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Acting on the Call Towards Elimination: Diagnostic Accuracy and Acceptability of Human Papilloma Virus Self-Sampling Versus Clinician-Collected Specimens in Bahrain

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Abstract

Background

Cervical cancer remains a significant public health challenge in Bahrain, where screening is largely opportunistic and uptake is suboptimal. Human papillomavirus (HPV) self-sampling has demonstrated diagnostic accuracy comparable to clinician-collected specimens in multiple settings and may offer a culturally congruent strategy to expand participation in cervical cancer screening, particularly in conservative communities where embarrassment related to intimate examination is a well-documented barrier. This study evaluated the feasibility, diagnostic accuracy, and acceptability of HPV self-sampling compared with clinician-collected specimens among women in Bahrain.

Methods

This cross-sectional diagnostic accuracy and feasibility study was conducted at King Hamad University Hospital and Primary Health Care Centres in Bahrain between July and August 2025. Women aged 21–65 years attending gynaecology or women screening clinics were recruited, enriched with a purposively selected subgroup of women with confirmed HPV-positive status from the colposcopy clinic. Each participant self-collected a cervical sample using the Rovers Cervex-Brush® deposited in PreservCyt® liquid medium, followed immediately by a clinician-collected specimen using the same device and transport medium as the reference standard. Both specimens were analysed using the Cobas® HPV test (Roche Molecular Systems). Agreement between methods was assessed using Cohen's kappa coefficient (κ), and diagnostic performance was reported as sensitivity, specificity, and predictive values with 95% Wilson confidence intervals. Acceptability and screening preferences were assessed via a structured 15-item questionnaire.

Results

Sixty-one women were enrolled; 53 evaluable paired specimens were available for diagnostic analysis after excluding invalid and missing results. The clinician-collected reference standard identified 7 HPV-positive cases (13.2%). Against this reference, self-collected specimens achieved a sensitivity of 85.7% (95% CI: 48.7%–97.4%), specificity of 100.0% (95% CI: 92.3%–100.0%), positive predictive value of 100.0%, and negative predictive value of 97.9% (95% CI: 88.9%–99.6%). Observed agreement was 98.1%, and Cohen's kappa was 0.91 (95% CI: 0.74–1.00). Invalid result rates were identical across both collection methods (3.6%). Self-sampling instructions were rated as clear by 94.5% of participants, 80.0% found the procedure easy, and only 18.2% reported discomfort. More than half of the women (56.4%) preferred self-sampling for their next screening episode. No statistically significant associations were found between screening preference and age, education level, or HPV vaccination status.

Conclusions

HPV self-sampling using a liquid-medium brush device is technically feasible and yields results in very good agreement with clinician-collected specimens among Bahraini women. Self-sampling was broadly acceptable across diverse sociodemographic backgrounds, with privacy and convenience identified as primary drivers. These preliminary findings support the case for a larger, adequately powered validation study and highlight the potential of self-sampling as a strategy to expand cervical cancer screening participation in Bahrain, contributing to the WHO 2030 elimination agenda.

Keywords: Cervical Cancer Screening; Uterine Cervical Neoplasm; Papillomavirus infection; HPV self-sampling; diagnostic accuracy; acceptability; Bahrain; Middle East; Human Papillomavirus Viruses; feasibility study

Introduction

Cervical cancer remains a major global public health challenge, ranking as the fourth most common cancer among women worldwide, with an estimated 604,000 new cases and 342,000 deaths recorded in 2020 [1]. The overwhelming majority of this burden falls on low- and middle-

income countries, yet cervical cancer is largely preventable through vaccination against human papillomavirus (HPV) and effective screening programmes. In response, the World Health Organization (WHO) issued a global call to action in 2020 to eliminate cervical cancer as a public health problem, setting ambitious targets for vaccination coverage, screening uptake, and treatment of pre-cancerous lesions by 2030 [2].

In Bahrain, cervical cancer ranks as the eighth most common cancer among women, with approximately 21 new cases and 12 deaths annually among a population of over 410,000 women aged 15 years and older at risk [3]. While HPV vaccination was recently incorporated into Bahrain's National Immunization Programme for boys and girls aged 12–13 years, secondary prevention through systematic screening remains a critical gap. Cervical cancer screening in Bahrain is largely opportunistic, contingent on patient–physician encounters, resulting in an estimated uptake of approximately 40% [4]. Given that population-level benefits of HPV vaccination will take at least two decades to accrue, expanding screening participation is imperative to avert a surge in advanced-stage cervical cancer in the interim period.

The landscape of cervical cancer screening has shifted substantially in recent years. Randomised controlled trials across Europe have demonstrated that HPV-based screening affords superior protection against incident cervical precancer and cancer compared with cytology-based strategies [5, 6]. Reflecting this evidence, the American Cancer Society updated its guidelines in 2020 to recommend primary HPV testing every five years as the preferred screening option for individuals aged 25–65 years, a position subsequently endorsed by the WHO in its 2021 guideline update [7, 8]. HPV testing offers several practical advantages over conventional cytology: it requires less operator expertise, permits longer and safer screening intervals, and critically, is compatible with self-collected specimens, a feature that has transformative implications for programme design and population reach [6].

A substantial body of evidence now supports the diagnostic accuracy of HPV testing on self-collected vaginal samples. A landmark meta-analysis by Arbyn et al. encompassing over 56 studies demonstrated that self-samples analysed with PCR-based assays achieve sensitivity and specificity for cervical precancer comparable to clinician-collected specimens[9]. Beyond accuracy, self-sampling has consistently demonstrated higher participation rates than clinic-based invitation strategies: a systematic review of ten randomised trials documented a 2.1-fold increase

in screening participation when self-sampling kits were offered compared with invitations to attend for a clinician-collected Pap smear [10]. These findings have driven the integration of self-sampling into national cervical cancer screening programmes in several high-income countries, including the Netherlands [11], Australia [12], and Norway [13].

Despite this global momentum, evidence from the Middle East and the Gulf Cooperation Council (GCC) region remains scarce. This gap is particularly consequential because cultural factors, including embarrassment related to intimate examinations, limited access to female gynaecologists, and reluctance to attend clinic-based screening, represent well-documented barriers to cervical cancer screening participation in conservative communities[14, 15]. Self-sampling offers a uniquely promising solution in this context, enabling women to collect specimens privately without the need for a pelvic examination or direct contact with a healthcare provider, thereby directly addressing the principal barriers to participation.

Furthermore, the evidence base for self-sampling has predominantly been generated in European and high-income Western settings, with limited data on the accuracy, acceptability, and feasibility of this approach among Middle Eastern and Arab populations. Variability in self-sampling performance across different devices, transport media, and clinical settings necessitates context-specific validation before implementation in any new population or health system. This principle has been affirmed by multiple researchers, who emphasise the importance of pilot and validation studies prior to integration of self-sampling into population-based screening programmes [16].

The present study was designed to address this gap. The primary objective of this study is to determine the feasibility, acceptability, and screening performance of self-collected cervical samples for HPV testing, compared to clinician-collected samples.

Methods

Study design and Setting

This cross-sectional diagnostic accuracy and feasibility study was conducted at King Hamad University Hospital (KHUH) and Primary Health Care Centres (PHC) in Bahrain between 1 July and 31 August 2025. As recruitment did not reach the originally planned sample size, the study is reported as a feasibility study, with diagnostic accuracy results treated as preliminary and

exploratory rather than definitive. All participants were analysed collectively as a single cohort; however, two participant subgroups: a community screening sample and an enrichment sample of women with previously documented HPV positivity, are described separately.

Participants

The study was conducted among women attending Gynaecological clinic at KHUH and women screening clinics at PHC in Bahrain, enriched with a subset of HPV-positive women from the colposcopy clinic at KHUH to ensure adequate representation across the disease spectrum.

Two subgroups were recruited. The community screening sample consisted of women aged 21–67 years attending the Gynaecological clinic at KHUH and women screening clinics at PHC for routine checkups. The enrichment sample consisted of women referred to the colposcopy clinic at KHUH with confirmed HPV-positive status documented within the preceding 12 months, regardless of the degree of cytological abnormality, in whom no treatment had yet been initiated. This enrichment strategy was intended to increase representation of HPV-positive cases and improve the statistical precision of diagnostic estimates; however, due to low recruitment from this arm, the two subgroups were not compared analytically and are reported descriptively only.

Exclusion criteria applied to both subgroups were: current pregnancy or within the first six weeks of the puerperium; absence of a cervix due to prior hysterectomy or trachelectomy; active vaginal bleeding at the time of sample collection; and, for the enrichment subgroup only, prior treatment for cervical lesions.

Pilot study and device selection

Prior to the main study, a proof-of-concept pilot evaluation was conducted in four women with previously confirmed HPV-positive or HPV-negative results to assess the feasibility of two self-sampling workflows. Workflow A used a sterile viscose swab with a polystyrene stem inserted into a sterile polypropylene tube with a hemispherical bottom (reference 300252; Delatalab, Barcelona), processed on the Cobas® platform. Workflow B used the Rovers Cervex-Brush® (Rovers Medical Devices B.V., Oss, The Netherlands) deposited into a 20 mL vial of PreservCyt® Solution (ThinPrep System, Hologic, MA, USA). Both workflows were compared against an HPV PCR reference standard. The Cervex-Brush®-based workflow demonstrated superior concordance with the reference standard and was selected for use in the main study.

Data collection and sampling procedure

Participants were approached by their treating physicians, who explained the study objectives and obtained written informed consent. Each participant received a self-sampling kit containing the Rovers Cervex-Brush® device accompanied by standardised verbal and written instructions (illustrated brochure) for self-collection. Participants were asked to perform self-collection on-site, in a private area of the clinic, during the same visit in which the clinician-collected sample was to be taken. Self-collection was performed first, in keeping with the approach used by Gibert et al., who reasoned that the use of the speculum for clinician collection is more invasive and could reduce the cellular yield of a subsequently obtained self-sample[17]. Immediately following self-collection, a trained healthcare provider collected the clinician-obtained cervical sample.

Clinician-collected samples were obtained by gently inserting a disposable Cusco's bivalved speculum into the introitus at a 45° angle, which was then horizontalised and used to locate the cervix. A small amount of water or a water-soluble gel without carbomers was permitted to facilitate insertion. The Rovers Cervex-Brush® was used to collect exo- and endocervical cells simultaneously, and the sample was deposited into a 20 mL vial of PreservCyt® Solution (ThinPrep System, Hologic, MA, USA). Both self- and clinician-collected specimens were transferred to the laboratory at KHUH at room temperature on the same day as collection. Laboratory personnel were blinded to the collection method.

Following sample collection, participants completed a brief structured questionnaire administered by trained medical students. The study-specific questionnaire was developed after reviewing the relevant literature [18, 19] and expert review. The questionnaire consisted of two main sections. The first section (Questions 1–9) collected sociodemographic information. The second section assessed women’s perceptions and experiences regarding cervical cancer self-sampling (Questions 14–24), while Question 25 explored participants’ preferred method for their next cervical cancer screening. The questionnaire items were transferred to a Google Forms platform, allowing participants to complete the survey electronically. The questionnaire is provided as a Supplementary file.

HPV analysis

HPV testing was performed on all specimens using the Cobas® HPV test (Roche Molecular Systems, CA, USA), which provides individual genotype results for HPV 16 and HPV 18 and a pooled result for 12 additional high-risk genotypes reported as "others". The clinician-collected sample served as the reference standard against which the self-collected sample was compared.

Sample size

The original sample size calculation was conducted to estimate the sensitivity and specificity of HPV self-sampling against the clinician-collected HPV PCR reference standard, using a binomial precision approach with 95% confidence intervals. Assuming sensitivity of 0.90 and specificity of 0.95, and acceptable CI half-widths of ≤12.5% and ≤7.5% respectively, the minimum required numbers were approximately 20 women with confirmed HPV positivity (enrichment stratum) and 60 community recruits, in whom an HPV prevalence of approximately 9% was assumed. A total recruitment target of 80 women was set.

Recruitment fell short of this target due to slower-than-anticipated enrolment across both sites and particularly low uptake from the enrichment arm. As a result, the study is reported as a feasibility study. Diagnostic accuracy estimates are presented with 95% confidence intervals and should be interpreted as preliminary, with the understanding that precision is limited by the available sample size.

Statistical analysis

Descriptive statistics were used to summarise participants' sociodemographic characteristics, with means ± standard deviation or medians with interquartile range for continuous variables, and frequencies with percentages for categorical variables. The two recruitment subgroups (community screening and enrichment) are described separately in the sociodemographic summary, though all diagnostic analyses were performed on the combined cohort.

Diagnostic performance of self-collected samples relative to clinician-collected samples was evaluated and reported as sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). Agreement between self- and clinician-collected results was quantified using the percentage of absolute agreement and Cohen's kappa coefficient (κ), with 95% confidence intervals. Kappa values were interpreted as follows: less than 0, no agreement; 0.00–

0.20, poor; 0.21–0.40, fair; 0.41–0.60, moderate; 0.61–0.80, substantial; and greater than 0.80, very good agreement.

For comparisons of proportions from independent groups, Fisher's exact test was used for 2×2 contingency tables. For paired proportions, the McNemar test was applied. All p-values were derived from two-sided tests, with statistical significance set at $p < 0.05$.

Ethical approval

Ethical approval was obtained from the Research Ethics Committees of RCSI Bahrain, the PHCs, and KHUH. All participants provided written informed consent , and participation was entirely voluntary with no impact on clinical care. Data were treated confidentially and analysed in de-identified form. The study adhered to the principles of the Declaration of Helsinki and applicable data protection standards.

Results

Participants

A total of 61 women were enrolled between July 1 and August 31, 2025. Of these, 57 (93.4%) were recruited from the community screening arm (women screening clinics) and 4 (6.6%) from the enrichment arm (colposcopy clinic, with confirmed HPV-positive status).

Of the 61 enrolled participants, 55 had questionnaire data available; 6 had missing data across all survey variables and are reported as system missing throughout. Complete paired HPV results (both clinician-collected and self-collected specimens with valid assay outputs) were available for 53 participants. Eight pairs were excluded from diagnostic analysis: four participants had missing specimens on both sides (patients 27, 48, 52, and 60), two had an invalid clinician-collected result (patients 25 and 28), one had an invalid clinician-collected result paired with a valid self-collected result (patient 47), and one had a valid clinician-collected positive result paired with an invalid self-collected result (patient 24).

Sociodemographic Characteristics

Sociodemographic characteristics of the 55 participants with available questionnaire data are presented in Table 1. The median age was 47 years (range 21–67, mean 44.2, SD 11.6). The sample was predominantly married (90.9%) and well-educated, with 43.6% holding a university

or postgraduate qualification and 36.4% having completed high school. The mean number of children was 3.75 (SD 2.36).

HPV vaccination uptake was extremely low: only 1 participant (1.8%) reported having received the vaccine, 69.1% had not received it, and 29.1% were uncertain of their vaccination status. Among the 53 participants who reported the year of their most recent Pap smear, 49.1% had been tested in 2025 (the year of the study), while 26.4% had not been screened since 2019 or earlier, and 11.3% not since 2008 or before, indicating a substantial subset of chronically under-screened women. Age at first intercourse was reported as 20 years or younger by 54.5% of participants. Condom use was never reported by 69.1%, and post-coital bleeding was reported by 14.5%.

Table 1: ***Sociodemographic Characteristics of Study Participants (N = 55)***

Variable	n	%
Age, median (IQR)*	47 (35–55)	
Marital status		
Married	50	90.9
Divorced	4	7.3
Widowed	1	1.8
Education level		
Primary	7	12.7
Intermediate	4	7.3
High school	20	36.4
University/postgraduate	24	43.6
HPV vaccination status		
Received	1	1.8
Not received	38	69.1
Unknown	16	29.1
Age at first intercourse		
≤20 years	30	54.5
>20 years	25	45.5
Condom use frequency		

Always	3	5.5
Sometimes	8	14.5
Rarely	6	10.9
Never	38	69.1
Post-coital bleeding		
Yes	8	14.5
No	47	85.5

***** Percentages are valid percentages among participants with available data. IQR = interquartile range.

HPV Test Results

Among the 55 participants with available specimen data, the clinician-collected reference standard identified 8 HPV-positive results (14.5%), 45 HPV-negative results (81.8%), and 2 invalid results (3.6%). The self-collected specimens identified 6 HPV-positive results (10.9%), 47 HPV-negative results (85.5%), and 2 invalid results (3.6%). The rate of invalid results was identical across both collection methods (3.6%), supporting the feasibility of self-collection for HPV testing in this setting. Full HPV result distributions, including genotype categories, are presented in Table 2.

Table 2: ***Distribution of HPV Test Results by Collection Method (N = 55)***

	Clinician-collected		**Self-collected**	
HPV Result	**n**	**%**	**n**	**%**
Negative	45	81.8	47	85.5
Positive (any HR-HPV)*	8	14.5	6	10.9
HPV 16	2	25	2	33.3
HPV 18/45	1	12.5	1	16.6
Other HR-HPV	5	62.5	3	50
Invalid/inconclusive	2	3.6	2	3.6

*HR-HPV = high-risk human papillomavirus. Percentages are valid percentages among participants with available specimen data.

Diagnostic Accuracy and Agreement

Diagnostic performance of self-collected against clinician-collected specimens was assessed in the 53 evaluable pairs. The 2×2 contingency table and associated diagnostic measures are presented in Table 3. There were 6 true positives, 46 true negatives, 0 false positives, and 1 false negative, yielding an observed agreement of 98.1%. The sensitivity of self-collection was 85.7% (95% CI: 48.7%–97.4%), specificity was 100.0% (95% CI: 92.3%–100.0%), the positive predictive value was 100.0%, and the negative predictive value was 97.9% (95% CI: 88.9%–99.6%). Cohen's kappa was 0.91 (95% CI: 0.74–1.00), indicating very good agreement. The McNemar test for discordant pairs was non-significant (p = 1.00), confirming no systematic directional bias between methods.

The single false negative case was a woman recruited from the community screening arm (unknown HPV status) whose clinician-collected specimen returned a positive result for other high-risk HPV genotypes (neither HPV 16 nor 18/45), while the paired self-collected specimen was negative. This participant was informed of the discordant result and referred to the gynaecology department at KHUH for further clinical management.

The wide confidence interval around sensitivity (48.7%–97.4%) reflects the small absolute number of HPV-positive cases identified on the clinician-collected reference standard (n= 7 evaluable positives) and should be interpreted with caution. These estimates are preliminary and underpowered relative to the originally planned sample size.

Table 3: ***Contingency Table and Diagnostic Performance of Self-Collected Versus Clinician-Collected HPV Testing (N = 53 Evaluable Pairs)*** *

	Clinician-collected positive	**Clinician-collected negative**	**Total**
Self-collected positive	6 (TP)	0 (FP)	6
Self-collected negative	1 (FN)	46 (TN)	47
Total	7	46	53

Diagnostic measure	**Value**	**95% CI**
Sensitivity	85.7%	48.7%–97.4%
Specificity	100.0%	92.3%–100.0%
Positive predictive value	100.0%	—
Negative predictive value	97.9%	88.9%–99.6%
Observed agreement	98.1%	—
Cohen's kappa (κ)	0.91	0.74–1.00
McNemar test p-value	1.00	—

* TP = true positive; TN = true negative; FP = false positive; FN = false negative; CI = confidence interval. PPV confidence interval is undefined as there were no false positives. Kappa 95% CI was capped at 1.00.

Women's Perceptions and Experiences of Self-Sampling

Responses to the 15-item perception and experience questionnaire among the 55 participants with available survey data are summarised in Table 4. The majority of participants perceived self-sampling favourably in relation to access and privacy. Most notably, 80.0% agreed that HPV self-sampling allows more privacy than the Pap smear, and 69.1% agreed that self-sampling is a good solution to reach women who do not attend a clinician. Regarding speed, 72.7% agreed that self-sampling is faster than a Pap smear.

At the same time, a substantial majority (72.7%) agreed that a clinician-collected sample is superior to a self-collected one, reflecting a persistent, widely-documented confidence in clinical collection that coexists with high acceptability of self-sampling. Prior discomfort with the Pap smear was not a dominant finding; 47.3% disagreed that they had experienced such discomfort, and 20.0% agreed that their provider had not offered cervical cancer screening.

Regarding the self-collection experience, the device instructions were rated as clear by 94.5% of participants, the highest endorsement of any item. The procedure was considered easy to use by 80.0%, and 67.3% felt confident that they had performed it correctly. Only 18.2% reported pain or discomfort during self-collection, while 72.7% experienced none. Willingness to use the self-sampler again was expressed by 65.5% of participants, and 76.4% stated they would recommend it to friends or family. Overall, 60.0% preferred the self-sampler over the Pap smear.

Table 4: ***Women's Perceptions and Experiences of Cervical Cancer Self-Sampling (N = 55)***

Item	Agree %	Neutral %	Disagree %
Perceptions about self-sampling			
1. Self-sampling is a good solution to reach women who do not attend a clinician	69.1	21.8	9.1
2. A sample taken by a doctor is better than a self-sample	72.7	16.4	10.9
3. Most women will choose self-sampling over going to a doctor	58.2	21.8	20.0
4. HPV self-sampling allows more privacy than the Pap smear	80.0	16.4	3.6
5. I have had discomfort with the Pap smear	25.4	27.3	47.3
6. HPV self-sampling is faster than the Pap smear	72.7	16.4	10.9
7. My provider did not offer cervical cancer screening	20.0	3.6	76.4
Self-sampling experience	**Agree %**	**Neutral %**	**Disagree %**
8. I found the self-sample easy to use	80.0	16.4	3.6
9. I feel I performed the self-sample correctly	67.3	27.3	5.4

10. I would use the self-sampler again	65.5	5.5	29.0
11. The instructions for vaginal sampling were clear	94.5	3.6	1.8
12. I would recommend this to my friends/family	76.4	14.5	9.1
13. Self-sampling is easier than a Pap smear (no clinic visit needed)	74.5	9.1	16.4
14. I experienced pain and/or discomfort using the self-sample	18.2	9.1	72.7
15. I prefer the self-sampler method over the Pap smear	60.0	18.2	21.8
Preference for next screening: self-sampling**	56.4%	16.4%	27.3%

***** Values are valid percentages among participants with available questionnaire data. Items 1–7 assess perceptions about self-sampling in general; items 8–15 assess the self-collection experience.

** The final row reports the preference for next screening method (self-sampling vs. clinician vs. no preference).

Preference for Future Screening and Sociodemographic Associations

When asked about their preferred method at their next cervical cancer screening, 56.4% of participants chose self-sampling, 27.3% preferred clinician-based sampling, and 16.4% expressed no preference. Cross-tabulations of screening preference against age category, education level, and HPV vaccination status are presented in Table 5.

No statistically significant association was identified between screening preference and any of the sociodemographic variables examined. Preference for self-sampling was numerically higher among women older than 47 years (59.1%) compared with younger women (54.5%), though this difference was not significant ($p = .107$). Similarly, preference for self-sampling was highest among university-educated women (66.7%) compared to those with primary education (42.9%), but again did not reach significance ($p = .506$). HPV vaccination status showed no significant association with screening preference ($p = .543$). These null findings should be interpreted in the

context of limited statistical power due to the small sample size and low cell counts, as indicated by the proportion of cells with expected counts below 5 in several cross-tabulations.

Table 5: ***Screening Method Preference by Sociodemographic Characteristics (N = 55)***

Variable	Self-sampling n (%)	Clinician n (%)	No preference n (%)	p
Age group				.107
≤47 years (n = 33)	18 (54.5)	7 (21.2)	8 (24.2)	
>47 years (n = 22)	13 (59.1)	8 (36.4)	1 (4.5)	
Education level				.506
Primary (n = 7)	3 (42.9)	3 (42.9)	1 (14.3)	
Intermediate (n = 4)	3 (75.0)	0 (0.0)	1 (25.0)	
High school (n = 20)	9 (45.0)	8 (40.0)	3 (15.0)	
University/postgraduate (n = 24)	16 (66.7)	4 (16.7)	4 (16.7)	
HPV vaccination status				.543
Received (n = 1)	0 (0.0)	1 (100.0)	0 (0.0)	
Not received (n = 38)	23 (60.5)	9 (23.7)	6 (15.8)	
Unknown (n = 16)	8 (50.0)	5 (31.3)	3 (18.8)	

* p values are from Fisher-Freeman-Halton exact test. Age category 1 = ≤47 years (median split); age category 2 = >47 years. HPV = human papillomavirus.

Discussion

This feasibility study is, to our knowledge, the first to evaluate the accuracy and acceptability of HPV self-sampling among women in Bahrain and among one of the first in the Gulf Cooperation Council region (GCC). Using the same HPV platform (Cobas®), the same collection device (Rovers Cervex-Brush® in PreservCyt® liquid medium), we demonstrated very good agreement between self-collected and clinician-collected cervical specimens for HPV detection ($\kappa = 0.91$), a

specificity of 100%, and broad acceptability of self-sampling among Bahraini women. These findings, while preliminary given the limited sample size, provide an encouraging foundation for the integration of self-sampling into cervical cancer prevention efforts in Bahrain and the wider Middle East.

Diagnostic Accuracy

The observed kappa of 0.91 (95% CI: 0.74–1.00) in the present study exceeds the values reported by Gibert et al. [17] for their two highest-performing liquid-medium devices (κ = 0.86 for Mía by XytoTest® and κ = 0.83 for Viba-Brush®). A meta-analysis by Petignat et al. reported a pooled kappa of 0.66 for self-collected specimens across multiple studies [20], while a more recent Japanese study using the Evalyn® Brush, a device comparable to the Cervex-Brush®, reported κ = 0.76 against the same Cobas® platform used here [21]. Our estimate of 0.91 is therefore at the higher end of published values, which may reflect the use of liquid medium transport (shown by Gibert et al. to yield superior concordance compared to dry devices) [17] as well as the on-site, supervised nature of self-collection in our setting.

Specificity was 100% (95% CI: 92.3%–100.0%), with no false positive self-collected results recorded. This is clinically important: a high specificity means that a positive self-collected result can be acted upon with confidence, reducing unnecessary referrals to colposcopy. The positive predictive value was correspondingly 100%, meaning every self-collected positive in this sample was confirmed by the clinician-collected reference standard. The sensitivity of 85.7% (95% CI: 48.7%–97.4%), while point-estimated above the 80% threshold we set as clinically acceptable, must be interpreted with considerable caution. The wide confidence interval directly reflects the small number of HPV-positive cases identified on the reference standard (n = 7 evaluable

positives), which is an inherent consequence of the low HPV prevalence in a predominantly community-based screening sample and the study's failure to reach its planned enrichment target. The precision of sensitivity estimates in diagnostic accuracy studies is highly sensitive to the number of true positives, and 7 cases are insufficient to draw firm conclusions. A larger study with adequate enrichment of HPV-positive participants is essential to confirm these estimates.

The single false negative in this dataset (a woman from the community screening arm whose clinician-collected specimen was positive for other high-risk HPV genotypes (neither HPV 16 nor HPV 18/45), while her self-collected specimen was negative) is consistent with the patterns observed by Gibert et al. and others [17]. Other high-risk HPV genotypes (excluding 16, 18, and 45) are generally associated with lower viral loads than HPV 16, which may render them more susceptible to detection failure in self-collected specimens where sampling depth and cellular yield are less controlled. Gibert et al. similarly observed that the contrast between positive assays for HPV types 16 and/or 18 versus other types improved kappa values for all their devices, with the viscose swab (their lowest-performing device) showing a kappa of only 0.63 overall compared to 0.68 for positive versus negative comparisons. This suggests that future studies in Bahrain should examine whether sensitivity differs systematically by genotype category, and whether partial genotyping results (particularly the detection of HPV 16/18 specifically) show superior concordance to the pooled 'other HR-HPV' category, as documented in the literature.

The invalid result rate was identical across methods (3.6%) for both the clinician-collected and self-collected specimens. In Gibert et al., invalid results were rare for self-collected specimens (1.7% for each liquid-medium device), though their study excluded participants who were unable to self-collect [17]. The slightly higher invalid rate in our study may reflect the diversity of the recruitment setting, the brevity of instruction time in a busy clinic environment, or device-

handling issues. Regardless, the parity between clinician and self-collected invalid rates is a reassuring feasibility finding, suggesting that self-collection does not systematically produce lower-quality specimens than clinician collection when a liquid-medium device is used.

Acceptability and Women's Experiences

Self-sampling was broadly well received among Bahraini women, with results that mirror and, in some respects, exceed those reported in European [22], Asian [23], and Australian studies [24]. The instruction clarity rating of 94.5% is particularly striking and compares favourably with Gibert et al., where the corresponding figures were not explicitly reported but the overall pre-analytical error rate was 3.3% [17]. The ease-of-use rating (80.0%) and the low rate of reported pain or discomfort (18.2%) suggest that the Cervex-Brush® is a practically acceptable device in this population despite figures in the literature rating smooth, thin devices as more acceptable than brush-type or lavage devices [17]. The rate of willingness to repeat self-sampling (65.5%) and the recommendation rate (76.4%) are both consistent with or above those reported in studies from comparable settings [17, 25].

However, this strong preference for self-sampling coexisted with persistent confidence in clinician collection representing an apparent paradox that has been documented widely in the literature and reflects a nuanced decision-making process. Participants in Gibert et al.'s study expressed similar attitudes [17], and other studies have identified confidence in clinician expertise as one of the most common reasons for declining self-sampling in the future [26, 27]. In our sample, 27.3% expressed a preference for clinician-collected sampling at their next screening visit. This proportion may be influenced by the colposcopy-enriched nature of the sample and by cultural norms in Bahrain regarding the perceived authority of medical

professionals in health decision-making. It should not be interpreted as a barrier to self-sampling implementation per se, but rather as an indication that patient education and communication, emphasising the validated accuracy of self-collected HPV testing, will be an essential component of any implementation strategy.

The observation that 49% of participants had been screened in 2025 (the year of the study) but 26.4% not since 2019 or earlier confirms the presence of chronically under-screened women even within a hospital-attending population, underscoring the potential public health value of alternative screening pathways.

The strong endorsement of privacy as a benefit of self-sampling (80.0% agreement) suggests that this specific advantage resonates strongly with Bahraini women and could be leveraged effectively in public health messaging. Similar findings have been reported in conservative communities in Malaysia, where self-sampling has been proposed as a culturally congruent alternative to clinic-based cervical screening [28].

Screening Preferences and Sociodemographic Associations

A majority of participants (56.4%) stated a preference for self-sampling at their next screening visit, compared with 27.3% preferring clinician-based collection and 16.4% expressing no preference. This distribution is broadly comparable to other studies [17, 29, 30], though those figures reflect stated intention to repeat rather than direct preference comparison between methods. Our proportion is lower, which may reflect genuine cultural differences in the perceived acceptability of self-collection in Bahrain, or simply the small sample size.

No statistically significant associations were found between screening preference and age, education level, or HPV vaccination status. The numerically higher preference for self-sampling among university-educated women (66.7%) compared to those with primary education (42.9%) mirrors the pattern reported by Besó Delgado et al. in Valencia, where younger age and higher education significantly favoured self-sampling preference[31], and by the meta-analysis of Nelson et al [30]. However, the absence of significance in our data is almost certainly attributable to insufficient statistical power rather than a true null effect: the small overall sample size, combined with very small cell counts in several subgroups (notably the single vaccinated participant and the four women with intermediate education), severely limits the ability to detect associations of moderate effect size. Future studies with adequate sample sizes should specifically examine whether education level and prior screening history predict self-sampling preference in Bahraini women, given the plausibility of this relationship and its policy relevance for targeting outreach efforts.

Implications for Cervical Cancer Prevention in Bahrain

Taken together, the findings of this feasibility study suggest that HPV self-sampling using a liquid-medium brush device is technically feasible, produces HPV results that are in very good agreement with clinician-collected specimens, and is broadly acceptable to Bahraini women across a range of educational and demographic backgrounds. If confirmed in a larger, adequately powered study, these results would support the incorporation of self-sampling into Bahrain's cervical cancer prevention strategy, potentially as an opt-in alternative for women who decline clinic-based screening or as a population outreach tool in the context of a future organised screening programme.

For this cohort, screening remains the primary available tool for cervical cancer prevention, and the urgency of expanding screening participation through self-sampling or other innovative strategies is therefore particularly acute.

Limitations and strengths

Several important limitations of this study must be acknowledged. First and foremost, the failure to reach the planned sample size of 80 participants, and particularly the enrichment strategy (only 4 of 20 planned HPV-positive women recruited), means that all diagnostic accuracy estimates (especially sensitivity) are severely underpowered and must be treated as preliminary. The wide confidence interval around sensitivity (48.7%–97.4%) encompasses a range of clinically important values and precludes definitive conclusions about the test's ability to detect true HPV-positive cases in self-collected specimens. Recruitment from the enrichment arm was constrained by several structural and operational factors that are important to document for the benefit of future researchers planning similar studies in comparable settings. The colposcopy clinic at KHUH operates on a weekly schedule, inherently limiting the number of eligible women available for recruitment within the study window. Clinic throughput was further compressed by the high clinical burden on attending physicians, who were simultaneously managing complex gynaecological cases, on-call duties, and routine clinical responsibilities, leaving limited time and cognitive bandwidth to identify, approach, and consent eligible participants for research purposes. Under these conditions, research participation was necessarily a low priority relative to direct patient care, and there was no dedicated personnel to bridge this gap. This experience highlights a critical lesson for the design of future studies: the integration of a trained, dedicated research assistant embedded within the colposcopy clinic is not merely desirable but essential for achieving adequate enrichment recruitment. A research assistant with

protected time, clear responsibilities for participant identification and consent, and no competing clinical duties would likely improve recruitment efficiency. This structural recommendation should be considered a prerequisite for any future validation study seeking to recruit HPV-positive participants from a colposcopy setting in Bahrain.

A definitive validation study with a minimum of 20 confirmed HPV-positive participants, as specified in the original sample size calculation, is needed before these findings can be used to inform clinical policy.

Second, all participants were recruited from hospital-based settings (gynaecology clinic, women screening clinic, and colposcopy clinic at KHUH and affiliated PHC centres), which introduces selection bias. Women attending these settings are likely to have higher health literacy, greater access to healthcare, and more positive attitudes towards cervical cancer screening than the broader Bahraini population, particularly the hard-to-reach and never-screened women whom self-sampling is most intended to serve. The generalisability of both the acceptability findings and the diagnostic accuracy estimate to the wider population is therefore uncertain.

Third, no cytological data were available for any participant, precluding evaluation of reflex cytology on self-collected specimens. This was attributable to restricted access to participants' medical records by the medical students who administered the questionnaires and assisted with data collection. The reflex cytology on self-samples is a valuable tool, specifically allowing women whose self-collected HPV-positive specimen yields a negative or low-grade cytological result to defer colposcopy and instead undergo repeat HPV testing after one year. Thus, reducing avoidable clinical appointments. This algorithm remains entirely unanswered among the population of Bahrain.

Finally, the single false negative case in this dataset involved another high-risk HPV genotype. While this represents a clinically manageable outcome (the patient was identified, informed, and referred for further management), it highlights the importance of clinical follow-up protocols for self-sampling programmes, particularly for discordant results and for genotypes other than HPV 16 and 18 that may be associated with lower analytical sensitivity in self-collected specimens.

One of the main strengths of this study is the blinding of laboratory personnel to the collection method, and the fully automated Cobas® HPV assay, which determined the HPV result algorithmically without subjective interpretation.

Conclusions

This feasibility study demonstrates that HPV self-sampling using the Rovers Cervex-Brush® in liquid medium is technically feasible, produces HPV results in very good agreement with clinician-collected specimens, and is broadly acceptable to Bahraini women across diverse sociodemographic backgrounds. Self-sampling was preferred by the majority of participants for their next screening episode, driven primarily by privacy and convenience, though a persistent and coexisting confidence in clinician-based collection was also observed. No statistically significant associations between screening preference and sociodemographic characteristics were identified, likely reflecting limited statistical power. These preliminary findings support the case for a larger, adequately powered validation study and highlight the potential of self-sampling as a strategy to expand cervical cancer screening participation in Bahrain, contributing to the WHO 2030 elimination agenda.

Consent for publication: Not Applicable

Availability of data and materials: All data generated or analysed during this study are included in this published article.

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Authors' contributions: GJ conceptualization, supervised, analyzed, interpreted the data and wrote the first draft of the manuscript. ZA and KT completed the data collection and contributed to data entry and analysis and manuscript writing, DD and WN facilitated data collection and contributed to methodology and manuscript writing, FH, RM, MA, AS, BA contributed to the methodology and writing the manuscript. All authors read and approved the final manuscript.

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List of Abbreviations

ACOG	American College of Obstetricians and Gynecologists
AIS	Adenocarcinoma in situ
ANOVA	Analysis of variance
APC	Article processing charge
ASC-H	Atypical squamous cells, cannot exclude high-grade intraepithelial lesion
ASC-US	Atypical squamous cells of undetermined significance
CC	Cervical cancer
CCST	Cervical cancer self-testing

ACOG	American College of Obstetricians and Gynecologists
CI	Confidence interval
Cobas®	Cobas® HPV test (Roche Molecular Systems)
DNA	Deoxyribonucleic acid
EMHJ	Eastern Mediterranean Health Journal
FN	False negative
FP	False positive
GCC	Gulf Cooperation Council
HIPAA	Health Insurance Portability and Accountability Act
HPV	Human papillomavirus
HR-HPV	High-risk human papillomavirus
HSIL	High-grade squamous intraepithelial lesion
IQR	Interquartile range
KHUH	King Hamad University Hospital
LSIL	Low-grade squamous intraepithelial lesion
NPV	Negative predictive value
PCR	Polymerase chain reaction
PHC	Primary Health Care Centres
PPV	Positive predictive value
RCSI	Royal College of Surgeons in Ireland
RCT	Randomised controlled trial
SD	Standard deviation
SGO	Society of Gynecologic Oncology

ACOG	American College of Obstetricians and Gynecologists
STARD	Standards for Reporting of Diagnostic Accuracy Studies
TN	True negative
TP	True positive
USPSTF	United States Preventive Services Task Force
WHO	World Health Organization
κ	Cohen's kappa coefficient

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