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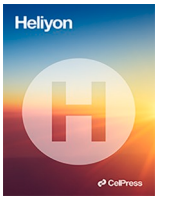

Research article

HPV self-sampling for cervical cancer screening in China: A multi-center study

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ABSTRACT

Background: Human papillomavirus (HPV) self-sampling is a new method for collecting cervical isolated cells, but research been carried out in multi-ethnic and multi-regional areas of China is scarce.
Objectives: We aimed to evaluate the accuracy and acceptability of HPV self-sampling and analyze the characteristics of HPV infection.
Study design: Women aged 25–65 years were recruited from 8 provinces in China. Women underwent clinician-sampling and self-sampling and were asked to complete a 65-question questionnaire on their acceptance of HPV self-sampling. The paired samples were analyzed for 23 genotypes of HPV by polymerase chain reaction.
Results: 5551 women were recruited, of which 5417 were eligible for analysis. 3163 women have completed and submitted the questionnaire. The top five infection genotypes were HPV 52, 58, 16, 39, and 68. The highest infection rate was in the 25–30 years group. The crude agreement between self-sampling and clinician-sampling was 93.06 %. 43.79 % of women preferred self-sampling over clinician-sampling, and 67.59 % preferred doing self-sampling at the hospital.
Conclusion: HPV self-sampling could be an effective supplement to traditional cervical screening in China. Clinicians' advocacy, timely reminders and guidance for women with abnormal self-sampling results are needed. In addition, new vaccination and cervical screening recommendations might be adjusted to fit populations with different characteristics.

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1. Background

Cervical cancer is the fourth most frequently diagnosed cancer and the fourth leading cause of cancer death in women worldwide, causing approximately 662,301 new cases and 348,874 deaths in 2022, which is increasing year by year [1]. More than 90 % of cervical cancers are caused by human papillomavirus (HPV) infection [2]. Incidence and mortality of cervical cancer have declined in several countries due to effective HPV vaccination and cervical cancer screening [3]. However, cervical cancer remains the fifth life-threatening and most common cancer in Chinese women [4]. 18 % of all cervical cancer cases and 17 % of deaths from cervical cancer occurred in China [5]. According to the report of the National Cancer Center and International Agency for Research on Cancer in 2024, the age-standardized incidence rates and age-standardized mortality rates of female cervical cancer in China were 13.83 % and 4.54 %, respectively, both increased significantly from 2000 to 2022 [4,6,7].

In 2020, the World Health Organization (WHO) proposed an intermediate target of eliminating cervical cancer, which is to have 90 % of adolescent girls vaccinated, 70 % of women screened regularly in the age range of 35–45 years, and 90 % of women with pre-cancerous lesion or cervical cancer received appropriate treatment [8]. While HPV vaccination has not been included in the Chinese national immunization program yet, cervical screening remains the principal method to prevent and eliminate cervical cancer [9,10]. Traditional cervical screening methods include visual inspection with acetic acid, pap smear test, liquid-based cytology test, and clinician-collected HPV testing [11]. These screening methods require professional medical personnel and equipment, which are relatively scarce in low- and middle-income countries and may not meet the requirement of increasing the participation rate of women. China is a vast country with 432.9 million females aged 15–59 years who are at risk of developing cervical cancer [12]. China has launched a free screening program called “Two-Cancer Screening” for women, which contains cervical and breast cancer screening [13]. Cervical cancer screening methods differ across China, with clinician-collected HPV test and Thinprep cytology test (TCT) being the mainstream methods in most areas. In 2015, the cervical screening coverage rate in China was only 37 %, far lower than the 70 % level set by the WHO [12].

HPV DNA testing could detect high-risk HPV (HR-HPV), which causes the vast majority of cervical cancers [14]. Unlike tests that rely on visual inspection, the HPV DNA test is an objective diagnostic method, leaving no space to interpret results. HPV self-sampling is a method for women to take a sample by inserting a brush or swab into their vagina, instead of being sampled by a gynecologist at the hospital. In some countries, HPV self-sampling has been promoted for national cervical cancer screening programs [15]. Few multi-center and population-based studies on HPV self-sampling have been conducted in China, and no self-sampling-based cervical screening program has been implemented.

2. Objectives

The aim of this study is to evaluate the accuracy and feasibility of HPV self-sampling in different regions and ethnic groups of China.

2.1. Study design

The Medical Ethics Committee of Beijing Obstetrics and Gynecology Hospital (BJOGH) approved this study on May 18, 2022. Eligible women were 25–65 years and had a need for cervical cancer screening. Women who were pregnant, had a history of vaginal bleeding, female genital tract tumors, previous hysterectomy and cervical surgery, had used topical drugs in the vagina within the past 3 days, or were unable to complete self-sampling were excluded.

2.2. Study populations

5551 eligible women were recruited for the study in Beijing, Shandong, Hubei, Yunnan, Qinghai, Inner Mongolia, Xinjiang and Tibet. All eligible women were invited to participate, and virtually everyone agreed and was accepted until our target number was reached. At gynecological clinics in each region, the trial was explained by a professional gynecologist and informed consent was obtained from all participants. Women included in the pooled analysis all received HPV DNA testing for self-collected and clinician-obtained samples.

2.3. Screening tests

2.3.1. HPV clinician-sampling

A physician obtained specimens for clinician-collected HPV tests from the endocervix during internal examination using a female sample collection kit (Hybribio, Chaozhou, China). After routine smears, the brush head was placed into a vial (Hybribio, Chaozhou, China) containing 3.5 ml of fixative solution for direct HPV detection. 48 h after clinician sampling, patients performed HPV self-sampling.

2.3.2. HPV self-sampling

All participants received both video and verbal instructions on how to perform self-sampling. The HPV self-tests were provided with a disposable brush, cap and column (Female self-sampling kit, Hybribio). Patients were instructed to clean and disinfect their hands before sampling, remove the cap, and insert the swab with the column into the vagina until the stopping plate reached the vaginal entrance. They were then to gently twist the swab in one direction for 5 rotations, noting a "tick" feeling for each rotation to count

easily. They took out the swab and column with care, twisted them back into the cover tube, held the cover tube, and twisted the cap tightly to secure the swab. The kit was then placed back into the plastic packaging, sealed with the provided zip bag, and the name and date were written on the information card provided before sending the kit within 7 days. The self-sampling kit was transported dry to the laboratory and then suspended in 3.5 mL of Hybribio cell preservation solution.

2.3.3. HPV testing

The 23 HPV Genotyping Real-time PCR Kit is designed for in vitro detection of 23 HPV types in cervical cell specimens, including HPV16, 18, 31, 33, 35, 39, 45, 51, 52, 56, 58, 59, 66, 68, 6, 11, 42, 43, 44, 53, 81, 73 and 82. Cellular internal control is included for each sample to monitor the whole testing process starting from DNA extraction to signal detection [16].

All samples were tested according to the manufacturer's instructions: 0.5–1 mL of the cervical or vaginal sample was pipetted into a 1.5 mL microcentrifuge or screw-cap tube. The sample was then centrifuged, the supernatant was discarded, and the pellet was lysed. After boiling the sample in a hot water bath, 2.0 μL of the DNA template was pipetted from the center of the volume for the PCR reaction. Through real-time fluorescence PCR, one-step nucleic acid amplification and detection are achieved. One sample is divided

Table 1
Sociodemographic characteristics of the study participants.

Characteristics	No.(%)
Total	5417
Completed the questionnaire	3163
Age(year)	
Mean ± standard deviation	44.25 ± 9.32
25–30	190(6.01)
31–40	1005(31.77)
41–50	1093(34.56)
51–65	875(27.66)
Marital status	
Unmarried	112(3.54)
Married	2915(92.16)
Divorced	103(3.26)
Widowed	33(1.04)
Parity	
0	107(3.64)
1	1600(54.38)
2	1075(36.54)
3	131(4.45)
4	20(0.68)
≥5	9(0.31)
Menstruation	
Not-Menopausal	2304 (72.84)
Menopausal	859(27.16)
Highest level of school attended	
Primary school	274(8.66)
Junior high school	699(22.1)
Senior high school	625(19.76)
College or higher	1565(49.48)
Occupation	
Worker	294(9.29)
Farmer	288(9.11)
Individual business	289(9.14)
Server	428(13.53)
Housewife	300(9.48)
Clerk	630(19.92)
Retired	294(9.29)
Others	640(20.23)
Income per month(CNY)	
<3000	1227(38.79)
3001–5000	979(30.95)
5001–8000	586(18.53)
>8000	371(11.73)
Medical insurance	
Insured	3020(95.48)
Not-insured	143(4.52)
Time of last cervical screening	
Within 1 year	581(18.37)
1–3 years	950(30.03)
3–5 years	281(8.88)
Above 5 years	141(4.46)
Never been screened	1000(31.62)
Forgotten	210(6.64)

into six reaction tubes by using four fluorescence channels to detect 23 types of HPV. The control, β-globin DNA, is used to evaluate sample quality and PCR inhibition results. If the Ct value of a sample is undetected, the sample is negative. If the Ct value of a sample is $\leq$ 40, the sample is positive. The cutoff Ct values of self- and clinician-collected samples were the same. All sample processing and laboratory testing were performed at BJOGH in Beijing, China. Tests for both sampling methods are free of charge.

2.4. Questionnaire

A 65-question questionnaire was used to investigate women's demographic data, awareness of cervical cancer screening, acceptance and feelings about HPV self-sampling.

2.5. Data analysis

Two researchers collected all the data and entered it into a Microsoft Excel sheet. Data analysis was performed using SPSS software version 22.0. Statistical significance was set at $p \leq 0.05$.

The sociodemographic characteristics of participants were analyzed using descriptive statistics. The accuracy of HPV self-sampling was examined by the concordance in PCR test results between paired self- and clinician-collected samples. The concordance was assessed by calculating the overall agreement rate and Cohen's kappa statistics with the following interpretation: poor or slight agreement (≤0.2), fair agreement (0.2–0.4), moderate agreement (0.4–0.6), good agreement (0.6–0.8), and very good agreement (0.8–1.0). Factors influencing women's acceptability of HPV self-sampling were analyzed using both univariate and multivariate logistic regression.

3. Results

1. Patient characteristics

A total of 5551 women were recruited, of which 5417 (97.59 %) were eligible for analysis. 134 women were excluded from the analysis because samples contained too few cells to perform PCR tests or leaked during transportation. The mean age of 5417 women was 43.82 ± 9.42 years. 3163 women have completed and submitted the questionnaire. Table 1 presents the sociodemographic characteristics of the study participants who completed questionnaires. The mean age was 44.25 ± 9.32 years old. The majority of women were married (92.16 %) and employed (72.15 %), had 1 or 2 children (84.57 %), and graduated from high school or higher education (69.23 %). Women who had never participated in cervical screening and women whose last screening interval was more than 3 years accounted for 44.96 %.

2. Characteristics of HPV infection

The top five infection genotypes were HPV 52, 58, 16, 39, and 68, and the infection rates were 23.17 %, 15.56 %, 12.73 %, 8.31 %, and 6.37 %, respectively. Fig. 1 shows the 14 HR-HPV genotypes detected in clinician-collected samples.

Fig. 2 shows infection rates of HR-HPV in different age groups. The highest infection rate was shown in the group of age 25–30 years (19.31 %), followed by 51–65 years (17.88 %), 31–40 years (15.11 %) and 41–50 years(13.14 %). Table 2 shows infection rates of each HR-HPV type in different age groups. In women aged 25–30, the top five infective types were HPV 16, 58, 52, 68, and 56. In ages 31–40 years, the top six infective types were HPV 52, 58, 16, 39, 59, and 68, in which the infection rates of HPV 59 and 68 were equal. In age 41–50 and 51–65, the top five were HPV 52, 58, 16, 39, and 51.

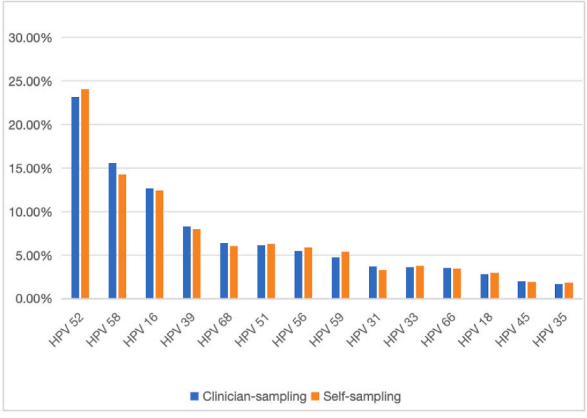

Fig. 1. 14 genotypes of HR-HPV detected in clinician-collected samples
Abbreviations: HPV, human papilloma virus; HR-HPV, high-risk HPV.

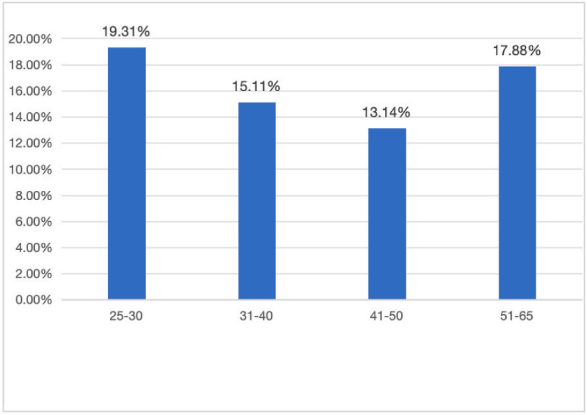

Fig. 2. Infection rates of HR-HPV in different age groups
Abbreviations: HR-HPV, high-risk human cytomegalovirus.

Table 2
Infection rates of each HR-HPV type in different age groups.

Age(yr, no)	25-30, 404	31-40, 1774	41-50, 1751	51-65, 1488
HR-HPV type	No.(%)	No.(%)	No.(%)	No.(%)
16	18(4.46)	31(1.75)	25(1.43)	34(1.08)
18	2(0.50)	10(0.56)	7(0.40)	8(0.54)
31	0(0)	10(0.56)	14(0.80)	14(0.94)
33	3(0.74)	12(0.68)	8(0.46)	10(0.67)
35	2(0.50)	5(0.28)	5(0.29)	5(0.34)
39	5(1.24)	23(1.30)	21(1.20)	25(1.68)
45	2(0.50)	6(0.34)	4(0.23)	8(0.54)
51	4(0.99)	13(0.73)	18(1.03)	20(1.34)
52	9(2.22)	69(3.89)	60(3.43)	74(4.97)
56	6(1.49)	9(0.51)	5(0.29)	24(1.61)
58	15(3.71)	41(2.31)	34(1.94)	48(3.23)
59	5(1.24)	17(0.96)	12(0.69)	12(0.81)
66	5(1.24)	10(0.56)	4(0.23)	14(0.94)
68	7(1.73)	17(0.96)	16(0.91)	19(1.28)
Total	83	273	233	315

Abbreviations: HR-HPV, high-risk human papilloma virus.

3. Accuracy of HPV self-sampling

Table 3 summarizes the test results obtained using the two sampling methods. When testing for 23 HPV types, 4036 women were tested negative for HPV in both samples. Of women with HPV detected in both samples, 795(14.68 %) had a complete HPV type match, and 205 (3.78 %) were incompletely matched. 5 (0.09 %) were completely mismatched. In 92 women (1.70 %), one or more HPV types identified in clinician-collected samples were missed in self-collected samples, while in 284 women (5.24 %), HPV was identified in self-collected samples but missed in clinician-collected samples. The crude overall agreement was 93.06 % (95 % confidence interval [CI] = 0.924–0.937). When the results with incomplete matches were excluded, the overall agreement was 89.18 % (95 % CI = 0.883–0.900), kappa value was 0.798 (95 % CI = 0.778–0.994).

When testing for HR-HPV, 4354 women were tested negative. 842 were tested positive in clinician-sampling, while 996 were tested positive in self-sampling. 669 women had completely matched genotypes in both sampling methods. 67 were clinician-sampling

Table 3
Test results obtained using the two sampling methods.

Characteristics	Self-sampling	Clinician-sampling	No. (%)
Negative in both samples	Negative	Negative	4036(74.51)
HPV detected in clinician-samples missed in self-samples	Positive	Negative	92(1.70)
HPV detected in self-sampling missed in clinician-sampling	Negative	Positive	284(5.24)
Complete match of HPV types in both samples	Positive	Positive	795(14.68)
HPV detected in both samples but incomplete matched	Positive	Positive	205(3.78)
HPV detected in both samples but completely mismatched	Positive	Positive	5(0.09)

Abbreviations: HPV, human papilloma virus.

positive and self-sampling negative. 221 were positive for self-sampling and negative for clinician-sampling. 104 were incompletely matched and 2 were utterly mismatched (Table 4).

Samples from women who were 25–30 years old showed the best concordance, the agreement was 95.79 % (95 % CI = 93.4–97.4), kappa value = 0.872 (95 % CI = 81.3–93.1). The agreement between self-sampling and physician-sampling in all age groups was more than 90 %, and the kappa value was higher than 0.8(Table 5).

4. Acceptability of self-sampling

Table 6 presents the results of the understanding and acceptance questionnaires. Among 3163 participants, 52.89 % reported that they weren't aware of HPV self-sampling at all. 56.94 % reported that the instructions for self-sampling were easy or very easy to understand, and 53.52 % felt comfortable collecting the sample by themselves. However, 44.19 % of women were concerned about the accuracy of the self-sampling test results. Regarding participant preferences, 43.79 % preferred self-sampling. However, 67.59 % preferred doing self-sampling at a hospital, and only 23.08 % preferred it at home. A total of 2682 women indicated that they could accept HPV self-sampling as a method for cervical cancer screening. Age and monthly income were identified as the independent factors influencing women's acceptability (Table 7).

4. Discussion

Despite several studies on HPV self-sampling have been implemented, this study is the first to cover all regions in China simultaneously [17–20]. China's vast size, varied natural environments, and diverse economic and medical development levels make finding an effective and convenient cervical cancer screening method crucial for advancing the WHO's strategy to eliminate cervical cancer. Beijing and Inner Mongolia represent northern China, Shandong Eastern China, Qinghai, Xinjiang and Tibet Western China, Hubei Central China, and Yunnan Southern China. Moreover, the above areas are different in economic development levels, medical resources, natural environment, and ethnic distribution. Ethnic minority women such as Mongolian, Tibetan, and Uyghur comprised more than 20 % of all women in this study. Both self- and clinician-collected samples from different parts of China remained valid when mailed to the laboratory in Beijing, which indicates that the sampler we used could overcome problems caused by high altitude, long-distance, and long-time transportation.

According to this analysis, the positive rates of self-sampling and clinician-sampling are 18.47 % and 14.66 %, respectively. HPV self-sampling has detected more positive results than clinician-sampling, which may associated with the process of sampling. Gynecologists used a speculum to open the vagina and brush directly on the surface of the cervix to get isolated cells, whereas, in the process of self-sampling, women put the swab into their vagina without a speculum. The swab might collect isolated cells not only from the cervix but also from the vulva and vagina, suggesting that self-sampling swabs capture a broader range and greater quantity of cells compared to clinician-sampling brushes. Incidences of vulva and vagina cancer are increasing [21,22], but there is no routine screening method for these cancers. HPV self-sampling may help to find HPV infection and lesions of vulva and vagina.

Our data showed that the top five frequent high-risk genotypes were HPV 52, 58, 16, 39, and 68, which was different from the results of several published studies previously [17,23]. HPV types 16 and 18 were considered the most pathogenic and were included in both the two-valent and four-valent HPV vaccines [24–27]. Given the different characteristics of the Chinese population and the expansion of HPV vaccination, the predominant infection types of HPV may change, and screening guidelines may be adjusted. Women older than 50 years had a higher HPV infection rate than women aged 31–50 years. The recommendations for vaccination may be changed in the future as well.

Most women enrolled in this study expressed a high acceptance and preference for HPV self-sampling, and they could understand how to collect samples by themselves. This suggests that HPV self-sampling has a broad prospect for application in China, especially for remote, ethnic minority and less developed areas. For women who are HPV-positive without cervical precancerous lesions but require follow-up, HPV self-sampling offers a convenient follow-up method for monitoring the persistence of the same HPV genotype. Additionally, the HPV assay used in this study could perform HPV genotyping, allowing for the triage of positive women and saving costs and medical resources. With the increase in HPV vaccination and cervical screening rates [21], a greater focus on screening the unscreened/hard-to-reach populations may improve the risk/benefit ratio of cervical cancer screening programs.

Despite the high level of acceptance of HPV self-sampling among women, more than 60 % had never heard of what self-sampling was. The lack of awareness of HPV self-sampling is also one of the critical reasons for it's limited application. More than half of the

Table 4
Test results of HR-HPV obtained using the two sampling methods.

Characteristics	Self-sampling	Clinician-sampling	No. (%)
Negative in both samples	Negative	Negative	4354(80.38)
HPV detected in clinician-samples missed in self-samples	Positive	Negative	67(1.24)
HPV detected in self-sampling missed in clinician-sampling	Negative	Positive	221(4.08)
Complete match of HPV types in both samples	Positive	Positive	669(12.35)
HPV detected in both samples but incomplete matched	Positive	Positive	104(1.92)
HPV detected in both samples but completely mismatched	Positive	Positive	2(0.03)

Abbreviations: HR-HPV, high-risk human papilloma virus.

Table 5
Agreement between self-sampling and physician-sampling in each age group.

Characteristics	Clinician-sampling		Self-sampling		Both positive	Both negative	Clinician-sampling positive and self-sampling negative	Clinician-sampling negative and self-sampling positive	Agreement (%)	95%CI	Kappa value	p-value	95%CI
Age(yr)	Positive	Negative	Positive	Negative									
25–30	78	326	89	315	75	312	3	14	95.79	(0.934,0.974)	0.872	0.000	(0.813,0.931)
31–40	268	1506	323	1451	247	1430	21	76	94.53	(0.934,0.955)	0.803	0.000	(0.766,0.840)
41–50	230	1521	275	1476	211	1457	19	64	95.26	(0.942,0.962)	0.808	0.000	(0.769,0.847)
51–65	266	1222	309	1179	242	1155	24	67	93.88	(0.926,0.950)	0.804	0.000	(0.765,0.843)
Total	842	4575	996	4421	775	4354	67	221	94.68	(0.941,0.953)	0.812	0.000	(0.790,0.834)

Abbreviations: CI, confidence interval.

Table 6
Understanding and acceptability of self-sampling versus clinician-sampling.

Characteristics	No.(%)
Total	3163
Awareness of self-sampling	
Not aware at all	1673(52.89)
Not aware much	292(9.23)
General aware	391(12.36)
Well aware	164(5.18)
Full aware	643(20.33)
Understanding of self-sampling instructions	
Very easy	1250(39.52)
Easy	551(17.42)
Moderate	646(20.42)
Difficult	168(5.31)
Very difficult	548(17.33)
Comfort of self-sampling	
Uncomfortable at all	462(14.61)
Not so well	230(7.27)
Moderate	778(24.60)
Comfortable	563(17.80)
Very comfortable	1130(35.72)
Pain	
Very painful	371(11.73)
Painful	167(5.28)
Moderate	804(25.42)
Not so painful	611(19.32)
No pain at all	1210(38.25)
Privacy protection	
Not private at all	226(7.15)
Not so private	120(3.79)
Moderate	598(18.91)
Private	532(16.82)
Very private	1687(53.34)
Embarrassment	
Very embarrassed	357(11.29)
Embarrassed	175(5.53)
Moderate	675(21.34)
Not so embarrassed	481(15.21)
Not embarrassed at all	1475(46.53)
Concern about the accuracy of the result	
Not concern at all	1005(24.15)
Not so concerned	393(10.59)
Moderate	666(21.06)
Concerned	335(12.42)
Very concerned	764(31.77)
Preference of self-sampling	
Not prefer at all	760(24.03)
Not so preferred	306(9.67)
Moderate	712(22.51)
Prefer	395(12.49)
Very prefer	990(31.30)
Preferred sites for self-sampling HPV screening	
Hospital	2138(67.59)
Clinics near home	68(2.15)
Home	730(23.08)
Regular physical examination center	92(2.91)
Others	135(4.27)

Abbreviations: HPV, human papilloma virus.

women enrolled in this study felt self-sampling comfortable, private and not embarrassing, and showed their preference for self-sampling. Younger women and those with higher incomes demonstrated greater acceptance of self-sampling, similar to He et al.'s study [28]. Those women were more likely to know about HPV and related healthcare knowledge. A study involving a predominantly Hispanic population living along the United States-Mexico border found that once participants were educated about the test, they showed a high level of acceptance for self-sampling [29]. Clinicians and social health workers are needed to carry out propaganda on HPV self-sampling to promote and improve the participation of cervical screening. Women also expressed their preference for doing self-sampling in hospitals and concerns about the accuracy of self-sampling results, indicating the importance of clinicians' instruction. Furthermore, the follow-up management of positive screening results is a matter of great account. When women take self-sampling at

Table 7
Univariate and multivariate logistic regression analysis for acceptability of HPV self-sampling.

Characteristics	Acceptance		Univariate analysis			Multivariate analysis		
	Yes	No	p-value	OR	OR (95 % CI)	p-value	OR	OR (95 % CI)
Age			<0.001			0.048		
25–30	175	14	Reference					
31–40	889	117	0.091	0.608	(0.341, 1.083)	0.155	0.634	(0.339, 1.187)
41–50	913	180	0.002	0.406	(0.230, 0.716)	0.023	0.480	(0.254, 0.905)
51–65	705	170	<0.001	0.332	(0.188, 0.586)	0.036	0.478	(0.239, 0.953)
Education level			<0.001			0.446		
Primary school	227	47	Reference			Reference		
Junior high school	564	135	0.437	0.865	(0.600. 1.247)	0.120	0.744	(0.512, 1.08)
Senior high school	516	109	0.917	0.980	(0.673. 1.427)	0.173	0.762	(0.516, 1.126)
College or above	1375	190	0.023	1.498	(1.057, 2.124)	0.318	0.812	(0.539, 1.222)
Monthly income (Chinese Yuan)*			<0.001			0.003		
<3000	985	242	Reference			Reference		
3001–5000	840	139	<0.001	1.485	(1.182, 1.865)	0.040	1.308	(1.012, 1.690)
5001–8000	528	58	<0.001	2.237	(1.648, 3.305)	<0.001	1.938	(1.354, 2.773)
>8000	329	42	<0.001	1.925	(1.355, 2.733)	0.018	1.644	(1.088, 2.483)
Marital status			0.004			0.147		
Unmarried	103	9	Reference			Reference		
Married	2474	441	0.042	0.490	(0.246, 0.976)	0.799	0.905	(0.420, 1.951)
Divorce	83	20	0.018	0.363	(0.157, 0.838)	0.341	0.643	(0.260, 1.594)
Widowed	22	11	<0.001	0.175	(0.065, 0.472)	0.131	0.438	(0.150, 1.278)
Medical insurance			0.650	0.893	(0.547, 1.458)	0.970	0.990	(0.601, 1.633)
Yes	2582	461						
No	100	20						
Menstrual status			<0.001	0.626	(0.509, 0.768)	0.209	0.817	(0.596, 1.120)
Not in menopause	1994	310						
Menopause	688	171						

Abbreviations: HPV, human papilloma virus.

home and mail the sample to the testing institution, special personnel to inform them of abnormal results and treatment methods are needed to avoid missed diagnoses of cervical cancer and precancerous lesions. Recently, new HPV testing methods, such as urine and menstrual blood sampling, have been developed for cervical cancer screening and have demonstrated high accuracy. However, these studies' had small sample sizes and needed further validation in larger populations. These new approaches hold promise for increasing participation rates in cervical cancer screening among women from diverse regions, religious beliefs, and cultures [30,31].

The strength of this study is that it covers women from all regions of China as well as different ethnic groups. However, there are also several limitations of this study. One weakness is that the outcome of cervical HPV infection remains unknown. However, we have built a platform from which we can follow and manage women's data over the long term. Moreover, our study enrolled women who went to the hospital only, which may weaken its representation given that some women attended cervical screening at community health centers in China.

In conclusion, this study shows the high consistency between HPV self- and clinician-sampling. HPV self-sampling was widely accepted by women in different regions of China and could be an effective alternative to traditional cervical screening methods. Professional gynecologists and social health workers are needed to publicize self-sampling and inform women with abnormal results. The HPV infection data represented by this analysis exhibited some unique features. New vaccination and cervical screening recommendations should be tailored to different population characteristics, which may have higher socioeconomic value.

CRediT authorship contribution statement

Xuechao Ji: Writing – original draft, Formal analysis, Data curation, Conceptualization. **Menglin Hao:** Formal analysis, Data curation. **Yixiao Wang:** Methodology, Funding acquisition. **Zangyu Pan:** Methodology, Formal analysis. **Ruiye Yang:** Methodology, Formal analysis. **Xinbo Wang:** Data curation. **Hui Wang:** Data curation. **Chunlian Zhang:** Data curation. **Yiqun Zhang:** Data curation. **Xumei Zhang:** Data curation. **Ge Yang:** Data curation. **Sarendalai:** Data curation. **Tunala:** Data curation. **Jinwei Miao:** Writing – review & editing, Funding acquisition, Conceptualization.

Data availability

The data supporting this study's findings are available from the corresponding authors upon reasonable request.

Ethics statements

The Medical Ethics Committee of Beijing Obstetrics and Gynecology Hospital approved this study (No.2022-KY043-01).

Ethics approval statement

The Human Subjects Review Boards of Beijing Obstetrics and Gynecology Hospital approved this study (No.2022-KY043-01).

Patient consent statement

All participants provided written informed consent.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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