Preventive Medicine Reports 34 (2023) 102243

Contents lists available at ScienceDirect

Preventive Medicine Reports

journal homepage: www.elsevier.com/locate/pmedr

Exploring factors associated with preferences for human papillomavirus (HPV) self-sampling among racially- and ethnically-diverse women in Minnesota: A cross-sectional study

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ARTICLE INFO

Keywords:
Human papillomavirus (HPV)
HPV self-sampling
Cervical cancer screening
Anderson's Behavioral Model

ABSTRACT

Pap tests are still underutilized by minority women due to limited awareness of cervical cancer screening (CCS), inadequate health care access, and cultural or religious beliefs. Human papillomavirus (HPV) self-sampling, a new CCS tool, has demonstrated potential to overcome some of these barriers. In 2021, women aged 30–65 years old were recruited across Minnesota to complete an online survey. The survey assessed five outcome measures related to HPV self-sampling: (1) awareness of test; (2) self-efficacy to conduct test; (3) location preference of test (clinic vs. home); 4) collector preference (self vs. clinician); and (5) preference of CCS strategy (HPV self-sampling vs. Pap test). Modified Poisson regressions tested associations between sociodemographic variables and outcomes. A total of 420 women completed the survey, of which 32.4% identified as Non-Hispanic white, 22.2% as Hispanic, 12.6% as Black/African-American, 28.3% as Asian, 1.9% as American Indian/Alaskan Native, and 1.4% as more than two races. Few women had heard of HPV self-sampling (6.5%), but a majority reported high self-efficacy to perform self-sampling (75.3%). Women also reported higher preferences for completing an HPV test in the clinic (52.2%) and for performing a self-collected HPV test themselves (58.7%), yet would choose a traditional Pap test over HPV self-sampling (56.0%). The low level of HPV self-sampling awareness, across all racial/ethnic groups, suggests a strong opportunity to promote widespread educational efforts around this new tool. Future HPV self-sampling research efforts should examine educational interventions targeted at healthcare providers to educate and encourage women on the importance of self-collection options.

1. Introduction

Cervical cancer continues to affect many women in the United States (US). Although preventable, 0.63% of all US women will develop cervical cancer in their lifetime. (American Cancer Society, 2022) Furthermore, the burden of this cancer is not equally distributed across races and ethnicities. (Ramondetta et al., 2015; Lee et al., 2010) Despite decreases in cervical cancer incidence in all racial/ethnic groups and a narrowing of differences between groups since 2000, disparities in cervical cancer incidence between non-Hispanic whites and minority groups persist. (SEER*Explorer: An interactive website for SEER cancer statistics [Internet]. Surveillance Research Program, National Cancer Institute;, 2023) The age-adjusted incidence rate of cervical cancer for all US women in 2020 was 7.1 cases per 100,000 women per year. In

Abbreviations: ACS, American Cancer Society; BRFSS, Behavioral Risk Factor Surveillance Survey; COVID-19, Coronavirus Disease 2019; HINTS, Health Information National Trends Survey; hrHPV, High-risk Human Papillomavirus; HPV, Human Papillomavirus; IRB, Institutional Review Board; KAPS, Knowledge and Perceptions Survey; MCAR, Missing completely at random; SEER, Surveillance, Epidemiology, and End Results; USPSTF, United States Preventive Services Task Force.

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https://doi.org/10.1016/j.pmedr.2023.102243
Received 7 November 2022; Received in revised form 5 May 2023; Accepted 10 May 2023
Available online 13 May 2023

Black/African-American and Hispanic/Latina women, the incidence of cervical cancer was 8.0 cases per 100,000 women and 9.2 cases per 100,000 women, respectively. (SEER*Explorer: An interactive website for SEER cancer statistics [Internet]. Surveillance Research Program, National Cancer Institute;, 2023) Multiple barriers contribute to the increased cervical cancer burden in racial and ethnic minorities. Individual factors (e.g., education, socioeconomic status, cancer knowledge, religious and cultural beliefs, limited English proficiency) and structural factors (e.g. health care access) are often cited barriers. (Kaiser Family Foundation (KFF), 2020; MacLaughlin et al., 2019; Abdi et al., 2020; Jacobs et al., 2005; Brouwers et al., 2011; Everett et al., ; Yin et al., 2010; Singh, 2003; Krieger et al., 2002; Goding Sauer et al., 2019) Many, if not all, of these barriers and concerns are modifiable. (Ghebre et al., 2015; Liles et al., 2015; Paskett et al., 2016).

Cancer screening interventions, such as Pap tests, have been proven effective in reducing cervical cancer incidence and mortality. (Gibb and Martens, 2011; Kitchener et al., 2006) However, they are still underutilized by many women from marginalized racial and ethnic groups. (Abdi et al., 2020; Jacobs et al., 2005; Brouwers et al., 2011; Everett et al.,) In Minnesota, for example, only 52% of Somali women were up-to-date with cervical cancer screening per recommendations compared to the statewide rate of 71.3%. (MN Community Measurement, 2020) The persistence of cervical cancer disparities suggests that Pap tests have not been entirely successful, likely due to their underutilization. Novel interventions that maximize cervical cancer prevention, therefore, are critical to eradicate this disease.

Primary human papillomavirus (HPV) testing is a newer method recommended by the US Preventive Services Task Force (USPSTF) as an alternative to Pap test screening. Currently, the USPSTF recommends three cervical cancer screening options for women ages 30–65: (1) a Pap test every 3 years; (2) a high-risk human papillomavirus (hrHPV) test every 5 years; or (3) a hrHPV testing in combination with Pap test (co-testing) every 5 years. (Curry et al., 2018) HPV self-sampling, the process of collecting a vaginal sample by oneself for HPV testing, has been proposed as an appropriate and effective alternative to Pap tests and clinician-collected HPV sample testing (Arbyn et al., 2014; Sultana et al., 2016; Montealegre et al., 2015; Racey et al., 2013) and is being considered by the USPSTF as a potentially evidence-based modality for facilitating primary HPV testing under the 2022 final research plan for cervical cancer screening. (U.S. Preventive Services Task Force, 2022).

Compared to Pap tests, HPV testing with self-collected vaginal samples (referred to as "HPV self-sampling" hereafter) has demonstrated higher sensitivity in detecting high grade cervical disease, (Racey et al., 2013; Arbyn et al., 2018) and shown good concordance with clinician-sampling methods. (Giorgi Rossi et al., 2015; Tranberg et al., 2018; Kellen et al., 2018) Multiple large randomized controlled trials (RCTs) report that HPV self-sampling can improve cervical cancer screening rates among women who may otherwise delay or opt out of cervical cancer screening. (Gupta et al., 2018; Ketelaars et al., 2017; Lazcano-Ponce et al., 2011; Arrossi et al., 2015) In countries with organized cervical cancer screening programs (e.g., Netherlands), HPV self-sampling has already been adopted as an adjunct cervical cancer screening strategy. (Nishimura et al., 2021; Virtanen et al., 2011; Darlin et al., 2013) Many women report high acceptability of self-collected HPV tests, and, in some cases, women indicate a higher preference for self-collected HPV tests than provider-collected procedures. (Anderson et al., 2018; Ortiz et al., 2012; Tisci et al., 2003) Cost-effectiveness analyses have found that self-collected HPV testing had a lower lifetime cost and a higher quality-adjusted life expectancy than Pap test screening. (Bais et al., 2007; Balasubramanian et al., 2010; Malone et al., 2020) These findings suggest that HPV self-sampling is an effective and cost-saving strategy to increase cervical cancer screening among women who may not readily access Pap test-based screening in health care systems.

Most research on HPV self-sampling has, however, focused on the home-based, mail-in self-sampling approach (Malone et al., 2020; Winer et al., 2018; Yeh et al., 2019), leaving an untapped opportunity to utilize clinic-based HPV self-sampling in health care systems. Clinic-based HPV self-sampling, wherein women can conduct the self-collection in real-time in a primary care exam room, can mitigate some of the mail-based challenges (e.g., missing samples, lack of follow-up) and offer opportunities for women to develop self-efficacy to conduct the self-collection (e.g., visual tutorials provided by clinic staff). (Buist et al., 2019) Only one pilot study (i.e., ROSE 1.0) has implemented clinic-based HPV self-sampling and found that this approach significantly increased follow-up in HPV positive-tested women. (Woo, 2019) These optimistic findings warrant additional research on clinic-based HPV self-sampling.

Currently, few US-based studies have explored the various location adaptations of an HPV self-sampling intervention; it remains to be explored whether clinic-based HPV self-sampling is preferable for underscreened women to initiate cervical cancer screening than home-based HPV self-sampling alone. To begin building an evidence base for clinic-based approaches, this cross-sectional study aimed to gather perspectives from racially- and ethnically-diverse women regarding their delivery preferences (clinic-based vs. home-based) for HPV self-sampling. This study also assessed women's awareness of, self-efficacy around, and additional preferences for HPV self-sampling (self-collected vs. clinician-collected, Pap test vs. HPV self-sampling) and potential factors associated with these outcomes.

2. Methods

2.1. Study sample and recruitment

From May to November 2021, women representing diverse groups across Minnesota were recruited to complete an online survey through community-based organizations, e-mail listservs, social media postings, and in-person events (e.g., health fairs). Community-based organizational partners ranged from cultural non-profits to faith-based organizations. Women first completed an online eligibility screener prior to beginning the survey. To be eligible, participants had to meet the following criteria: (1) no prior hysterectomy; (2) no prior history of invasive cervical cancer; and (3) be within the USPSTF age range for HPV testing (30–65 years old). Only study participants who were recruited through in-person community events were compensated with a $5 gift card. All study protocols and materials were approved by the University of Minnesota's IRB (STUDY00011906).

2.2. Data collection and procedures

The online survey was administered through Qualtrics (Babitsch et al., 2012) and made available in English, Hmong, Spanish, and Somali. All translated surveys were pilot tested with seven bicultural female community members (two Hmong, two Spanish, two Somali, and one American-Indian) prior to data collection.

2.3. Measures

2.3.1. Theory and factors examined

Prior research on barriers experienced by minority women accessing cervical cancer screening informed the factors that were included in the survey (Abdi et al., 2020; Jacobs et al., 2005; Brouwers et al., 2011; Everett et al.,) Drawing from Andersen's Behavioral Model of Health Services Use, these factors were categorized into three distinct categories – predisposing, enabling, and need (Andersen, 1995). Predisposing factors refer to the sociocultural characteristics of an individual that exist prior to their illness, for example, an individual's age and gender. Enabling factors are defined as conditions that facilitate an individual to use health services, for example, having health insurance. Finally, need factors refer to the conditions that elicit an individual's need to use a health service.

Five predisposing factors were included in the survey: age (in years), race/ethnicity (Non-Hispanic white, Hispanic, Black/African-American, Asian, American Indian/Alaskan Native, Multirace), sexual orientation (straight, queer), marital status (single, married/partnered), and nativity (foreign-born, US-born). Annual household income (<$34,999, $35,000 – $89,999, ≥ $90,000), health insurance (no, yes), educational level (less than a high school degree, high school degree or equivalent, Bachelor's degree or higher), English language capability (limited, advanced), HPV awareness (no, yes), and knowledge of cervical cancer were included as enabling factors. Knowledge of cervical cancer was assessed with a seven-item HPV literacy index adapted from the Knowledge and Perceptions Survey (KAPS) (McPartland et al., 2005) and validated with several diverse female populations. (Beltran et al., 2016; Bynum et al., 2011; Iliyasu et al., 2010) A total knowledge score was calculated for each respondent by summing up all of their correct responses. The knowledge score was further dichotomized by the mean into low and high. Need factors included routine exam and Pap test in past year (no, yes), previous Pap test experiences (pleasant, neutral, unpleasant), and perceived health status (fair/good, very good/excellent). Most measures were adapted from the 2019 Health Information National Trends Survey 5 Cycle 3 (HINTS 5, Cycle 3) (NCI, 2019) and the 2019 Behavioral Risk Factor Surveillance Survey (BRFSS) (Centers for Disease Control and Prevention., 2019) (Appendix Table A1).

2.3.2. Outcome measures

Five outcomes were collected in the survey: (1) awareness of HPV self-sampling; (2) self-efficacy to complete an HPV self-sampling test; (3) location preference for HPV self-sampling collection; (4) collector preference for HPV testing; and (5) overall preference of cervical cancer screening strategy (Pap or HPV self-sampling). Awareness was assessed with the following question, "Have you ever heard of self-collected HPV testing?" (yes, no, and unsure). Following the awareness question, survey participants were provided with a definition of self-collected HPV testing and an illustration of how to do the self-collection process (Appendix Fig A1). Self-efficacy was measured with the following question, "How confident are you that you could successfully collect a vaginal sample for an HPV test on your own?" (four response options: very confident to not at all confident). Both location and collector preferences were assessed with the following item, "If your clinic offered you a self-collected HPV test, which option below would you choose?" with four response options: (1) Receive the test by mail and complete the test by myself at home. (2) Pick up the test at the clinic and complete the test by myself at home. (3) Receive and complete the test by myself at my clinic. (4) Have my doctor or nurse complete the test on me when I am at the clinic. Preference of cervical cancer screening strategy was measured with the following question, "Now that you know more about self-collected HPV testing, what would be your preference for cervical cancer screening?" with two response options: (1) A Pap test; or (2) Do self-collected HPV testing on your own. Respondents were also asked to rank-choice their reasons for selecting or not selecting HPV self-sampling as their preferred cervical cancer screening strategy. Reasons included privacy, convenience, transportation/healthcare access, embarrassment, pain, spousal influence, and free-write options.

2.3.3. Data analysis

Descriptive frequencies were calculated for all variables including outcomes. All outcome measures were operationalized as binary variables. Bivariate and adjusted analyses using modified Poisson regression were conducted to assess exploratory associations between all potential factors and each outcome. Since associations were similar in age- and multivariable-adjusted models, relative risks and 95% confidence intervals were adjusted only for age, except when age was examined as a factor, consistent with previous HPV self-sampling studies. (Gottschlich et al., 2019; Scarinci et al., 2021) Additionally, an age trend was assessed with Mantel-Haenszel's test for linear trend. Subgroup analyses were also conducted to test if significant correlations differed by three racial/ethnic groups (Non-Hispanic white, Hispanic, Asian); all interactions were tested using the Likelihood Ratio chi-square test. Stata version 17 (StataCorp) was used to conduct all statistical analyses.

3. Results

3.1. Description of sample

Four hundred twenty women (n = 420) completed the online survey (Table 1). Approximately 32.4% identified as Non-Hispanic white, 22.2% as Hispanic, 12.6% as Black/African-American, 28.3% as Asian, 1.9% as American Indian/Alaskan Native, and 1.4% as more than two races (multirace). Respondents had a mean age of 41.6 years (SD: ±10) and were predominantly straight (81.4%), married/partnered (69.3%), US-born (63.5%), had an annual household income of ≥ $90,000 (41.2%), were insured (88.8%), had a Bachelor's degree or higher (69.3%), had advanced English language capability (90.5%), were aware of HPV (85.3%), had high knowledge of cervical cancer (59.8%), had a routine exam in the past year (60.7%), had not completed a Pap test within the past year (63.3%), reported neutral previous Pap test experiences (50.7%), and had very good/excellent perceived health status (71.9%).

3.2. Outcomes and exploratory associations

Few women had ever heard of HPV self-sampling (n = 27, 6.4%; Table 1). Only one factor was statistically significantly associated with HPV self-sampling awareness after adjusting for age – with increasing annual household income, women were less likely to report awareness of HPV self-sampling. In contrast to awareness, the majority of women reported high self-efficacy to complete an HPV self-sampling test (n = 311, 74.0%; Table 1). Many of the predisposing, enabling, and need factors were statistically significantly associated with high self-efficacy in the crude analyses (Appendix Table A2). After adjusting for age, however, most of these associations were attenuated and no longer statistically significant, with two exceptions (Table 2): high self-efficacy was less likely to be reported only among women who identified as Asian (age-adjusted RR = 0.7, 95% CI: 0.6,-0.9) and women reporting previous neutral and/or negative experiences with Pap tests (age-adjusted RR = 0.8, 95% CI: 0.7,-0.9; age-adjusted RR = 0.8, 95% CI: 0.6–0.9, respectively).

In location preference for completing an HPV test, less than half of survey respondents preferred a home-based approach compared to a clinic-based approach (n = 197, 47.8%; Table 1). As was found for self-efficacy, age confounded most of the crude associations. The two associations that remained statistically significant after adjusting for age were among women who identified as Black/African-American, who were less likely to prefer the home-based approach (age-adjusted RR = 0.6, 95% CI: 0.4,-1.0), and among women reporting previous unpleasant experiences with Pap tests, who were more likely to prefer the home-based location (age-adjusted RR = 1.6, 95% CI: 1.0,-2.4) (Table 2).

Regarding collector preference, more than half of respondents preferred self-collected compared to clinician-collected approaches (n = 242, 57.6%; Table 1). Although several factors were associated with this outcome in the crude analyses, no correlations remained statistically significantly after adjusting for age. Due to a survey design flaw discovered during analysis, only 343 women responded to the question about their preferred cervical cancer screening strategy (n = 77, 18.3% missing; Table 1). Among those who answered the question, more than one-third preferred HPV self-sampling over a traditional Pap test (n = 151, 36.0%; Table 1). Similar to collector preference, no statistically significant associations remained after adjusting for age (Table 2). No meaningful differences were identified between all factors and outcomes when stratified by three racial/ethnic groups (Non-Hispanic whites, Hispanics, and Asians; data not shown) with p-values for interaction exceeding 0.05.

Table 1
Study participant characteristics and outcomes of data in a multi-ethnic sample of women in Minnesota (n = 420), 2021.

n (%)		
Predisposing Factors (5)		
Age (years): mean ± SD	41.6 ± 10.0	
Age (years): group		
30–39	190	(45.2)
40–49	102	(24.3)
50–59	53	(12.6)
60+	29	(6.9)
Missing	46	(11.0)
Race/ethnicity		
Non-Hispanic White	136	(32.4)
Hispanic	93	(22.2)
Black/African-American	53	(12.6)
Asian	119	(28.3)
American Indian/Alaskan Native	8	(1.9)
Multirace	6	(1.4)
Missing	5	(1.2)
Sexual orientation		
Straight	342	(81.4)
Queer	70	(16.7)
Missing	8	(1.9)
Marital status		
Single	124	(29.5)
Married/partnered	291	(69.3)
Missing	5	(1.2)
Nativity		
Foreign-born	149	(35.5)
US-born	267	(63.5)
Missing	4	(1.0)
Enabling Factors (6)		
Annual household income		
< $34,999	79	(18.8)
$35,000 - $89,999	156	(37.1)
≥ $90,000	173	(41.2)
Missing	12	(2.9)
Health insurance		
No	35	(8.3)
Yes	373	(88.8)
Missing	12	(2.9)
Educational level		
Less than a high school degree	33	(7.9)
High school degree or equivalent	90	(21.4)
Bachelor's degree or higher	291	(69.3)
Missing	6	(1.4)
English language capability		
Limited	37	(8.8)
Advanced	380	(90.5)
Missing	3	(0.7)
HPV awareness		
No	56	(13.3)
Yes	358	(85.3)
Missing	6	(1.4)
Knowledge of cervical cancer (0–7): mean ± SD	3.67 ± 1.91	
Knowledge of cervical cancer (dichotomized at the mean)		
Low	158	(37.6)
High	251	(59.8)
Missing	11	(2.6)
Need Factors (4)		
Routine exam in past year		
Yes	255	(60.7)
No	162	(38.6)
Missing	3	(0.7)
Pap test in past year		
Yes	151	(36.0)
No	266	(63.3)
Missing	3	(0.7)
Previous Pap test experience		
Pleasant	54	(12.9)
Neutral	213	(50.7)
Unpleasant	139	(33.1)
Missing	14	(3.3)
Perceived health status		
Fair/good	113	(26.9)
Very good/excellent	302	(71.9)
Missing	5	(1.2)
Outcomes (5)		
HPV self-sampling awareness		
No	386	(91.9)
Yes	27	(6.4)
Missing	7	(1.7)
Self-efficacy		
Low	102	(24.3)
High	311	(74.0)
Missing	7	(1.7)
Location preference		
Clinic-based	215	(51.2)
Home-based	197	(46.9)
Missing	8	(1.9)
Collector preference		
Clinician-collected	170	(40.5)
Self-collected	242	(57.6)
Missing	8	(1.9)
Preferred cervical cancer screening (CCS) strategy		
Pap test	192	(45.7)
HPV self-sampling	151	(36.0)
Missing	77	(18.3)

In addition to age being included as a confounder in adjusted models, it was also examined separately in relation to each outcome (Table 2). Age was not strongly associated with awareness of HPV self-sampling, high self-efficacy, or location preference. However, compared to younger women, older women were less likely to prefer the self-collected approach over the clinician-collected approach and less likely to prefer HPV self-sampling over Pap tests. Further, in the preferred cervical cancer screening strategy, the age trend was statistically significant ($p < 0.05$) – with increasing age, older women were less likely to prefer HPV self-sampling.

Among women who selected HPV self-sampling as their preferred cervical cancer screening strategy, the top three reasons for their decision were due to privacy, convenience, and perception of less pain (Table 3). Other reasons included less embarrassment, not needing transportation/health care access, and ease of use. In contrast, the top three reasons for women not choosing HPV self-sampling included strong reliance on provider expertise, lack of self-efficacy, and perceived lack of concordance between self-collected samples and clinician-collected samples. Additional reasons included spousal influence, less convenience, and less perceived accuracy of HPV self-sampling tests. Reasons for selecting HPV self-sampling slightly differed for Non-Hispanic white women, with less pain being their top choice rather than privacy. Meanwhile, reasons for not selecting HPV self-sampling did not differ between racial/ethnic groups.

4. Discussion

HPV-based screening is important for curbing and preventing cervical cancer. Recent guideline adoptions for primary HPV testing in 2018 by the USPSTF (Curry et al., 2018) and in 2020 by the ACS (Fontham et al., 2020) signal an important change in cervical cancer screening efforts. HPV self-sampling, in particular, may help to facilitate the uptake of primary HPV testing and cervical cancer screening adherence. (U.S. Preventive Services Task Force, 2022) This is the first cross-sectional study to explore a sample of racially and ethnically-diverse women's awareness, self-efficacy, and preferences of HPV self-sampling and potential correlates of those outcomes.

Across all outcomes, this study found no factors that were consistently correlated with awareness, self-efficacy, and preferences for HPV self-sampling. One key finding is that few women, including those that are racially- and ethnically-diverse, had heard of HPV self-sampling, suggesting that the dissemination of HPV self-sampling information within US contexts is still in its infancy, and further, may not be reaching

Table 2
Frequencies and relative risks** examining factors associated with HPV self-sampling outcomes in a multi-ethnic sample (n = 420) of women in Minnesota, 2021.

	Awareness	Self-Efficacy	Home-Based	Self-Collected	Preferred CCS: HPV Self-Sampling					
	N RR**(%*) (95% CI)	N RR** (%*) (95% CI)	N RR** (%*) (95% CI)	N RR** (%*) (95% CI)	N RR** (%*) (95% CI)					
Predisposing Factors										
Age										
30–39	11/190 (5.8)	ref	157/190 (82.6)	ref	100/190 (52.6)	ref	126/190 (66.3)	ref	86/158 (54.4)	ref
40–49	9/100 (9.0)	1.6 (0.7, 4.0)	74/100 (74.0)	0.9 (0.8, 1.0)	42/100 (42.0)	0.8 (0.6, 1.0)	53/100 (53.0)	0.8 (0.7, 1.0)	32/88 (36.4)	0.7 (0.5, 0.9)
50–59	1/53 (1.9)	0.9 (0.0, 2.5)	38/53 (71.7)	0.9 (0.7, 1.0)	23/52 (44.2)	0.8 (0.6, 1.2)	26/53 (50.0)	0.8 (0.6, 1.0)	15/43 (34.9)	0.6 (0.4, 1.0)
60+	2/29 (6.9)	1.4 (0.6, 1.0)	19/29 (65.5)	0.8 (0.6, 1.0)	15/29 (51.7)	1.0 (0.7, 1.4)	15/29 (51.7)	0.8 (0.5, 1.1)	8/25 (32.0)	0.6 (0.3, 1.1)
Race/ethnicity										
Non-Hispanic White	8/136 (5.9)	ref	121/136 (89.0)	ref	86/136 (63.2)	ref	97/136 (71.3)	ref	71/121 (58.6)	ref
Hispanic	7/90 (7.8)	0.7 (0.1, 4.1)	64/90 (71.1)	0.9 (0.7, 1.1)	36/90 (40.0)	1.0 (0.6, 1.4)	48/90 (53.3)	0.9 (0.7, 1.3)	26/74 (35.1)	0.8 (0.5, 1.3)
Black/African-American	4/52 (7.7)	1.1 (0.2, 6.1)	37/52 (71.2)	0.9 (0.7, 1.1)	16/51 (31.4)	0.6 (0.4, 1.0)	23/51 (45.1)	0.7 (0.5, 1.0)	11/45 (24.4)	0.6 (0.3, 1.1)
Asian	6/119 (5.0)	1.2 (0.2, 5.3)	77/119 (64.7)	0.7 (0.6, 0.9)	53/119 (44.5)	0.9 (0.6, 1.2)	66/119 (55.5)	0.8 (0.6, 1.1)	39/94 (41.5)	0.7 (0.5, 1.1)
American Indian/ Alaska Native	1/8 (12.5)	5.7 (0.3, 148.1)	5/8 (62.5)	1.5 (1.0, 2.3)	2/8 (25.0)	0.4 (0.1, 2.3)	3/8 (37.5)	0.6 (0.2, 1.9)	2/5 (40.0)	0.7 (0.2, 3.3)
Multirace	1/6 (16.6)	1.7 (0.1, 41.9)	5/6 (83.3)	0.8 (0.4, 1.5)	2/6 (33.0)	0.4 (0.1, 1.4)	3/6 (50.0)	0.4 (0.1, 1.6)	2/4 (50.0)	0.7 (0.2, 2.4)
Sexual orientation										
Straight	21/338 (6.2)	ref	257/338 (76.0)	ref	165/337 (49.0)	ref	199/337 (59.1)	ref	125/281 (44.5)	ref
Queer	5/70 (7.1)	1.1 (0.3, 4.2)	50/70 (71.4)	1.0 (0.9, 1.1)	31/70 (44.3)	1.0 (0.8, 1.3)	40/70 (57.1)	1.0 (0.8, 1.3)	25/58 (43.1)	1.0 (0.7, 1.4)
Marital status										
Single	10/123 (8.1)	ref	85/123 (69.1)	ref	60/122 (49.2)	ref	72/122 (59.0)	ref	42/102 (41.2)	ref
Married/partnered	17/288 (5.9)	1.1 (0.3, 3.4)	225/288 (78.1)	1.0 (0.9, 1.2)	137/288 (47.6)	1.0 (0.8, 1.3)	170/288 (59.0)	1.0 (0.9, 1.3)	109/239 (45.6)	1.2 (0.9, 1.7)
Nativity										
Foreign-born	12/146 (8.2)	ref	100/146 (68.5)	ref	58/146 (39.7)	ref	78/146 (53.4)	ref	44/118 (37.3)	ref
US-born	15/266 (5.6)	0.7 (0.2, 2.6)	210/266 (78.9)	0.9 (0.8, 1.0)	139/265 (52.5)	1.1 (0.8, 1.6)	163/265 (61.5)	1.0 (0.8, 1.3)	106/224 (47.3)	1.0 (0.7, 1.5)
Enabling Factors										
Annual household income										
< $34,999	10/79 (12.7)	ref	42/79 (53.3)	ref	22/79 (27.8)	ref	32/79 (40.5)	ref	19/66 (28.8)	ref
$35,000 - $89,999	10/156 (6.4)	0.2 (0.1, 0.9)	125/156 (80.1)	1.3 (0.9, 1.8)	86/155 (55.5)	1.2 (0.8, 2.0)	105/155 (67.7)	1.1 (0.8, 1.6)	61/126 (48.4)	1.7 (0.9, 3.3)
≥ $90,000	7/170 (4.1)	0.2 (0.0, 0.9)	140/170 (82.4)	1.2 (0.9, 1.8)	88/170 (51.8)	1.0 (0.6, 1.6)	104/170 (61.2)	0.9 (0.6, 1.3)	70/145 (48.3)	1.4 (0.7, 2.9)
Health insurance										
No	2/35 (5.7)	ref	22/35 (62.9)	ref	7/35 (20.0)	ref	11/35 (31.4)	ref	6/28 (21.4)	ref
Yes	24/369 (6.5)	6.1 (0.5, 92.2)	286/369 (77.5)	0.7 (0.5, 1.0)	187/368 (50.8)	1.1 (0.6, 2.3)	226/368 (61.4)	1.3 (0.7, 2.4)	141/308 (45.8)	1.3 (0.4, 4.2)
Educational level										
Less than a high school degree	4/33 (12.1)	ref	16/33 (48.5)	ref	6/33 (18.2)	ref	10/33 (30.3)	ref	8/28 (28.6)	ref
High school degree/ GED	7/90 (7.8)	1.1 (0.2, 6.8)	57/90 (63.3)	1.4 (0.9, 2.2)	34/90 (37.8)	1.0 (0.3, 3.3)	45/90 (50.0)	1.2 (0.5, 2.6)	22/70 (31.4)	0.4 (0.2, 1.2)
Bachelor's degree or higher	16/287 (5.6)	0.5 (0.1, 3.7)	236/287 (82.2)	1.4 (0.9, 2.3)	156/286 (54.5)	1.0 (0.3, 3.4)	186/286 (65.0)	1.2 (0.5, 2.6)	121/243 (49.8)	0.5 (0.2, 1.4)
English language capability										
Limited	5/37 (13.5)	ref	18/37 (48.6)	ref	5/37 (13.5)	ref	10/37 (27.0)	ref	7/34 (20.6)	ref
Advanced	22/376 (5.9)	0.5 (0.0, 5.3)	293/376 (77.9)	1.3 (0.8, 2.1)	192/375 (51.2)	3.1 (0.8, 12.0)	232/375 (61.9)	2.3 (0.9, 5.9)	144/309 (46.6)	4.1 (0.7, 24.0)
HPV awareness										
No	1/56 (1.8)	ref	28/56 (50.0)	ref	18/56 (32.1)	ref	26/56 (46.4)	ref	14/43 (32.6)	ref
Yes	26/357 (7.3)	9.4 (0.5, 194.8)	283/357 (79.8)	1.2 (0.9, 1.6)	179/356 (50.3)	1.0 (0.6, 1.6)	216/356 (60.7)	0.9 (0.6, 1.3)	137/300 (45.7)	1.0 (0.5, 1.6)

(*continued on next page*)

Table 2 (*continued*)

	Awareness	Self-Efficacy	Home-Based	Self-Collected	Preferred CCS: HPV Self-Sampling					
	N RR** (%*) (95% CI)	N RR** (%*) (95% CI)	N RR** (%*) (95% CI)	N RR** (%*) (95% CI)	N RR** (%*) (95% CI)					
Knowledge of cervical cancer										
Low	7/158 (4.4)	ref	101/158 (63.9)	ref	58/158 (36.7)	ref	77/158 (48.7)	ref	46/131 (35.1)	ref
High	19/250 (7.6)	2.7 (0.7, 10.5)	206/250 (82.4)	1.1 (0.9, 1.2)	137/249 (55.5)	1.1 (0.8, 1.4)	163/249 (65.5)	1.1 (0.9, 1.3)	101/207 (48.8)	1.1 (0.8, 1.4)
Need Factors										
Routine exam in past year										
Yes	14/253 (5.5)	ref	193/253 (76.3)	ref	116/252 (46.0)	ref	142/252 (56.4)	ref	89/211 (42.2)	ref
No	13/160 (8.1)	1.0 (0.4, 3.0)	118/160 (73.8)	1.0 (0.9, 1.1)	81/160 (50.6)	1.2 (1.0, 1.5)	100/160 (62.5)	1.1 (1.0, 1.4)	62/132 (47.0)	1.3 (1.0, 1.7)
Pap test in past year										
Yes	8/150 (5.3)	ref	106/150 (70.7)	ref	57/149 (38.3)	ref	71/149 (47.7)	ref	49/118 (41.5)	ref
No	19/263 (7.2)	1.4 (0.4, 4.4)	205/263 (77.9)	1.1 (1.0, 1.3)	140/263 (53.2)	1.1 (0.9, 1.5)	171/263 (65.0)	1.2 (1.0, 1.5)	102/225 (45.3)	0.9 (0.6, 1.1)
Previous Pap test experience										
Pleasant	5/54 (9.3)	ref	48/54 (88.9)	ref	19/54 (35.2)	ref	26/54 (48.2)	ref	15/42 (35.7)	ref
Neutral	14/210 (6.7)	0.6 (0.2, 2.1)	154/210 (73.3)	0.8 (0.7, 0.9)	86/209 (41.1)	1.3 (0.8, 2.0)	107/209 (51.2)	1.1 (0.8, 1.6)	55/173 (31.8)	1.0 (0.7, 1.7)
Unpleasant	7/138 (5.1)	0.8 (0.2, 3.2)	101/138 (73.2)	0.8 (0.6, 0.9)	85/138 (61.6)	1.6 (1.0, 2.4)	101/138 (73.2)	1.3 (1.0, 1.8)	75/119 (63.0)	1.6 (1.0, 2.5)
Perceived health status										
Fair/good	8/112 (7.1)	ref	72/112 (64.3)	ref	41/112 (36.6)	ref	52/112 (46.4)	ref	32/90 (35.6)	ref
Very good/excellent	19/299 (6.4)	0.7 (0.2 2.3)	238/299 (79.6)	1.0 (0.8, 1.2)	115/298 (38.6)	1.0 (0.8, 1.4)	189/298 (63.4)	1.1 (0.8, 1.4)	118/251 (47.0)	1.0 (0.7, 1.5)

*=Percent total in category with respective outcome, **. = Relative Risk adjusted for age, except when age is examined as a factor, CI = confidence interval based on modified Poisson regression, Preferred CCS = preferred cervical cancer screening strategy, ref. = referent group.

all women, regardless of race/ethnicity. The low level of awareness is consistent with previous US-based research where HPV self-sampling interventions are being introduced. (Marshall et al., 2019; Le et al., 2022) Additionally, much of the development and assessment of HPV self-sampling interventions have occurred in international contexts (e.g., Mexico, Netherlands) and the implementation of this modality has been slow in the US, with only one large pragmatic trial in the Pacific Northwest. (Winer et al., 2019).

Despite not having heard of HPV self-sampling, many women reported a high sense of self-efficacy to complete an HPV self-sampling test. The strongest negative correlates of high self-efficacy were neutral and unpleasant experiences with previous Pap tests. These findings may suggest that women, who have had neutral or unfavorable pelvic exams in the past for Pap test screening, may be less likely to feel confident in conducting their own tests. Several studies examining self-efficacy in HPV self-sampling interventions have found that women with previous negative screening experiences were more likely to report pain and be averse to initiating self-sampling. (Catarino et al., 2015; Howard et al., 2009) In the present study, Asian women were also found to be less likely to report high self-efficacy. This finding is consistent with many studies that have examined the feasibility of HPV self-sampling within Asian women. (Ma et al., 2022; Hanley et al., 2016; Phoolcharoen et al., 2018) Compared to Non-Hispanic white women, Asian women have been found to be less experienced and confident with vaginal applicators (e.g., tampons). Additional theory-based HPV self-sampling interventions are needed to further elucidate predictors of high self-efficacy and explore whether these predictors differ across racial/ethnic groups.

This study also found that women may potentially prefer the clinic-based approach. Within clinic settings, women can either conduct their own self-collection or have a clinician perform the collection onsite at the clinic (i.e., point of care). Only one pilot study has implemented clinic-based HPV self-sampling and conferred positive results supporting an increase uptake in cervical cancer screening and adherence to follow-up of abnormal results. (Woo, 2019) Support for the clinic-based approach has also been documented in several pre-implementation studies and protocols of HPV self-sampling interventions. (Bansil et al., 2014; Tang et al., 2021) Advantages to the clinic location include having providers be present in the exam rooms to address questions from patients in real-time, allowing patients to examine the brush and testing kit first-hand, providing a sanitary and private location for self-collection, and mitigating challenges around the return of missing or lost samples with the mail-based approach. Future research efforts should explore the feasibility, efficacy and effectiveness of various delivery approaches, including point-of-care, for HPV self-sampling.

This study, moreover, found that many women prefer to HPV self-sampling. However, the biggest potential barriers to women taking up HPV self-sampling were the strong reliance on provider expertise and the perceived concordance and reliability of the test. Despite this, many HPV self-sampling interventions with laboratory validation studies have shown and demonstrated that self-collected samples are highly concordant with clinician-collected samples. (Tranberg et al., 2018; Gök et al., 2012) Future implementation studies on HPV self-sampling should focus on strategies to mitigate these concerns around collection concordance and promote women's self-efficacy to collect their own cervicovaginal samples.

Despite women's preference for HPV self-sampling, this study found that Pap tests were still preferred by women overall. Older women, in particular, were less likely to choose the self-sampling approach as their preferred cervical cancer screening strategy; though this finding should

Table 3
Comparison of top three reasons for selecting and not selecting HPV self-sampling by percent reporting within a multi-ethnic sample (n = 355) of women in Minnesota, 2021.

	Overall (n = 186)	**Non-Hispanic White** (n = 76)	**Hispanic** (n = 35)	**Asian** (n = 54)
Reasons for *Selecting*				
Privacy	First (38.2%)	Second (25.0 %)	First (45.7%)	First (53.7%)
Convenience	Second (18.8%)	Third (19.7)	Third (17.1)	Second (16.7 %)
Transportation/ health care access		Second (25.0%)		Third (11.1 %)
Embarrassment				Third (11.1%)
Pain	Third (17.7%)	First (26.3%)	Second (20.0%)	
	Overall (n = 169)	**Non-Hispanic White** (n = 45)	**Hispanic** (n = 47)	**Asian** (n = 51)
Reasons for *Not Selecting*				
Provider expertise	First (46.8%)	First (35.6%)	First (44.7%)	First (51.0%)
Lack of self-efficacy	Second (27.2%)	Second (28.9%)	Second (27.7%)	Second (27.4%)
Concordance	Third (17.8%)	Second (28.9%)	Third (17.0%)	Third (11.7%)
Other (e.g., less convenient, less accurate)		Third (6.7%)		

be interpreted cautiously given the small representation of older women in this study. This result, however, corroborates many existing studies that have found that self-driven healthcare technologies are perceived to be less acceptable for older than younger women. (Horvath et al., 2022; Johnson et al., 2021) As previously noted, the primary reason why the Pap test was the preferred cervical cancer strategy was because of the strong reliance on providers. The strong trust that exists between women and their healthcare providers have consistently been reported in many cancer screening interventions as an important facilitator for cervical cancer screening uptake. (Anderson et al., 2018; Sormani et al., 2021; Ma'som et al., 2016; Presser et al., 2018) Future HPV self-sampling research efforts should examine educational interventions targeted at healthcare providers to educate and encourage women on the importance of self-collection options.

Given the pre-implementation context of this study – the limited awareness of HPV self-sampling and the perceptions of potentially conducting an HPV self-sampling test across various settings – it is unclear if the link between these women's perceived self-efficacy and preferences to perform an HPV test will be consistent with their actual experiences. Pragmatic HPV self-sampling interventions need to be more widely implemented and tested so that all women not only become aware of this new modality but also experience the self-collection and its respective location options, before further scale-out and adaptations of an HPV self-sampling practice can be instituted in US contexts. Until greater population uptake of HPV self-sampling has occurred in the United States, it remains unknown the extent to which this method may be preferable to Pap tests for reducing cervical cancer disparities among minority women.

4.1. Strengths and limitations

The strengths of the study included a racially- and ethnically-diverse sample and theory-based survey design. A limitation was the non-random and convenience sampling of survey respondents, which may have introduced selection bias in the recruitment process. Participants who took part in the survey may have been more willing to explore alternative cervical cancer screening modalities than those who chose not to participate. Additionally, the study was limited by not being able to offer women HPV self-sampling test kits and their responses may not have been based on their actual experiences. Finally, the moderate amount of missing data for the preferred cervical cancer strategy outcome may be a result of a survey design flaw. This particular survey item asked participants to select one of two images related to HPV self-sampling or Pap test as response options. However, the format of the images did not make clear to participants that they had to select a specific image to respond to the question. As a result of the instrument error, a missing completely at random (MCAR) assumption and complete case analysis were reasonable. The assumption of MCAR, however, resulted in a loss of statistical power to truly detect a statistically significant difference in participants' preferred cervical cancer screening strategy.

5. Conclusion

The limited awareness of HPV self-sampling across all racial and ethnic groups suggest a strong opportunity to promote widespread educational efforts around this new tool. Until more women have experience with this procedure, the factors associated with their uptake of HPV self-sampling remain to be identified. While many women in this study, including those that are racially- and ethnically-diverse, still preferred the Pap test, the biggest barrier to their potential uptake of HPV self-sampling was a strong reliance on provider. Future research should leverage the provider role in HPV self-sampling interventions, including how provider communication with women could enhance their education and decision to select cervical cancer screening options available to them. Finally, future pragmatic HPV self-sampling studies should compare the feasibility and effectiveness of the various locations (e.g., home-based versus clinic-based sites) where women will conduct the self-collection for HPV testing.

6. Ethics approval and consent to participate

All procedures performed in the study were in accordance with the ethical standards of the University of Minnesota Institutional Review Board on Social and Behavioral Research. Informed consents were obtained from all participants included in the study.

7. Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Funding

Effort for the first author (SX) was supported by the National Institutes of Health's (NIH) National Center for Advancing Translational Sciences grant TL1R002493 (PI: Fulkerson), NIH National Cancer Institute grant T32CA190194 (MPI: Colditz/James) and by the Foundation for Barnes-Jewish Hospital and by Siteman Cancer Center. The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH.

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.

Data availability

Data will be made available on request.

Acknowledgements

The authors would like to thank Christopher Campbell, Pilar de la Parra, Faiza Hassan, Amna Hussein, Janis Johnson, Melissa Melgar, Sakhaudiin Mohamud, Vayong Moua, Christina Nelson, Juan Pablo Higuera, GayLynn Richards, Benita Robinson, Nongnut Thao, Kong Mieng Vang, Clemen Wilcox, and Mary Xiong for their contribution to this research project.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pmedr.2023.102243.

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