JIDC | THE JOURNAL OF INFECTION IN DEVELOPING COUNTRIES

*Original Article*

# Human papillomavirus DNA detection in cervical samples from women of reproductive age in Mogadishu, Somalia

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## Abstract

Introduction: Somalia is among the countries with a high burden of human papillomavirus (HPV) infection in Sub-Saharan Africa. In 2022, 660,000 infections are reported among women globally, out of which 350,000 died from the disease. Most of the studies on HPV reported from Somalia are based on cytologic analysis which is a subjective and suboptimal assessment. The recent World Health Organization (WHO) guidelines for HPV recommend DNA-based testing as a better alternative to the traditional pap smear test.

Methodology: This study was undertaken to determine the prevalence of HPV based on the preferred HPV DNA assay on cervical samples of women of reproductive age in Mogadishu, Somalia. The HPV DNA detection was carried out using real-time quantitative polymerase chain reaction (RT-PCR) assays to identify high-risk oncogenic HPV16, HPV18, and other high-risk HPV types.

Results: Overall, 31.7% (60/189) of cervical samples were positive for HPV DNA. Out of this, 19.6% were high risk-HPV (hrHPV), 13.8% were HPV16, and 5.3% were HPV18. Moreover, age, income and education level were found to be significant risk factors for HPV infection.

Conclusions: These results provide further proof that HPV continues to be a serious public health challenge in Somalia with the risk of progressing to fatal cervical cancer.

**Key words:** human papillomavirus; cervical cancer; risk factors; HPV-DNA; Somalia.

*J Infect Dev Ctries* 2024; 18(11):1746-1755. doi:10.3855/jidc.19982

(Received 10 February 2024 – Accepted 27 March 2024)



## Introduction

Infection with the human papillomavirus (HPV), typically transmitted during sexual intercourse, is the most significant risk factor for cervical cancer [1]. The majority of HPV infections resolve spontaneously and do not cause clinical disease. However, persistent infection with specific types of HPV may lead to precancerous lesions, and if untreated, to invasive cancer some years later [2]. In 2022, cervical cancer was found to be the 4$^{th}$ most common cancer in women globally, where an estimated 660,000 women were diagnosed with the disease and about 350,000 women died from it [3]. African counties make up 16 of the 20 countries with the highest incidence of cervical cancer and the highest incidence among these were reported in 2018 in East Africa with 52,633 new cases and 37,017 deaths [4]. There is insufficient data on the incidence of the disease in Somalia. Nevertheless, cervical cancer is recognized as a major public health problem. The Somali National Bureau of Statistics estimated in 2020 that 1,055 women are diagnosed with cervical cancer annually, of which 812 die from the disease [5]. This is significant considering that with a total population of 18.1 million, reproductive aged women (15–49 yrs) are 4.8 million amounting to 37.7% of the total population [6,7]. Furthermore, a 2023 report from the HPV

information center indicated that cervical cancer is the 2nd most common cancer among all women in Somalia as well as the 2nd most frequent cancer among women between 15 and 44 years of age [6].

According to another report by the HPV Information Centre, the most prevalent oncogenic types among women in East Africa are HPV16, followed by HPV18 and HPV52 [8]. Recently, diversity of HPV types within and across East African countries has been reported [6,9]. HPV cannot be cultured reliably in a laboratory setting and the popular cytological screening tests are often erroneous. Therefore, HPV diagnostics rely on molecular technologies that detect HPV-DNA in cervical/vaginal samples. This technique is also able to identify the various HPV types including the high-risk HPV types that account for over 70% of cervical cancers. Moreover, primary high-risk HPV (hrHPV) DNA screening has been shown to be more effective and cost-effective than cytology screening for the detection of pre-malignant and malignant cervical lesions [2,3].

In many high-income countries, the incidence and mortality of cervical cancer have decreased significantly following screening programs designed to detect and treat pre-cancerous lesions [3]. Somalia has serious challenges in its healthcare delivery system and does not currently have a national screening program for cervical cancer. Moreover, substantive evidence relating to knowledge, attitudes and participation rates of Somali women in cervical screening is lacking.

Therefore, this study aimed to determine the prevalence of HPV and its subtypes, as well as assess the knowledge about cervical cancer and its associated risk factors among women of reproductive age in Mogadishu, Somalia.

## Methodology

*Ethical considerations*

The study was conducted in compliance with the approval and recommendations granted by the ethics review board of the SIMAD University, Mogadishu, Somalia (Ref. No.: 2022/IMRSU/FMHS/FR18/P049). All the patients/parents and guardians of the research subjects were informed about the study's purpose and their written informed consent was obtained before enrollment.

*Study design and settings*

This study employed a mixed-methods design, including both primary analysis of quantitative laboratory data from real-time polymerase chain reaction (RT-PCR) screening of the cervical smear samples collected, and qualitative data collection and analysis. A qualitative descriptive study design using semi-structured questionnaire interviews was used to explore perceptions of cervical cancer and its associated risk factors among women in Mogadishu, Somalia.

The study was conducted at the Dr Sumait hospital where genital samples were collected from consenting patients, and each participant was interviewed to assess their knowledge and awareness of cervical cancer and factors that predispose to cervical cancer.

*Study population*

The study participants comprised women who were residents of the capital city Mogadishu, Somalia, which is a densely populated area housing close to 2.7 million people, including most of the internally displaced population (IDP) camp residents in Somalia [10]. The survey comprised of systematic collection of socio-demographic and clinical information from the consenting patients, followed by collection of a vaginal swab.

*Sample size*

According to Tahtabasi *et al.* [11], the prevalence of cervical cancer in Somalia is 13.3%. We used Cochran's formula for sample size calculation:

$N = Z^2 \times P\ (1 - |P) \div \varepsilon^2$

where, Z is 1.96 (constant), e is the desired level of precision (i.e. 5% margin of error at 95% confidence interval), p is the reported prevalence (13.3%), and q is 1 – p.

Therefore

$N = Z^2 \times P\ (1\text{-}P) \div \varepsilon^2$

$N = 3.8416 \times 0.133\ (1\text{-}0.133) \div 0.0025$

$N = 177.19$ samples

However, 189 samples were collected to increase the chances of detection.

*Sampling method*

The convenience sampling technique was used to recruit participants who agreed to enroll in the study. Clinical examination involved a gynecological examination with inspection of the cervix uteri and specimen collection by a gynecologist in a separate room in the hospital. All sexually active women attending the hospital's gynecology unit and who gave informed verbal consent were included in the study, regardless of their age.

*Study materials*

The data were collected by interviewing the participants using a questionnaire that sought to

understand the socioeconomic and demographic characteristics, in addition to the knowledge, and awareness of the participants on cervical cancer and its associated risk factors. The questionnaire was adapted from a previous published report with some slight modifications [12]. The questionnaire was administered in English or Somali language, depending on the preference of the participant.

Cervical cytology samples were collected using the cervi-broom specimen collection kit (DiaPath S.p.A, Martinengo, Italy) and transported in a specimen bottle containing universal transport medium. About 10 mL of the cervical samples were centrifuged at 2000 rpm for 15 minutes for cervical cells concentration. The sedimented cell pellet was then resuspended in 2.5 mL of phosphate buffered saline (PBS) and then aliquoted in 500 µL volume and stored at -20 °C until required for DNA extraction.

*DNA extraction*

DNA extraction from a 500 µL cell pellet aliquot of cervical sample was carried out using the silica-based (spin column) viral nucleic acid isolation kit (Jiangsu BioPerfectus Technology Ltd., Taizhou, China) according to the manufacturer's protocol. Briefly, the stored samples were thawed, washed with PBS, and centrifuged again at 2000 rpm for 10 minutes at room temperature. The supernatant was eliminated, and the sediment was resuspended and treated with lysis buffer and proteinase K. The DNA was finally isolated by eluting 50 µL after multiple wash steps.

*HPV detection and subtyping*

HPV DNA amplification was carried out using the HPV RT-PCR in-vitro diagnostic (IVD) kit (Jiangsu BioPerfectus Technology Ltd., Taizhou, China), for the detection of 18 HPV types (16, 18, 31, 33, 35, 39, 45, 51, 52, 56, 58, 59, 66, 68, 73, 53, 82, and 26) in cervical exfoliated cells in one reaction tube. The kit's high risk HPV genotype-specific assays allow for the detection of HPV16, HPV18, and other HPV types alongside internal control (β-globin) using fluorescence channels (FAM, VIC, ROX and CY5 respectively) which are among the high-risk types most frequently associated with cervical cancer development in the geographical area. The primers and probes in the kit are designed to target the L1, L2, and E1 genes of the 18 high-risk HPV types. The amplification was performed using LineGene 9600 device (Bioer Technology, Hangzhou, China) using thermal cycling conditions that comprised of one cycle of uracil N-glycosylase (UNG) treatment at 50 °C for 5 minutes, followed by pre-denaturation at 95 °C for 10 minutes, denaturation at 95 °C for 15 seconds, and then 45 cycles of annealing, extension, and fluorescent signal collection at 58 °C for 50 seconds.

*Data analysis*

Data generated from the questionnaire and laboratory investigation was entered into an Excel spreadsheet, coded, and then analyzed using the SPSS statistical software v27. (IBM® SPSS® Statistics, IBM Corp, Armonk, NY, USA). The data was summarized using descriptive statistics. The prevalence of cervical cancer was calculated as the number of RT-PCR positive patients divided by the total number of patients examined, multiplied by 100 [13]. Logistic regression in univariate and multivariate models was used. Variables with a $p$ value < 0.25 in the univariate logistic regression model were candidates for multivariate logistic regression analysis. In multivariate logistic regression analysis, variables with a $p$ value < 0.05 were considered statistically significant.

*Quality control*

As a means of quality control, the questionnaire prepared to assess the sociodemographic traits and potential risk factors for cervical cancer was pre-tested before the main study on patients. The questionnaire was subjected to the item objective congruence validation that involved three external expert evaluations [14]. In addition, a pilot study involving 30 participants with different demographics from our target population was done to ascertain the questionnaire's reliability and clarity to the respondents. This was achieved after Cronbach's alpha value of 0.71 was obtained. The data was collected by trained healthcare workers under the supervision of a senior medical officer/gynecologist. In the case of the RT-PCR assay, the BioPerfectus HPV test kit included a positive and negative control panel to ensure that false negative results are not recorded. Prior to evaluation of the study specimen, the procedure was conducted on the positive and negative controls and interpreted to conform with the kit's specifications. Additionally, the kit contained a ready-to-use master mix, with uracil-DNA glycosylase and dUTPs that helped eliminate possible carryover contamination.

## Results

*Prevalence of human papillomavirus (HPV)*

Samples with a DNA amplification were set as "positive", and samples which had too low or undetectable.

**Figure 1.** Fluorescence signals (colored) indicating amplification curves of the HPV subtypes and controls. An amplification curve corresponding to the cut-off cycle threshold for each target HPV DNA indicates positive amplification.

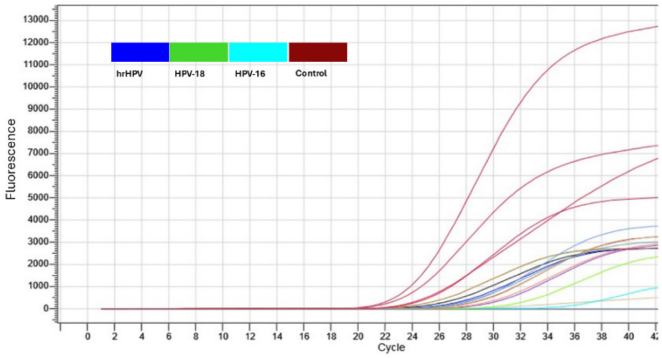


**Table 1.** Prevalence of human papillomavirus (HPV).

| Prevalence of HPV | n (%) | 95% CI |
|---|---|---|
| **Overall HPV Status** | | |
| Negative | 129 (68.3) | 60.9–74.6 |
| Positive | 60 (31.7) | 25.4–39.1 |
| **hrHPV** | | |
| Positive | 37 (19.6) | 13.8–25.4 |
| Negative | 152 (80.4) | 74.6–86.2 |
| **HPV16** | | |
| Positive | 26 (13.8) | 9.0–19.0 |
| Negative | 163 (86.2) | 81.0–91.0 |
| **HPV18** | | |
| Positive | 10 (5.3) | 2.1–9.0 |
| Negative | 179 (94.7) | 91.0–97.9 |

hrHPV: high risk human papillomavirus; CI: Confidence Interval.

**Table 2.** Multivariate logistic regression to determine relationship between sociodemographic characteristics and human papillomavirus (HPV) infection.

| Characteristics | Overall HPV Status | | Total n (%) | OR (95% CI) | *p* value | AOR (95 % CI) | *p* value |
|---|---|---|---|---|---|---|---|
| | Positive n (%) | Negative n (%) | | | | | |
| **Age group** | | | | | | | |
| 17–27 years | 14 (23) | 47 (77) | 61 (32.3) | 1.00 | | 1.00 | |
| 28–38 years | 33 (35.5) | 60 (64.5) | 93 (49.2) | 0.54 (0.26–1.13) | 0.10 | 0.50 (0.24–1.07) | 0.074 |
| 38–60 years | 13 (37.1) | 22 (62.9) | 35 (18.5) | 0.50 (0.20–1.25) | 0.14 | 0.46 (0.19–1.17) | 0.104 |
| Mean = 31.71 ± 8.905 years | | | | | | | |
| **Marital status** | | | | | | | |
| Married | 55 (30.9) | 123 (69.1) | 178 (94.2) | 1.86 (0.55–6.37) | 0.32 | | |
| Divorced/widowed | 5 (45.5) | 6 (54.5) | 11 (5.8) | 1.00 | | | |
| **Education** | | | | | | | |
| Informal | 21 (36.2) | 37 (63.8) | 58 (30.7) | 1.00 | | | |
| Primary school | 18 (29.5) | 43 (70.5) | 61 (32.3) | 1.35 (0.62–2.92) | 0.44 | | |
| Secondary school | 10 (35.7) | 18 (64.3) | 28 (14.8) | 1.02 (0.40–2.62) | 0.96 | | |
| Post-secondary | 11 (26.2) | 31 (73.8) | 42 (22.2) | 1.60 (0.67–3.82) | 0.29 | | |
| **Employment status** | | | | | | | |
| Employed | 14 (29.8) | 33 (70.2) | 47 (24.9) | 1.12 (0.55–2.31) | 0.74 | | |
| Unemployed | 46 (32.4) | 96 (67.6) | 142 (75.1) | 1.00 | | | |
| **Economic status** | | | | | | | |
| Less than $100 | 17 (39.5) | 26 (60.5) | 43 (22.8) | 1.00 | | | |
| $100 –$500 | 35 (28.7) | 87 (71.3) | 122 (64.6) | 0.16 (0.79–3.36) | 0.19 | | |
| > $500 | 8 (33.3) | 16 (66.7) | 24 (12.7) | 1.30 (0.46–3.72) | 0.62 | | |
| **Avoiding unprotected sexual intercourse is a preventive measure against cervical cancer** | | | | | | | |
| No | 52 (39.4) | 80 (60.6) | 132 (69.8) | 1.73 (0.91–3.33) | 0.10 | 1.87 (0.96–3.64) | 0.064 |
| Yes | 18 (31.6%) | 39 (68.4) | 57 (30.2) | 1.00 | | 1.00 | |
| **Early sexual activity is a risk factor for cervical cancer** | | | | | | | |
| No | 53 (36.3) | 93 (63.7) | 146 (77.2%) | 1.78 (0.88–3.60) | 0.11 | | |
| Yes | 17 (39.5) | 26 (60.5) | 43 (22.8) | 1.00 | | | |
| **Long-term use of contraceptives is a risk factor for cervical cancer** | | | | | | | |
| No | 51 (36.7) | 88 (63.3) | 139 (73.5) | 1.01 (0.51–2.00) | 0.96 | | |
| Yes | 19 (38) | 31 (62) | 50 (26) | 1.00 | | | |
| **Multiple sexual partners is a risk factor for cervical cancer** | | | | | | | |
| No | 54 (39.1) | 84 (60.9) | 138 (73) | 0.41 (0.09–1.93) | 0.26 | | |
| Yes | 16 (31.4) | 35 (68.6) | 51 (27) | 1.00 | | | |
| **Multiparity is a risk factor for cervical cancer** | | | | | | | |
| No | 66 (37.3) | 111 (62.7) | 177 (93.7) | 1.58 (0.81–3.09) | 0.18 | | |
| Yes | 4 (33.3) | 8 (66.7) | 12 (6.3) | 1.00 | | | |
| **Smoking is a risk factor for cervical cancer** | | | | | | | |
| No | 63 (38.2) | 102 (61.8) | 165 (87.3) | 0.68 (0.26–1.83) | 0.45 | | |
| Yes | 7 (29.2) | 17 (70.8) | 24 (12.7) | 1.00 | | | |

AOR: adjusted odds ratio; OR: odds ratio.

DNA quality and no amplification were set as "negative". In the case of HPV16, if the Ct value was ≤ 35.4, the specimen was considered positive, otherwise, the specimen was considered negative.

Similarly, a sample was considered positive for HPV18 if the Ct value was ≤ 34.6. Likewise, a sample was positive for other HPV types if the Ct value was ≤ 33.6. In all other circumstances, the sample was considered negative. Based on these criteria, the overall prevalence of HPV was 60 (31.7%), representing women who were found to be positive for one or more of the hrHPVs investigated. Positive detection was indicated by a fluorescence signal detection in the FAM (HPV16), VIC (HPV18), and ROX (hrHPV) channels in correspondence with the positive control (Figure 1).

The results also revealed that 26.7% of the HPV DNA positive women had infection with multiple subtypes, while the specific prevalence for each of the major HPV subtypes was 19.6%, 13.8%, and 5.3% for hrHPV, HPV16, and HPV18 respectively (Table 1).

*Correlation between HPV infection and sociodemographic characteristics*

The majority (55%), of the 31.7% women who had HPV infection were aged 28–38 years, with a mean age of 31.71 years and a standard deviation of 8.905 years. Similarly, most of the women with HPV infection were married (91.6%) and unemployed (76.7%). Regarding education levels, the majority (35%) had informal education, 30% had primary education, 16.7% had secondary education, and 18.3% had post-secondary education. In terms of economic status, most (58.3%) earned between USD 100 and USD 500 monthly, 28.3% earned less than USD 100 monthly, and 13.3% earned over USD 500 monthly (Table 2).

In the univariable logistic regression model, only 2 variables (age and economic status) were significantly

**Table 3.** Sociodemographic characteristics and risk factors associated with high-risk human papillomavirus (HPV).

| Characteristics | High-risk HPV | | Total n (%) | OR (95% CI) | *p* value | AOR (95 % CI) | *p* value |
|---|---|---|---|---|---|---|---|
| | Positive n (%) | Negative n (%) | | | | | |
| **Age group** | | | | | | | |
| 17–27 years | 14 (23.0) | 47 (77.0) | 61 (32.3) | 1.00 | | | |
| 28–38 years | 33 (35.5) | 60 (64.5) | 93 (49.2) | 1.48 (0.69–3.19) | 0.316 | | |
| 38–60 years | 13 (6.9) | 22 (62.9) | 35 (18.5) | 3.79 (1.02–14.11) | 0.047 | | |
| Mean = 31.71 ± 8.905 years | | | | | | | |
| **Marital Status** | | | | | | | |
| Married | 55 (30.9) | 123 (69.1) | 178 (94.2) | 1.55 (0.40–6.30) | 0.511 | | |
| Divorced / Widowed | 5 (45.5) | 6 (54.5) | 11 (5.8) | 1.00 | | | |
| **Education** | | | | | | | |
| Informal education | 21 (36.2) | 37 (63.8) | 58 (30.7) | 3.47 (1.31–9.23) | 0.013 | 2.84 (1.03–7.81) | 0.043 |
| Primary school | 18 (29.5) | 43 (70.5) | 61 (32.3) | 3.68 (1.39–9.76) | 0.009 | 3.22 (1.19–8.74) | 0.021 |
| Secondary school | 10 (35.7) | 18 (64.3) | 28 (14.8) | 2.03 (0.68–6.13) | 0.205 | 2.12 (0.70–6.42) | 0.183 |
| Post-secondary | 11 (26.2) | 31 (73.8) | 42 (22.2) | 1.00 | | 1.00 | |
| **Employment status** | | | | | | | |
| Employed | 14 (29.8) | 33 (70.2) | 47 (24.9) | 1.03 (0.45–2.39) | 0.932 | | |
| Unemployed | 46 (32.4) | 96 (67.6) | 142 (75.1) | 1.00 | | | |
| **Economic status** | | | | | | | |
| < $100 | 17 (39.5) | 26 (60.5) | 43 (22.8) | 1.00 | | | |
| $100–$500 | 35 (28.7) | 87 (71.3) | 122 (64.6) | 0.44 (0.16–1.23) | 0.118 | | |
| > $500 | 8 (33.3) | 16 (66.7) | 24 (12.7) | 0.65 (0.16–2.73) | 0.564 | | |
| **Avoiding unprotected sexual intercourse is a preventive measure against cervical cancer** | | | | | | | |
| No | 37 (28.0) | 95 (72.0) | 132 (69.8) | 0.15 (0.73–3.27) | 0.259 | | |
| Yes | 23 (40.4) | 34 (59.6) | 57 (30.2) | 1.00 | | | |
| **Early sexual activity is a risk factor for cervical cancer** | | | | | | | |
| No | 42 (28.8) | 104 (71.2) | 146 (77.2) | 1.33 (0.59–3.04) | 0.490 | | |
| Yes | 18 (41.9) | 25 (58.1) | 43 (22.8) | 1.00 | | | |
| **Long-term use of contraceptives is a risk factor for cervical cancer** | | | | | | | |
| No | 44 (31.7) | 95 (68.3) | 139 (73.5) | 1.03 (0.46–2.33) | 0.930 | | |
| Yes | 16 (32.0) | 34 (68.0) | 50 (26.5) | 1.00 | | | |
| **Multiple sexual partners is a risk factor for cervical cancer** | | | | | | | |
| No | 40 (29.0) | 98 (71.0) | 138 (73.0) | 1.00 (0.45–2.26) | 0.995 | | |
| Yes | 20 (39.2) | 31 (60.8) | 51 (27.0) | 1.00 | | | |
| **Multiparity is a risk factor for cervical cancer** | | | | | | | |
| No | 58 (32.8) | 119 (67.2) | 177 (93.7) | 1.40 (0.36–5.46) | 0.626 | | |
| Yes | 2 (16.7) | 10 (83.3) | 12 (6.3) | 1.00 | | | |
| **Smoking is a risk factor for cervical cancer** | | | | | | | |
| No | 54 (32.7) | 111 (67.3) | 165 (87.3) | 1.09 (0.38–3.15) | 0.868 | | |
| Yes | 6 | 18 (75.0) | 24 (12.7) | 1.00 | | | |

AOR: adjusted odds ratio; OR: odds ratio.

associated with HPV infection. These variables were selected as candidates for inclusion in the multivariable logistic regression analysis. The variables with *p* values less than 0.05 were considered statistically significant and are presented in Table 2. The multivariate logistic regression analysis revealed no significant associations with HPV infection. However, factors that were close to being associated with HPV infection were age group and those who did not avoid unprotected sexual intercourse. Adjusted odds ratio (AOR) at 95% confidence interval (CI) showed that women aged 28–38 years had a higher risk of HPV infection than women aged 17–27 years (AOR = 0.50, 95% CI = 0.241–1.068, $p = 0.074$). Women who did not avoid unprotected sexual intercourse had a higher risk of HPV infection than women who avoided unprotected sexual intercourse (AOR = 1.87, 95% CI = 0.964–3.643, $p = 0.064$) (Table 2).

*Sociodemographic characteristics and their association with hrHPV*

In the univariable logistic regression model, only 3 variables, age, education and economic status, were significantly associated with the other 16 hrHPVs (31, 33, 35, 39, 45, 51, 52, 56, 58, 59, 66, 68, 73, 53, 82, and 26). These variables were further selected as candidates for inclusion in the multivariable logistic regression, and variables with *p* values less than 0.05 were considered statistically significant and are presented in Table 3. In the multivariable logistic regression model, women who had informal education were 2.84 times (95% Cl = 1.034–7.814) more likely to have any of the 16 hrHPV infections compared to those with post-secondary education. In addition, those with primary education were 3.22 times (95% CI = 1.191–8.744) more likely to become infected with any of the HPV subtypes classified under the high-risk HPV compared to those with post-secondary education (Table 3).

**Table 4.** Multivariate logistic regression for sociodemographic characteristics and human papillomavirus 16 (HPV16).

| Characteristics | HPV 16 | | Total n (%) | OR (95% CI) | *p* value | AOR (95% CI) | *p* value |
|---|---|---|---|---|---|---|---|
| | Positive n (%) | Negative n (%) | | | | | |
| **Age group** | | | | | | | |
| 17–27 years | 6 (9.8) | 55 (90.2) | 61 (32.3) | 1.00 | | | |
| 28–38 years | 16 (17.2) | 77 (82.8) | 93 (49.2) | 0.52 (0.19–1.43) | 0.398 | | |
| 38–60 years | 4 (11.4) | 31 (88.6) | 35 (18.5) | 0.80 (0.85–0.22) | 0.207 | | |
| Mean = 31.71, SD ± 8.905 | | | | | | | |
| **Marital status** | | | | | | | |
| Married | 24 (13.5) | 154 (86.5) | 178 (94.2) | 1.42 (0.29–7.00) | 0.662 | | |
| Divorced/Widowed | 2 (18.2) | 9 (81.8) | 11 (5.8) | 1.00 | | | |
| **Education** | | | | | | | |
| Informal | 8 (13.8) | 50 (86.2) | 58 (30.7) | 1.00 | | | |
| Primary School | 10 (16.4) | 51 (83.6) | 61 (32.8) | 0.81 (0.30–2.24) | 0.693 | | |
| Secondary School | 3 (10.7) | 25 (89.3) | 28 (14.8) | 1.33 (0.33–5.47) | 0.689 | | |
| Post-secondary | 5 (11.9) | 37 (88.1) | 42 (22.2) | 1.18 (0.36–3.91) | 0.782 | | |
| **Employment status** | | | | | | | |
| Employed | 7 (14.9) | 40 (85.1) | 47 (24.9) | 0.88 (0.35–2.25) | 0.794 | | |
| Unemployed | 19 (13.4) | 123 (86.6) | 142 (75.1) | 1.00 | | | |
| **Economic status** | | | | | | | |
| < $100 | 3 (7.0) | 40 (93.0) | 43 (22.8) | 1.00 | | | |
| $100–$500 | 19 (15.6) | 103 (84.4) | 122 (64.6) | 0.40 (0.11–1.45) | 0.165 | | |
| > $500 | 4 (16.7) | 20 (83.3) | 24 (12.7) | 0.37 (0.07–1.84) | 0.227 | | |
| **Avoiding unprotected sexual intercourse is a preventive measure against cervical cancer** | | | | | | | |
| No | 16 (12.1) | 116 (87.9) | 132 (69.8) | 1.54 (0.65–3.64) | 0.323 | | |
| Yes | 10 (17.5) | 47 (82.5) | 57 (30.2) | 1.00 | | | |
| **Early sexual activity is a risk factor for cervical cancer** | | | | | | | |
| No | 19 (13.0) | 127 (87.0) | 146 (77.2) | 1.30 (0.51–3.34) | 0.586 | | |
| Yes | 7 (16.3) | 36 (83.7) | 43 (22.8) | 1.00 | | | |
| **Long-term use of contraceptives is a risk factor for cervical cancer** | | | | | | | |
| No | 19 (13.7) | 120 (86.3) | 139 (73.5) | 1.02 (0.40–2.62) | 0.954 | | |
| Yes | 7 (14.0) | 43 (86.0) | 50 (26.5) | 1.00 | | | |
| **Multiple sexual partners is a risk factor for cervical cancer** | | | | | | | |
| No | 18 (13.0) | 120 (87.0) | 138 (73.0) | 1.24 (0.50–3.01) | 0.640 | | |
| Yes | 8 (15.7) | 43 (84.3) | 51 (27.0) | 1.00 | | | |
| **Multiparity is a risk factor for cervical cancer** | | | | | | | |
| No | 26 (14.7) | 151 (85.3) | 177 (93.7) | - | 0.999 | | |
| Yes | 0 | 12 (100) | 12 (6.3) | 1.00 | | | |
| **Smoking is a risk factor for cervical cancer** | | | | | | | |
| No | 24 (14.5) | 141 (85.5) | 165 (87.3) | 0.53 (0.12–2.42) | 0.416 | | |
| Yes | 2 (8.3) | 22 (91.7) | 24 (12.7) | 1.00 | | | |

AOR: adjusted odds ratio; OR: odds ratio.

*Sociodemographic characteristics and their association with HPV16*

In the univariable logistic regression model, only 2 variables, age and economic status, were found to be significantly associated with HPV16 infection. Multivariate logistic regression analysis revealed that none of the variables had significant association with HPV16 infection. (Table 4).

*Sociodemographic characteristics and their association with HPV18*

In the univariable logistic regression model, only 2 variables, avoiding unprotected sexual intercourse and long-term contraceptives, were significantly associated with HPV18 infection at a significance level of $p < 0.25$. These variables were selected as candidates for inclusion in the multivariable logistic regression analysis, and variables with $p$ values less than 0.05 were considered statistically significant and are presented in Table 5. After the inclusion of the multivariable regression model, there were no factors significantly associated with HPV18 infection (Table 5).

## Discussion

Cervical cancer continues to cause high mortality rates among women globally. The situation is even worse among women living in resource-limited countries such as Somalia, which is experiencing protracted conflict and humanitarian crisis. In order to address this global public health challenge, the World Health Organization (WHO) and the Human Reproduction Program have developed a new guideline to enable early and effective detection and treatment of this devastating disease. The Global Strategy for Cervical Cancer Elimination recommends that 70% of the women population globally should be screened regularly using a high-performance HPV DNA test. The HPV-DNA test was recommended because of its

**Table 5.** Sociodemographic characteristics and risk factors associated with human papillomavirus 18 (HPV18).

| Characteristics | HPV 18 | | Total n (%) | OR (95% CI) | *p* value | AOR (95 % CI) | *p* value |
|---|---|---|---|---|---|---|---|
| | Positive n (%) | Negative n (%) | | | | | |
| **Age group** | | | | | | | |
| 17–27 years | 3 (4.9) | 58 (95.1) | 61 (32.3) | 1.00 | | | |
| 28–38 years | 7 (7.5) | 86 (92.5) | 93 (49.2) | 0.63 (0.16–2.56) | 0.523 | | |
| 38–60 years | 0 | 35 (100) | 35 (18.5) | - | 0.998 | | |
| Mean = 31.71 ± 8.905 years | | | | | | | |
| **Marital Status** | | | | | | | |
| Married | 10 (10) | 168 (94.4) | 178 (94.2) | - | - | | |
| Divorced/widowed | 0 | 11 (100) | 11 (5.8) | 1.00 | | | |
| **Education** | | | | | | | |
| Informal | 6 (10.3) | 52 (89.7) | 58 (30.7) | 1.00 | | | |
| Primary School | 0 | 61 (100) | 61 (32.3) | - | - | | |
| Secondary School | 1 (3.6) | 27 (96.4) | 28 (14.8) | 3.11 (0.36–27.22) | 0.304 | | |
| Post-secondary | 3 (7.1) | 39 (92.9) | 42 (22.2) | 1.50 (0.35–6.37) | 0.583 | | |
| **Employment status** | | | | | | | |
| Employed | 4 (8.5) | 43 (91.5) | 47 (24.9) | 0.4 (0.13–1.76) | 0.265 | | |
| Unemployed | 6 (4.2) | 136 (95.8) | 142 (75.1) | 1.00 | | | |
| **Economic status** | | | | | | | |
| < $100 | 2 (4.7) | 41 (95.3) | 43 (22.8) | 1.00 | | | |
| $100–$500 | 7 (5.7) | 115 (94.3) | 122 (64.6) | 0.89 (0.08–10.37) | 0.927 | | |
| > $500 | 1 (4.2) | 23 (95.8) | 24 (12.7) | | | | |
| **Avoiding unprotected sexual intercourse is a preventive measure against cervical cancer** | | | | | | | |
| No | 4 (3.0) | 128 (97.0) | 132 (69.8) | 3.76 (1.02–13.90) | 0.047 | | |
| Yes | 6 (10.5) | 51 (89.5) | 57 (30.2) | 1.00 | | | |
| **Early sexual activity is a risk factor for cervical cancer** | | | | | | | |
| No | 9 (6.2) | 137 (93.8) | 146 (77.2) | 0.36 (0.05–2.94) | 0.342 | | |
| Yes | 1 (2.3) | 42 (97.7) | 43 (22.8) | 1.00 | | | |
| **Long-term use of contraceptives is a risk factor for cervical cancer** | | | | | | | |
| No | 5 (3.6) | 134 (96.4) | 139 (73.5) | 2.97 (0.82–10.76) | 0.096 | | |
| Yes | 5 (10.0) | 45 (90.0) | 50 (26.5) | 1.00 | | | |
| **Multiple sexual partners is a risk factor for cervical cancer** | | | | | | | |
| No | 6 (4.3) | 132 (95.7) | 138 (73.0) | 1.87 (0.51–6.93) | 0.347 | | |
| Yes | 4 (7.8) | 47 (92.2) | 51 (27.0) | 1.00 | | | |
| **Multiparity is a risk factor for cervical cancer** | | | | | | | |
| No | 10 (5.6) | 167 (94.4) | 177 (93.7) | - | 0.999 | | |
| Yes | 0 | 12 (6.3) | 12 (6.3) | 1.00 | | | |
| **Smoking is a risk factor for cervical cancer** | | | | | | | |
| No | 10 (6.1) | 155 (93.9) | 165 (87.3) | - | 0.998 | | |
| Yes | 0 | 24 (100) | 24 (12.7) | 1.00 | | | |

AOR: adjusted odds ratio; OR: odds ratio.

superiority over the popular subjective cytologic tests in detecting the high-risk strains of HPV which are the cause for almost all cervical cancers [15].

In this study, the overall frequency of HPV-DNA was 31.7%, which represents samples from all women with one or more of the HPV subtypes (HPV16, HPV18, and hrHPV). This result is consistent with the 31% global pooled prevalence reported among women, and slightly lower than the 34% pooled incidence proportion of estimates for 19 Sub-Saharan countries [16,17]. However, the result of this study is higher than the recently published 24% prevalence of cervical HPV among women in sub-Saharan Africa [3]. The high prevalence of HPV recorded in this study could be attributed to the dire economic situation in the country limiting access to screening and early treatment, socio-economic determinants (such as age and economic status) affecting utilization of services, as well as the global HPV vaccine inequity driven by the inadequate supply and access to HPV vaccination, screening, and treatment services [18]. Addressing this important public health challenge would require considerable investment into provision of screening and treatment services, which have proven to be effective as demonstrated in developed countries which consistently report of reduced incidence of the disease.

This study found a significant association between HPV, and age (28–38 years) and economic status (unemployment). This finding is similar to a study on age of acquiring HPV infection using a simulation model which found that 75% of HPV infection occurs among 31 years old women [19]. Similar to most sexually transmitted infections, young and middle-aged people are more prone to these diseases due to risk factors such as increased tendency to engage with multiple sex partners and failure to do routine screening. Our finding that 75% of the unemployed women were HPV positive is consistent with other studies reporting association between HPV infection with unemployment and low-income [20]. It is highly likely that unemployed individuals would equally be in the low-income earner category which is known to be associated with poor health seeking behaviors and increased risk of contracting sexually transmitted infections [20–22].

The WHO guideline for screening and treatment of cervical cancer recommends the use of DNA-based HPV testing as a first-choice screening method as it is effective in detecting HPV and is less prone to human errors when compared to the highly subjective cytology method (pap smear) [18,23].

In this study, the HPV-DNA analysis revealed a substantially higher prevalence of hrHPV (19.6%), followed by HPV16 (13.8%), and HPV18 (5.3%). Available reports show that in Somalia and most of the East Africa region, 4.7% of women in the general population carry HPV16 and HPV18 [8]. This is in congruence with a systematic review of HPV infection in Sub-Saharan Africa which revealed that the most common HPV subtype detected based on a broad-spectrum DNA PCR test showed that HPV16 predominated with 38.5% in Mali, 16.7% in Uganda, and 81.8% in Tanzania [9,24–26]. HPV16 and HPV18 are known to be responsible for 70% of all genital cancers according to WHO [27]. Among the other 16 hrHPV types, 19.6% of the women studied were found to harbor HPV 31, 33, 35, 39, 45, 51, 52, 56, 58, and 59. These other HPV types are commonly associated with several types of cancers including cancers of the vulva, vagina, penis, anus, and the oropharynx [28,29]. These findings highlight the need for the procurement of polyvalent vaccines that can confer protection against HPV16, HPV18, and other high-risk HPVs for the Somali population.

Multivariate logistic regression analysis did not identify any statistically significant relationship between infection with HPV16, 18, and hrHPV and the women's sociodemographic and risk factor characteristics, except for educational level, where significant association was found ($p < 0.05$) between women with informal education and infection with hrHPV. Among the many documented risk factors that predispose women to HPV infection, illiteracy or low-level educational status has been consistently found to be significant [30,31]. Being educated is synonymous with being aware and knowledgeable about HPV, which in turn translates to favorable attitudes towards prevention of the disease. Notwithstanding, educated individuals have been found to exhibit poor attitude towards cervical cancer screening and prevention. Despite the lack of statistical significance for some of the risk factors studied, earlier reports show that prevalence of HPV infection and viral genotypes correlate with sexual activity (multiple sexual partners), age, smoking, and long-term use of contraceptives among others. Therefore, it has become necessary to plan for targeted education to the younger population, as well as provision of screening and treatment services in order to effectively prevent and control HPV infection in the country.

## Conclusions

This study provides further evidence that HPV DNA analysis is a suitable and sensitive technique for the detection of HPV and its subtypes compared to the subjective pap smear test. This is in line with the recommendation of WHO which is advocating for a shift in priority testing technique for HPV. The study also revealed high rates of HPV infection, predominantly the high-risk strains of the virus, in our population. This means that many women of child bearding age in Somalia are potentially at risk of developing cancers related to these infections. Somalia in a country with almost no cancer treatment facilities at present and the majority of the population are poor who must pay out of pocket for health care. However, long term and more diverse studies including populations from rural areas where healthcare service is grossly inadequate are required to further evaluate the prevalence of HPV among the general population in Somalia.

*Strength and limitations*

This was a single hospital-based study; hence it will not suffice to infer the findings to the general population. In addition, we used the BioProfectus HPV DNA testing kit which identifies HPV16, HPV18, and 16 other high-risk types in a pool. Therefore, we could not determine specifically the prevalence of the other 16 hrHPV subtypes. Notwithstanding, the DNA-based testing method used in this study has demonstrated it efficiency, not only at detecting HPV infection, but also identifying the circulating subtypes in the study area.

## Acknowledgements

The authors would like to acknowledge Dr Sumait Hospital, SIMAD University, Mogadishu, Somalia, and the other data collectors. We would also like to express our gratitude to the SIMAD university Centre for Research and Development for their kind support.

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**Conflict of interests:** No conflict of interests is declared.