	123 (19.1%)
On ART, n (%)	
No	12 (9.8%)
Yes	89 (73.0%)
Unknown	20 (16.4%)
Duration on ART (years), median (IQR)	5 (2–7)
Cytologic results, n = 76 (%)	
Low-grade lesions	
ASCUS	12 (15.8%)
LSIL	2 (2.6%)
High-grade lesions	
ASC-H	2 (2.6%)
HSIL	12 (15.8%)
AGUS	3 (3.9%)
AIS	1 (1.3%)
NILM	44 (57.9%)
UNSAT	3 (3.9%)

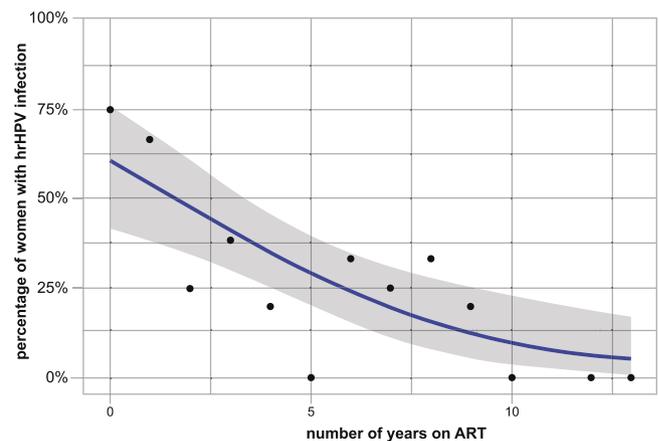
75% (9/12) of them had hrHPV infections. Treatment duration had a significant effect on hrHPV prevalence ( $p \leq 0.001$ ; Figure 2). Overall, a longer period of ART decreased the probability of being HPV positive. Women not on antiretroviral treatment differed slightly by age category: 12% (6/48) among women under 40, 21% (7/33) among women 40–50, and 18% (3/17) in women over 50.

#### Cervical cytology

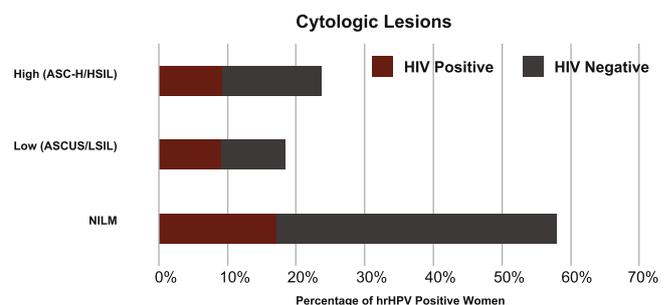
Of the hrHPV positive women, 76 women received cytology testing. Cervical cytology was considered negative for intraepithelial lesions among 58% (44/76), 18% (14/76) were characterized as either ASCUS or LSIL, and 24% (18/76) were considered high-grade lesions including AIS, AGC, HSIL, or ASC-H (Figure 3). Among HIV-positive women, 48% (13/27) had negative cytology, 26% (7/27) had ASCUS or LSIL, and the remaining 26% (7/27) had AIS, AGC, HSIL, or ASC-H. We did not reach statistical power to infer hrHPV type differential risk of cytological lesions.

#### Xpert HPV typing

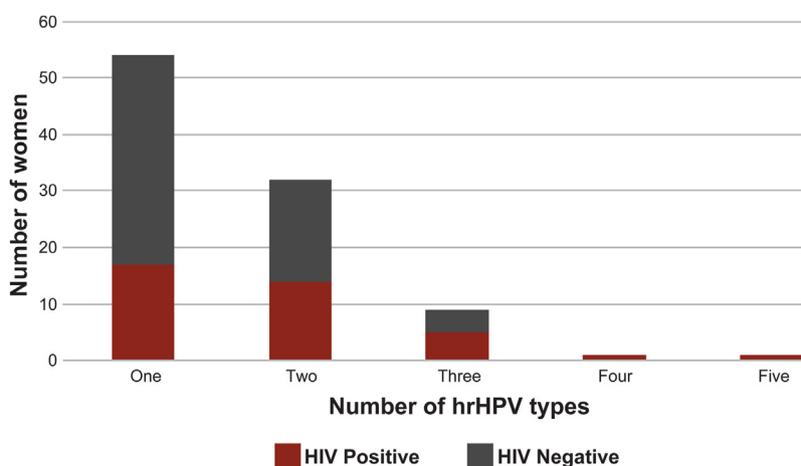
Xpert HPV typing revealed that 13% (15/112) of the Xpert hrHPV positive women had an HPV16 infection (channel 1), including 5%



**Figure 2. Duration of Antiretroviral Therapy (ART) and probability of hrHPV infection.** The percentage of women with an hrHPV infection as a function of years on antiretroviral therapy. The black dots represent the hrHPV infection rate by year of ART. The blue curve shows the fit of the data to a binomial generalized linear model and the gray area indicates the 95% confidence interval.



**Figure 3. Distribution of cytologic lesions in the hrHPV study population.** The percentage of hrHPV-positive women with and without cytological findings. Cytologic lesions were classified based on Bethesda criteria. Low-grade lesions included atypical squamous cells of undetermined significance (ASCUS) and low-grade intraepithelial lesions (LSIL) [Low (ASCUS, LSIL)]. High-grade lesions included atypical squamous cells – cannot rule out high-grade (ASC-H) and high-grade intraepithelial lesions (HSIL) [High (ASC-H/HSIL)]. NILM, negative for intraepithelial lesion or malignancy. The percentage of HIV-positive (crimson bars) and HIV-negative women (grey bars) are indicated.

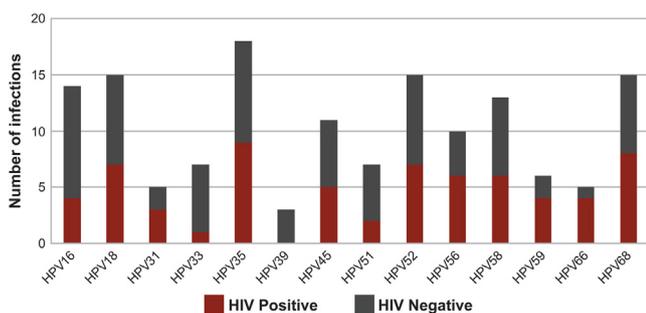


**Figure 4.** hrHPV-positive women may be infected with multiple hrHPV types. The number of HIV-positive (crimson bars) and HIV-negative women (grey bars) are plotted on the Y-axis with the number of hrHPV types detected by the Anyplex II HPR Detection kit on the X-axis.

(6/112) infected with one or more additional hrHPV types (channel 1 plus any other channel). Twenty-six percent (29/112) were infected with HPV18/45 (channel 2), including 8% (9/112) infected with one or more additional hrHPV types (channel 2). hrHPV 'other' accounted for 71% (80/112, channels 3, 4, 5) of the infections. Four women had infections detected in three separate Xpert channels: two with HPV18, category 3, and category 5 infections; one with HPV16, category 3, and category 5 infections; and another with HPV16, HPV18, and category 3 infections simultaneously. HPV31-related infections (HPV31, 33, 35, 52, 58; channel 3) were the most common 'other' classification (48%, 54/112). No statistical differences between HIV-positive versus -negative women were identified.

#### Anyplex hrHPV typing

Eighty six percent (97/112) of the Xpert HPV positive specimens were available for hrHPV typing with the Anyplex II HPV HR Detection kit. Though the percentage of HIV-positive women [55.0% (21/38)] infected with multiple HPV types was higher than in HIV-negative women [37.0% (22/59)], this difference did not reach statistical significance ( $p=0.063$ ) (Figure 4). The most common types were HPV16, HPV18, HPV35, HPV52, HPV58, and HPV68, each of which appeared in 14 to 19 infections (14–20% of infections; Figure 5). There was no statistical difference among HIV-positive and HIV-negative women.



**Figure 5.** Anyplex hrHPV typing reveals the presence of non-HPV16/18 types. The number of infections among HIV-positive (crimson bars) and HIV-negative women (grey bars) is plotted on the Y-axis with the hrHPV type determined by the Anyplex II HPR Detection kit listed on the X-axis.

#### Xpert hrHPV typing compared to Anyplex hrHPV typing

89.8% (97/108) of the women tested by both Xpert HPV and Anyplex II HPV HR Detection had Xpert HPV typing data available for comparison. For each woman and each Xpert HPV category, it was determined whether Anyplex II HPV HR Detection identified one of the HPV types in that category (Table 2). Overall, Xpert and Anyplex typing provided good agreement (77.7%, kappa=0.703).

#### Potential impact of HPV vaccines

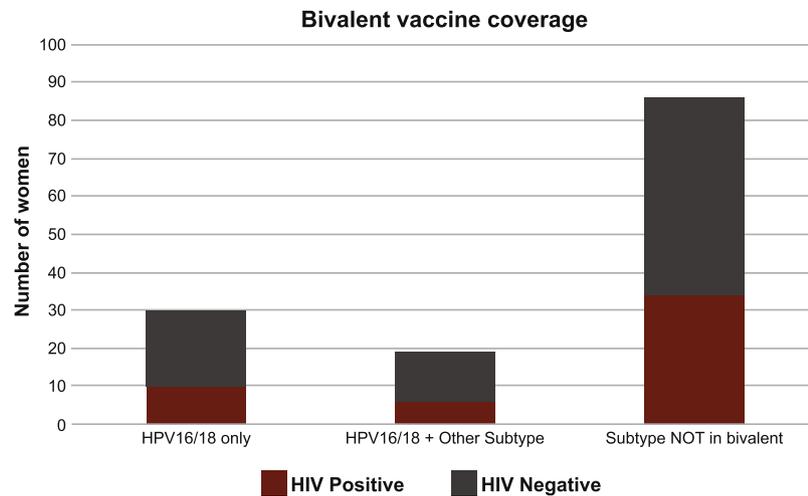
The bivalent and quadrivalent vaccines include HPV16 and 18 virus-like-particles, while the nine-valent vaccine incorporates 5 additional high-risk types (HPV31, 33, 45, 52 and 58). Sixty-nine percent (67/97) of women in the study had at least one of the 12 hrHPV types not present in the bivalent vaccine (HPV16/18; Figure 6). Of these, 32% (31/97) had at least one hrHPV type not included in the nine-valent vaccine. Overall, 30 women in the hrHPV-positive group had only types not covered by the nine-valent vaccine (30.9% of hrHPV-positive women; Figure 7).

#### Discussion

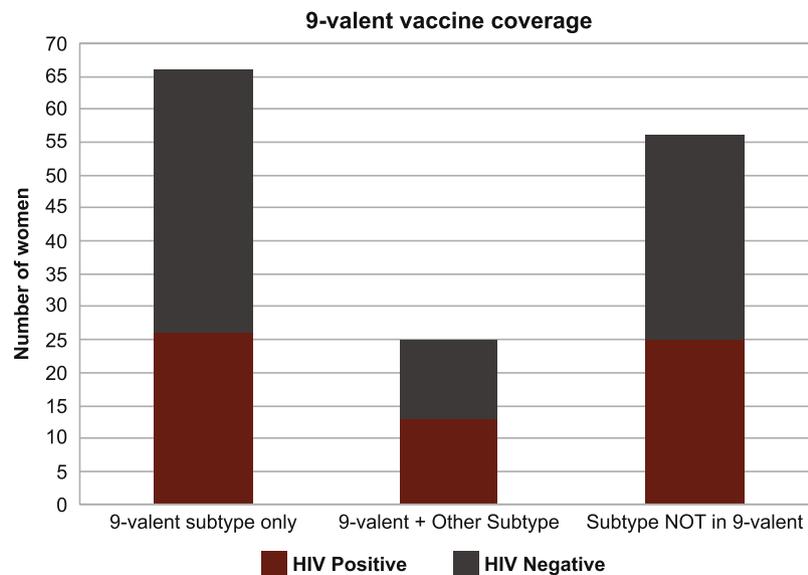
High-risk human papillomavirus is the causative agent of cervical cancer (Walboomers et al., 1999; Ferlay et al., 2015). The prevalence of hrHPV and cervical cancers have increased in the last few decades, especially in LMIC where 80% of new cervical cancer diagnoses are made (Crosbie et al., 2013). Effective prevention of hrHPV via vaccination and the timely detection and treatment of precancerous lesions are essential for cervical cancer control. While HPV vaccination has potent prophylactic efficacy against targeted HPV types, vaccination rates remain low in many LMICs (Schiller and Lowy, 2018; Gallagher et al., 2018). Furthermore, not

**Table 2**  
Comparison of Xpert and Anyplex hrHPV typing.

		Xpert					Total
		Ch1	Ch2	Ch3	Ch4	Ch5	
Anyplex	Ch1	11	1	2	0	1	15
	Ch2	0	21	3	1	1	26
	Ch3	3	4	49	0	1	57
	Ch4	1	1	0	14	0	16
	Ch5	5	3	4	2	20	34
	Total	20	30	58	17	23	148



**Figure 6. Predicted vaccine coverage using an HPV 16 and HPV 18 vaccine.** Number of women (Y-axis) predicted to be covered by a bivalent vaccine given the hrHPV types identified in this study. The number of HIV-positive (crimson bars) and HIV-negative women (grey bars) are indicated.



**Figure 7. Predicted vaccine coverage using the nine-valent hrHPV vaccine.** Number of women (Y-axis) predicted to be covered by the nine-valent vaccine given the hrHPV types identified in this study. The number of HIV-positive (crimson bars) and HIV-negative women (grey bars) are indicated.

all carcinogenic types are cross-covered by existing vaccines, necessitating continued cervical cancer screening for disease resulting from infection with a non-vaccine type (Paz-Zulueta et al., 2018).

Most hrHPV prevalence studies are performed in urban referral centers, which introduces potential bias due to self-selection of women who can afford/seek care (Cuddeback et al., 2004). In contrast, our study was designed to assess the population prevalence of hrHPV in rural Zimbabwe, and self-collection methods achieved higher participation rates (Catarino et al., 2015; Verdoodt et al., 2015; Gupta et al., 2018).

The hrHPV prevalence by GeneXpert HPV testing among women 30–65 who participated in our study was 17%. Most HPV prevalence studies have been conducted in urban centers among women with known cervical lesions, where the prevalence of HPV infections is higher, in the range of 50–99% (Chin'ombe et al., 2014; Dube Mandishora et al., 2017; Mudini et al., 2018). A prior population-based rural cross-sectional study in Zimbabwe found a total HPV prevalence (low-risk and high-risk) of 27% (Baay et al., 2004). This

prevalence is higher than studies from the United States and Europe, but lower overall than other studies from SSA with similar prevalence of HIV (19% in the present study) (Grulich et al., 2007; Franceschi et al., 2006; Forman et al., 2012; Cubie et al., 2017).

We found that hrHPV infection was more common among HIV-positive women compared to HIV-negative women, and that the duration of ART decreased the risk of infection. Our findings are consistent with a recent meta-analysis that found that >2 years on ART and a low virus load (defined as less than 1000 copies/mL) significantly decreased both hrHPV prevalence and the incidence of CIN2+ (Kelly et al., 2018). HIV-infected women have an increased prevalence of hrHPV infection and the early development of cervical cancers; therefore, initiation and maintenance of ART is crucial (Kelly et al., 2018; Konopnicki et al., 2016). In addition, HPV vaccination and vigilant screening programs should be adopted to address the continued need for cervical cancer prevention (Black and Richmond, 2018).

Types other than HPV16 and 18 are common in the Hurungwe district of Zimbabwe, specifically types HPV35, HPV52, and HPV68.

High-risk HPV data is limited from rural Zimbabwe, with other data available only from Baay et al. (Baay et al., 2004), who also detected high levels of types other than HPV16 and 18. Regional studies from Malawi and Mozambique have also found similar hrHPV prevalence (Castellsague et al., 2008; Cubie et al., 2017).

Two of the most frequently detected hrHPV types in our study (HPV35, HPV68) are **not** included in any hrHPV vaccine (Black and Richmond, 2018). Given that vaccine efficacy has not been consistently demonstrated against non-vaccine types such as HPV35 or HPV68 (Wheeler et al., 2012; Woestenberg et al., 2018), further work is required to understand cross-protection (Malagon et al., 2012).

Limitations of this study include the lack of cytologic data for all participants with hrHPV infections, as well as the absence of cervical biopsy correlation, as cytology alone has imperfect sensitivity, and may classify precancerous lesions incorrectly (Solomon and Nayar, 2004; Sinha et al., 2018; Bigoni et al., 2015). In addition, this study was designed to characterize hrHPV prevalence and type distribution at a population level in rural Zimbabwe and did not evaluate the hrHPV types present in cervical cancers in this population. However, studies from Zimbabwe, Malawi, Tanzania, and South Africa emphasize that hrHPV types not included in the available vaccines are present in a substantial proportion of cervical pre-cancerous lesions and invasive carcinomas in the region (Chin'ombe et al., 2014; Allan et al., 2008; Stanczuk et al., 2003; Said et al., 2009; Dols et al., 2012; Howitt et al., 2017).

Our findings, when combined with these regional studies on invasive cervical cancers, demonstrate the importance of types other than HPV16 and 18 in vaccine coverage as well as cancer surveillance in SSA. While HPV vaccination is of critical importance in these populations, it may not obviate the need for continued cervical cancer screening in the coming decades. Additionally, it may be useful in the future for commercial kits to detect and report all high-risk types for risk stratification given the varying carcinogenicity of types and regional variation of hrHPV (Cubie et al., 2017; Dols et al., 2012; Schiffman et al., 2009).

## Conclusions

Our study adds to the region-specific hrHPV type distribution and carcinogenicity among an understudied rural African population. Community-based cervicovaginal self-collection with near-point-of-care GeneXpert HPV testing identified women at high-risk for cervical cancer in this rural, low-resource setting. hrHPV infections were common (17% overall); more so in HIV-positive women. Our results emphasize the continued importance of cervical cancer screening and prophylactic HPV vaccinations in rural Zimbabwe, particularly among HIV positive women. hrHPV types not commonly identified in high-resource settings were prevalent in our study (HPV35, HPV52, HPV58, HPV68). The nine-valent HPV vaccine includes most of the additional types identified in our study. Notable exceptions are HPV35 and HPV68.

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## Competing interests

None declared.

## Author contributions

MBF, RM, DAK, KM, ZMC, and BAP conceived and planned the study. MBF, RM, and ZMC obtained IRB approvals. MBF, KM, JW, MKS, JM, and BAP collected the study data, and MBF, KM, DAK, JW, MKS, JM, and BAP contributed to the interpretation of the results. MBF took the lead in writing the manuscript. All authors provided critical feedback and helped shape the research, analysis, and manuscript.

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