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Development and validation of the cervical cancer knowledge scale and HPV testing knowledge scale in a sample of Canadian women

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ABSTRACT

Knowledge of cervical cancer and HPV testing are important factors in proactive and continued engagement with screening and are critical considerations as countries move towards the implementation of HPV-based primary screening programs. However, existing scales measuring knowledge of both cervical cancer and HPV testing are not up to date with the current literature, lack advanced psychometric testing, or have suboptimal psychometric properties. Updated, validated scales are needed to ensure accurate measurement of these factors. Therefore, the aim of this study was to develop and validate two scales measuring cervical cancer knowledge and HPV testing knowledge. A pool of items was generated by retaining relevant existing items identified in a 2019 literature search and developing new items according to themes identified in recent systematic reviews. Items were assessed for relevance by the research team and then refined through seven cognitive interviews with Canadian women. A web-based survey including the remaining items (fourteen for each scale development) was administered to a sample of Canadian women in October and November of 2021. After data cleaning, N = 1027 responses were retained. Exploratory and Confirmatory Factor Analysis were conducted, and Item Response Theory was used to select items. The final cervical cancer knowledge scale (CCKS) and HPV testing knowledge scale (HTKS) were unidimensional, and each consisted of eight items. CFA demonstrated adequate model fit for both scales. The developed scales will be important tools to identify knowledge gaps and inform communications about cervical cancer screening, particularly in the context of HPV-based screening implementation.

1. Introduction

Worldwide, cervical cancer is the fourth most common cancer amongst women and all people with a cervix and is responsible for approximately 311,000 deaths annually (Arbyn et al., 2020). For decades, cytology (Pap test) has been the standard screening method for cervical cancer. Almost all cervical cancers are caused by persistent infection with high-risk, oncogenic human papillomavirus (HPV) types (Crosbie et al., 2013; Bosch et al., 2002). HPV DNA testing (i.e., the HPV test) detects the presence of HPV infection and has been shown to be highly effective in identifying women at risk of developing cervical cancer when used as the primary method of screening (Mayrand et al., 2007; Tota et al., 2017). Furthermore, the possibility of self-collection of cervical samples (i.e., self-sampling) presents a promising option for those who experience barriers to in-person screening (Nelson et al., 2017). Several organizations (e.g., the World Health Organization,

Abbreviations: CFA, Confirmatory Factor Analysis; EFA, Exploratory Factor Analysis; HPV, Human Papillomavirus; IRT, Item Response Theory; HTKS, HPV Testing Knowledge Scale; CCKS, Cervical Cancer Knowledge Scale.

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United States Preventive Services Task Force) (World Health Organization, 2021; United States Preventive Services Task Force, 2018) and countries (Maver and Poljak, 2020; Jeronimo et al., 2016; Canadian Partnership Against Cancer, 2020) have now updated their cervical cancer screening recommendations to incorporate HPV testing.

Knowledge of cervical cancer and HPV testing varies and is associated with sufficient screening for cervical cancer (Tatar et al., 2020; Kasting et al., 2017). In low-income countries, which have the highest incidence of cervical cancer, low knowledge about cervical cancer is an additional barrier to screening, help-seeking, and subsequent early detection of cervical cancer beyond the limited access to screening resources (Getachew et al., 2019; Getahun et al., 2013; Mwaka et al., 2013; Ott et al., 2009; Kangmennaang et al., 2018; Islam et al., 2017; Chidyaonga-Maseko et al., 2015). In high-income countries like Canada, where screening is widespread and often administered through organized programs, knowledge is generally high. However, lower cervical cancer knowledge observed in ethnic minority and immigrant populations suggests effort is needed to engage these groups who are often under-screened (Kasting et al., 2017; Vahabi and Lofters, 2016; Lindau et al., 2002; Marques et al., 2020; Canadian Partnership Against Cancer, 2020; Ferdous et al., 2018). A mixed methods research synthesis by Tatar et al. (2018) identified that low knowledge of the HPV test's procedure, results, and difference from the Pap test limited the test's acceptability. Failing to address such knowledge gaps could contribute to aversive emotional responses to HPV diagnosis, which might adversely impact screening re-attendance and help-seeking amongst women who are at increased risk of cervical cancer (McBride et al., 2020; Mulcahy Symmons et al., 2021; McBride et al., 2021).

Several scales exist to measure cervical cancer knowledge (Simon et al., 2012; Williams and Templin, 2013; Özdemir and Kısa, 2016), and Waller et al. (2013) developed a subscale of HPV testing knowledge in their measure of HPV knowledge . However, there is a need for scales that are up-to-date with current recommendations and options for cervical cancer screening (e.g., HPV self-sampling) and that are psychometrically valid in women independent of their screening status. Updated, easy to administer, and validated scales will facilitate the accurate measurement of cervical cancer and HPV testing knowledge and identification of knowledge gaps that could be barriers to acceptability and uptake. In addition, availability of such measures will discourage researchers from using ad-hoc, non-validated items to measure knowledge which could be a threat to validity (Drost, 2011) and aid the standardization of measurement across studies to assist population-based comparisons. Accordingly, the objective of the present study was to develop and validate a measure of cervical cancer knowledge and a measure of HPV testing knowledge in a sample of Canadian women.

2. Methods

2.1. Study design and participants

The present study is part of a larger project aimed at examining the psychosocial correlates of Canadian women's intentions to participate in HPV-based primary screening for cervical cancer. A detailed overview of the project methodology can be found elsewhere (Griffin-Mathieu et al., 2022). In summary, we invited Canadian women to complete a web-based survey in October and November of 2021. Participants were biologically female Canadians aged 21–70 (the youngest and oldest ages to be eligible for screening in Canada) who had a cervix and had not previously been diagnosed with cervical cancer.

2.2. Procedure

Participants were first shown a diagram of the female reproductive system with the cervix identified, and informed that the HPV test was an alternative to the Pap test to screen for cervical cancer. Following this, they completed a survey related to their health behaviors and risk factors for cervical cancer before completing items about their knowledge of cervical cancer and HPV testing. The survey could be completed in either English or French, Canada's two official national languages.

Participant recruitment was conducted by Dynata, a multi-national survey company, through a combination of email, website, and in-app invitations. Census-based quotas for primary language and province of residence were used to increase sample representativeness. Considering the critical challenge of engaging underscreened groups in cervical cancer screening, oversampling was used to ensure that half of the sample were currently underscreened (>3 years or never had a Pap test) and the other half adequately screened (<3 years since previous Pap test) for cervical cancer. This was to ensure that the developed scales were relevant to the underscreened group. This study received ethical approval from the Research Ethics Board of The Integrated Health and Social Services University Network (CIUSSS) West-Central Montreal (Project ID: 2021-2632).

2.3. Measures

To identify items for inclusion in scale development, a review of existing measures was conducted. A pool of items, in English, was generated from items included in these scales, and additional items were developed according to factors (e.g., intervals between HPV-based screenings) identified in two systematic reviews conducted by our research team (Tatar et al., 2020; Tatar et al., 2018). Each item was reviewed individually in team meetings, and rejected or retained according to its uniqueness, relevance to current guidelines, and applicability to the established study design [e.g., use of multiple-choice response options instead of open-ended responses; see study protocol (Griffin-Mathieu et al., 2022)].

In total, twenty-eight knowledge items were retained for inclusion in the survey: fourteen related to cervical cancer knowledge and fourteen to HPV testing. All items presented the following response options: *True*, *False*, and *I don't know*. Items were translated into French by a professional translation service and translations were reviewed by a bilingual member of the research team (GGM). Finally, cognitive interviews were conducted with seven Canadian women to examine item comprehension, and revisions were made to improve item clarity. Cognitive interviews were conducted in both English (n = 4) and French (n = 3).

2.4. Statistical analyses

All items were recoded into binary variables reflecting correct or incorrect answers (*I don't know* was coded as incorrect). We randomly selected observations to create two approximately equal datasets so that item selection analyses were carried out on one dataset and results were validated on the other dataset. We used tetrachoric correlations matrices and Exploratory Factor Analysis (EFA) principal axis factoring with varimax (orthogonal) rotation to explore factor structure. After checking for unidimensionality (using Confirmatory Factor Analysis (CFA) to compare one and two-factor solutions), we used Item Response Theory (IRT) modelling and fitted two-parameter logistic regression models that account for item difficulty (i.e., the difficulty of answering the item correctly) and discriminant capacity (i.e., variation in the probability of a correct response as a function of latent construct ability levels).

The selection of items was done iteratively. We examined the distribution of items' difficulty, discriminant capacity, and information value as shown by item information curves obtained by plotting information against the latent construct ability (theta). We retained items that ensured an approximately symmetrical distribution from lower to higher difficulty, that had higher discriminant capacity reflected by a rapid increase in the probability of a correct response as an individual's latent ability increases, and higher information value reflected by higher slopes of the information curves. For equivocal value of retaining certain items, we explored their impact on the skewness and kurtosis of the test information function curve and retained items that ensured a

symmetrical distribution of information across a wider range of theta values.

We used CFA and evaluated the fit of the scale on the second dataset. To improve model fit, we allowed for within-factor correlation of error terms. The following indices were selected to report CFA model fit: (a) Wheaton et al.'s relative/normed chi-square ($\chi 2/df$), (b) the standardized root mean square residual (SRMR), (c) the root mean square error approximation (RMSEA), (d) the comparative fit index (CFI), and (e) the Tucker-Lewis index (TLI). The following cutoff criteria were used: (a) $\chi 2/df$ between 2 and 5, (b) SRMR <0.08, (c) RMSEA of 0.06 or less, (d) CFI of 0.95 or greater, and (e) TLI of 0.95 or greater (Hooper et al., 2008). We used the Bayesian Information Criterion (BIC) to compare nested models and selected the model with the lower BIC value. To evaluate the appropriateness of the scale we conducted CFA analyses for the following subgroups: underscreened; adequately screened; participants who answered the survey in English; and participants who answered the survey in French.

The internal consistency of the scales was calculated on the full sample using Cronbach's α.

To examine criterion validity of each scale, independent samples t-tests were performed to compare the final mean knowledge scores between adequately screened and underscreened women. Independent samples t-tests were also used to compare final mean knowledge scores between women who intended to use the HPV test for screening, and those who did not intend to use the test; and between those who did and did not identify as a visible minority. HPV test intentions were measured using the Precaution Adoption Process Model (PAPM), which provides a stage-based framework for understanding readiness to adopt health behaviors (Weinstein et al., 2020; Shapiro et al., 2018). After completing all knowledge items, participants would place themselves in one of five PAPM intentions stages (i.e., *unengaged*, *undecided*, *decided not*, *decided to*, *already used*) for using the HPV test. Stages were dichotomized to facilitate analysis: *already used* or *decided to* (intenders), *decided not*, *unengaged*, or *undecided* (non-intenders). Effect sizes were calculated using Cohen's d.

Statistical analyses were performed using STATA 17.0, StataCorp, Texas, USA (StataCorp, 2021).

3. Results

3.1. Participants

In total, 1230 participants completed the survey. To ensure response fidelity data cleaning methods were applied (Meade and Craig, 2012), and 203 responses were excluded see Griffin-Mathieu et al. (2022). Accordingly, 1027 responses were retained for analyses. A full

Table 1
Sample characteristics (N = 1027).

Variable	Total (N = 1027)	Adequately Screened (n = 503)	Underscreened (n = 524)	Between-Group Difference[a] – *P* value[b]
Age (yr), mean (SD)	48.36 (12.58)	48.80 (12.02)	47.94 (13.08)	0.277
Gender, n (%)				
Female	1023 (99.6)	501 (99.6)	522 (99.6)	0.513
Other	4 (0.4)	2 (0.4)	2 (0.4)	
Ethnicity, n (%)				
North American Aboriginal	30 (3.0)	17 (3.4)	13 (2.5)	**0.015**
Other North American	461 (44.9)	231 (45.9)	230 (43.9)	
European	340 (33.1)	176 (35.0)	164 (31.3)	
Asian	139 (13.5)	50 (9.9)	89 (17.0)	
Other[c]	57 (5.5)	29 (5.8)	28 (5.3)	
Self-perceived visible minority, n (%)	195 (19.0)	75 (14.9)	120 (22.9)	**0.001**
Canadian Region, n (%)				
Western	313 (30.5)	157 (31.2)	156 (29.8)	**0.01**
Central	651 (63.4)	303 (60.2)	348 (66.4)	
Eastern	61 (5.9)	42 (8.3)	19 (3.6)	
Territories	2 (0.2)	1 (0.3)	1 (0.2)	
Main Language spoken at home, n (%)				
English	765 (74.5)	394 (78.3)	371 (70.8)	**0.017**
French	211 (20.5)	90 (17.9)	121(23.1)	
Other	51 (5.0)	19 (3.8)	32 (6.1)	
Completed post-secondary education, n (%)	718 (69.9)	359 (71.4)	359 (68.5)	0.318
Employment status, n (%)				
Employed full time	496 (48.3)	273(54.3)	223 (42.6)	**<0.001**
Employed part time	131(12.7)	58 (11.5)	73 (13.9)	
Not employed	95 (9.3)	33 (6.6)	62 (11.8)	
Student	16 (1.6)	4 (0.8)	12 (2.3)	
Retired	182 (17.7)	84 (16.7)	98 (18.7)	
Caregiver	58 (5.6)	33 (6.6)	25 (4.8)	
Other	49 (4.8)	18 (3.6)	31(5.9)	
Household income, n (%)				
Below $60,000	454 (44.2)	182 (36.2)	272 (51.9)	**<0.001**
Above $60,000	554 (53.9)	312 (62.0)	242 (46.2)	
Prefer not to answer	19 (1.9)	9 (1.8)	10 (1.9)	
Living in Canada for past 10 years or more, n (%)	990 (96.4)	490 (97.4)	500 (95.4)	0.086
Relationship status, n (%)				
Married/common law partner	611 (59.5)	326 (64.8)	285 (54.4)	**0.001**
Single	377 (36.7)	155 (30.8)	222 (42.4)	
Dating	39 (3.8)	22 (4.4)	17 (3.2)	

Note:
[a]Between-group analyses for adequately and underscreened participants were conducted using independent samples t-tests for continuous data, and Pearson's chi-squared test for categorical data.
[b] Significant *p*-values are bolded ($p < 0.05$).
[c]Includes Caribbean, Latin, Central and South American, African, Oceania, and other (please specify).

Table 2
Results of Item Response Theory analysis for cervical cancer knowledge items (n = 512).

	Difficulty	Discrimination	Information
1. Cervical cancer cannot be prevented (F)	−0.76	0.62	0.09
2. A woman is at higher risk for developing cervical cancer if she has a weakened immune system (T)	0.25	1.03	0.26
3. A woman is at lower risk for developing cervical cancer if she smokes (F)	**−1.85;** −1.67	**0.91;** 1.04	**0.21;** 0.27
4. A woman is at higher risk of developing cervical cancer if she has had more than five sexual partners in her lifetime (T)	**0.37;** 0.34	**0.99;** 1.14	**0.25;** 0.32
5. Cervical cancer cannot be cured even if it is detected early (F)	−1.26	0.89	0.19
6. Vaginal bleeding between periods can be a sign of cervical cancer (T)	**0.10;** 0.10	**3.63;** 3.37	**3.30;** 2.82
7. Persistent vaginal discharge that smells unpleasant can be a sign of cervical cancer (T)	**0.41;** 0.41	**1.85;** 1.88	**0.85;** 0.88
8. Discomfort or pain during sex can be a sign of cervical cancer (T)	**0.29;** 0.29	**2.48;** 2.53	**1.55;** 1.60
9. Vaginal bleeding after menopause can be a sign of cervical cancer (T)	**0.08;** 0.09	**2.38;** 2.35	**1.42;** 1.38
10. Vaginal bleeding during or after sex can be a sign of cervical cancer (T)	**0.40;** 0.40	**3.15;** 3.17	**2.48;** 2.51
11. The Pap test can detect abnormal cells of the cervix before they become cancer (T)	**−2.86;** −2.52	**0.99;** 1.18	**0.24;** 0.35
12. Women who are currently in, or who have gone through menopause, do not need a Pap test (F)	−1.64	0.65	0.11
13. A woman should get a Pap test every year (F)	6.50	0.14	0.01
14. A woman who has never been sexually active still needs to get a Pap test (F)	–32.35	-0.07	0.001

Note: The 8 retained items included in the CCKS and the final IRT model parameters are bolded .In the Information column are provided maximum information values as per item information functions.

Table 3
Confirmatory Factor Analysis for the cervical cancer knowledge scale (8 items).

Fit indices	First dataset (n = 512)	Second dataset (n = 515)
Wheaton's χ2/df	0.04	0.38
SRMR	**0.002**	**0.006**
RMSEA	**<0.001**	**<0.001**
CFI	**1.000**	**1.000**
TLI	**1.012**	**1.009**

Note: Fit indices that met cutoff criteria are bolded.

description of the sample is available in Table 1.

3.2. Cervical cancer knowledge

In EFA, we found that items loaded on two factors with Eigenvalues of 4.96 and 1.35. However, unidimensionality was confirmed in CFA as the one-factor solution had a better fit than the two-factor solution (See Appendix A, Table 1). Using IRT, we eliminated items 1, 5, 12, 13, and 14 because these items had low information value (<0.2) and discrimination capacity (<1). Moreover, among all items, item 13 showed the highest and item 14 the lowest difficulty (6.50 and –32 respectively). Items 2 and 4 performed similarly on our evaluation criteria but we decided to keep item 4 because it had slightly higher discrimination capacity and provided greater information compared to item 2 at higher theta values. The final cervical cancer knowledge scale included eight items and internal consistency was α = 0.76. For each item, difficulty, discrimination, and information are provided in Table 2 and item and test information functions are available in Appendix B. Model fit indices are reported in Table 3. The CFA revealed good model fit in all four subgroups (See Appendix A, Table 3 and Table 4). The final scale items in English and French are included in Appendix C.

The mean cervical cancer knowledge score in the full sample was 4.31 (SD = 2.23) out of a total of eight items. Scores ranged from 0 to 8 correct answers. Skewness was 0.12 and kurtosis was −1.11. Scores were not significantly different between adequately screened ($M = 4.45$, $SD = 2.15$) and underscreened ($M = 4.18$, $SD = 2.30$) women, $t(1025) = 1.90$, $p = 0.058$. Those women who intended to use the HPV test ($M = 4.58$, $SD = 2.14$) had significantly higher cervical cancer knowledge scores compared to those who did not intend to use the HPV test ($M = 4.20$, $SD = 2.26$), $t(1025) = 2.48$, $p = 0.013$, $d = 0.17$. There was no significant difference in scores between those who did (M = 4.38, SD = 2.44) and did not (M = 4.29, SD = 2.18) identify as a visible minority, $t(1025) = 0.465$, $p = .642$.

3.3. HPV testing knowledge

In EFA we found that items loaded on two factors with Eigenvalues of 4.88 and 1.47, but unidimensionality was confirmed using CFA (See Appendix A, Table 2). Items 6, 7 and 9 showed similar discrimination and information but we retained item 6 because it offered better information at higher theta values. For items 8 and 13 the shape of item information curve was similar, and we retained item 13 because of higher discrimination and information. For items 10, 11,12 and 14 discrimination and information were similar, and we fitted the model without items 7,8 and 9 and decided to keep item 10 as it performed better than items 12 and 14 in the revised model. Finally, we decided to remove item 11 from the model because it had no impact on the test

Table 4
Results of Item Response Theory analysis for HPV testing knowledge items (n = 512).

	Difficulty	Discrimination	Information
1. An HPV test can tell a woman how long she has had HPV (F)	**0.88;** 0.96	**1.65;** 1.41	**0.68;** 0.49
2. An HPV test can be done at the same time as a Pap test (T)	**0.16;** 0.16	**1.33;** 1.99	**0.44;** 0.99
3. If the HPV test shows that a woman has HPV, this means she is at increased risk for cervical cancer (T)	**−0.47;** -0.44	**1.43;** 1.53	**0.51;** 0.58
4. If the HPV test shows a woman has HPV, this means she already has cervical cancer (F)	**-0.11;** -0.11	**2.51;** 1.91	**1.56;** 0.91
5. If the HPV test shows a woman has HPV, this means she needs further follow-up (T)	**−1.32;** −1.31	**1.32;** 1.34	**0.43;** 0.45
6. The HPV test sample can be collected by the woman herself using a specialized HPV self-sampling kit (T)	**3.69;** 2.83	**0.53;** 0.72	**0.07;** 0.13
7. A Pap test is used to detect the presence of an HPV infection (F)	2.20	0.71	0.13
8. The procedure to collect both a Pap test sample and an HPV test sample are the same (T)	1.19	1.06	0.28
9. A negative HPV test means a lower risk of developing cervical cancer than a negative Pap test (T)	2.32	0.68	0.12
10. Women who have received the HPV vaccine do not need the HPV test (F)	**−0.09;** -0.08	**1.30;** 1.25	**0.42;** 0.39
11. The HPV test is only recommended in women who have symptoms (F)	−0.11	1.45	0.52
12. The HPV test shows a woman whether she has HPV, a sexually transmitted infection (T)	−0.27	1.27	0.40
13. If HPV is found during HPV testing, this is the same thing as an abnormal Pap test result (F)	**1.16;** 1.24	**1.48;** 1.30	**0.55;** 0.42
14. The HPV test is taken through the vagina (T)	0.07	1.37	0.47

Note: The 8 retained items included in the HTKS and the final IRT model parameters are bolded.In the Information column are provided maximum information values as per item information functions.

Table 5
Confirmatory Factor Analysis for the HPV testing knowledge scale (8 items).

Fit indices	First dataset (n = 512)	Second dataset (n = 515)
Wheaton's χ2/df	**2.33**	**3.77**
SRMR	**0.018**	**0.018**
RMSEA	**0.051**	**0.073**
CFI	**0.996**	**0.993**
TLI	**0.974**	**0.952**

Note: Fit indices that met cutoff criteria are bolded.

information function curve. The final HPV testing knowledge scale included eight items and internal consistency was α = 0.71. For each item, difficulty, discrimination, and information are provided in Table 4 and item and test information functions are available in Appendix D. Similar to results for the cervical cancer knowledge scale, the model consisting of eight HPV testing knowledge items showed good fit in all four subgroups. (See Table 5 and Appendix A, Table 5 and Table 6). The final scale items in English and French are available in Appendix C.

The mean HPV testing knowledge score in the full sample was 3.61 (*SD* = 2.04) out of a total of eight items. Scores ranged from 0 to 8 correct answers. Skewness was -0.0.10 and kurtosis was -0.81. Adequately screened women (*M* = 3.87, *SD* = 1.99) demonstrated significantly higher HPV testing knowledge scores than underscreened women (*M* = 3.36, *SD* = 2.06), *t*(1025) = 4.02, *p* <.001, *d* = 0.25. Additionally, HPV test intenders (*M* = 4.22, *SD* = 1.94) had significantly higher HPV testing knowledge scores compared to the HPV test non-intenders (*M* = 3.35, *SD* = 2.02), *t*(1025) = 6.84, *p* <.001, *d* = 0.43. There was no significant difference in scores between those who did (M = 3.55, SD = 2.11) and did not (M = 3.62, SD = 2.02) identify as a visible minority, *t*(1025) = -0.424, *p* =.672.

4. Discussion

The aim of the current study was to develop two valid and reliable scales to measure women's cervical cancer and HPV testing knowledge. In each scale, eight items were retained after examining factor loadings and evaluating the item and test characteristics using item-response theory (see Appendix C for final scales). Both final scales were unidimensional and had acceptable internal consistency.

The eight remaining items included in the Cervical Cancer Knowledge Scale (CCKS), demonstrated varying concepts related to cervical cancer. Items 3 ("A woman is at lower risk of developing cervical cancer if she smokes" [False, F]), 4 ("A woman is at higher risk of developing cervical cancer if she has had more than five sexual partners in her lifetime" [True, T]), and 11 ("The Pap test can detect abnormal cells of the cervix before they become cancer" [T]) relate to primary prevention strategies while items 6, 7, 8, 9, and 10 involve symptoms and signs of cervical cancer. These five items were adapted from the cervical cancer warning signs scale of the Cervical Cancer Awareness Measure (Cervical CAM) developed by Simon et al. (2012), a measure designed to examine knowledge gaps preventing early detection of cancer. Consequently, our scale complements the CAM by including additional items related to cervical cancer prevention strategies in addition to symptoms. Five items (1, 5, 12, 13, 14) of the CCKS were removed due to low information values or discriminant capacity in IRT analyses. Item 1 and Item 5, which respectively asked participants whether cervical cancer could be prevented (T) or was incurable even if detected early (F) demonstrated both low information values and discriminant capacities. This could suggest that asking participants broadly about whether cervical cancer could be prevented does not provide sufficient information about the breadth of their cervical cancer knowledge, despite similar items being retained in other scales [e.g., "Cervical cancer is preventable" (Williams and Templin, 2013)]. Interestingly, the three remaining items removed (Items 12, 13, and 14) were related to specific recommendations for use of the Pap test. While understanding what the Pap test identifies is important in identifying cervical cancer knowledge (e.g., Item 11: the Pap test detects abnormal cells of the cervix [T]), knowledge of specific recommendations (e.g., Item 12: women who have been through menopause do not need a Pap test [F]) might not be informative for assessing women's general cervical cancer knowledge.

Compared to similar scales in the literature (Simon et al., 2012; Williams and Templin, 2013; Özdemir and Kısa, 2016), the CCKS is the first that was both developed combining IRT with widely used approaches that include EFA, CFA and reliability analysis. Cervical cancer knowledge scores were not significantly higher in adequately screened women, and although the result was approaching significance (*p* = 0.058), the effect size was small (*d* = 0.12). Those who later suggested they intended to use the HPV test for cervical cancer screening had significantly higher cervical cancer knowledge scores, suggesting that the scale might predict proactive engagement with HPV testing, although the effect size was small (*d* = 0.17).

Eight items were retained in the HPV Testing Knowledge Scale (HTKS), three of which (Items 1, 2, and 3) were adapted from the HPV testing knowledge subscale developed by Waller et al. (2013). The HTKS expands on the scale developed by Waller et al. (2013) by including important components of HPV testing such as self-sampling (Item 6: "The HPV test sample can be collected by the woman herself using a specialized HPV self-sampling kit" [T]) and difference between HPV test and Pap test results (Items 13: "If HPV is found during HPV testing, this is the same thing as an abnormal Pap test result" [F]). Item 10 ("Women who have received the HPV vaccine do not need the HPV test" [F]) showed good discriminatory ability in IRT analysis and could provide valuable information to identify the prevalence of knowledge gaps that might prevent those who are vaccinated from pursuing HPV-based cervical cancer screening.

Waller et al. (2013) identified the low internal consistency of their HPV testing knowledge subscale (α = 0.521) to preclude its use as an independent scale, and instead suggested using the scale as part of a broader HPV knowledge measure or using individual items from it. Importantly, the HTKS improved on the reliability of this scale (α = 0.71) and represents the first scale with acceptable reliability measuring HPV testing knowledge scale as a conceptually distinct construct. Those who were adequately screened for cervical cancer demonstrated significantly higher scores on the HTKS, suggesting that experience with cervical cancer screening is associated with greater knowledge of HPV testing as a screening option. In addition, those who intended to use the HPV test for cervical cancer screening also demonstrated greater scores on the HTKS versus those who did not intend to use the test, providing preliminary evidence that increased knowledge of the HPV test might correspond to greater acceptability as a screening method.

5. Study strengths and limitations

This study evaluated item and scale characteristics with item response theory and classical test theory with the goal of parsimony. The developed measures are brief and easy to administer and could be used to accurately evaluate knowledge of cervical cancer and HPV testing and subsequently guide communication about cervical cancer prevention, screening, and treatment. The use of a comprehensive literature search and item development process suggests that the retained items are relevant to the existing literature on cervical cancer and HPV testing. Furthermore, the use of a national sample of Canadian women, oversampling for underscreened women, extends the generalizability of our scales and should encourage their use in this group, which includes low income, rural, recent immigrant, and racial and ethnic minority populations and faces the greatest burden from cervical cancer (Canadian Partnership Against Cancer, 2020).

This study has some limitations. Given that the present study was conducted as part of an extended survey, to ensure a reasonable response time, established scales like the C-CAM Simon et al. (2012) and Waller et al.'s (2013) scale were not included to compare with our

developed scales. This precludes examination of concurrent, convergent, and divergent validity. Future longitudinal studies are needed to examine the test–retest reliability and predictive validity of the developed scales.

6. Future directions

Further research is needed to validate the developed measures in other countries and other cultural contexts. This is particularly important for countries without cervical cancer screening programs or with low screening engagement, where experience with, and subsequently knowledge of, cervical cancer and screening is likely lower than in the present sample of Canadians. Given the low number (n = 4) of individuals not identifying as female in the present study, additional research is needed to test and adapt (e.g., by using gender neutral language) the present scales in this population that faces significant barriers to screening and which might have specific knowledge gaps that need to be addressed (Dhillon et al., 2020). Attention must also be given to the convergence of psychosocial factors and identities which might augment barriers to accessing knowledge about cervical cancer and screening (Kelly-Brown et al., 2022).

7. Conclusion

Adequate uptake of available screening programs is essential for reducing cancer incidence, mortality, and morbidity. There is a critical need to consider knowledge of cervical cancer and the HPV test as HPV-based screening is widely introduced. This study developed and validated the Cervical Cancer Knowledge Scale (CCKS), an updated and validated scale to examine knowledge of cervical cancer and HPV Testing Knowledge Scale (HTKS), the first reliable and conceptually distinct measure of HPV test-based screening knowledge. These tools can be used to identify knowledge gaps and develop interventions to improve the acceptability and uptake of HPV testing for cervical cancer screening.

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Credit author statement

All authors had substantial contribution in study conceptualization and design. OT and BH completed data analysis and wrote the first draft of the manuscript. OT, BH, PZ, GGM, SP, GS, EM, GZ and ZR critically reviewed, contributed to data interpretation, edited the manuscript, and approved the final manuscript. ZR supervised all stages of the project.

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.

Appendices A–D. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pmedr.2022.102017.

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