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Extending and validating a human papillomavirus (HPV) knowledge measure in a national sample of Canadian parents of boys

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ABSTRACT

As the human papillomavirus (HPV) vaccine is now recommended for males, a reliable, comprehensive HPV knowledge measurement tool which addresses issues relevant to males is needed. We aimed to replicate, validate and test the comprehensiveness of an existing general HPV and an HPV vaccination knowledge scale in English and French. We also measured parental HPV knowledge and changes over time. An online questionnaire was administered in February (Time 1; T1) and November 2014 (Time 2; T2) to a nationally representative sample of Canadian parents of boys. Dimensionality, internal consistency and model fit were evaluated at both time points and separately in English and French sub-samples. Differences in knowledge scores were measured. Analyses were performed on 3117 participants at T1 and 1427 at T2. The 25-item HPV general knowledge and an 11-item HPV vaccination scale were unidimensional, showed high internal consistency ($\alpha > 0.87$, $\alpha > 0.73$) and had good model fit. Both general HPV and vaccine-specific knowledge significantly increased over time in both languages, but remained low at T2, with only about half of the items being answered correctly. Correct responses at T2 are best explained by correct responses at T1, with some small changes from 'Don't know' at T1 to correct at T2. The extended general and vaccine-specific knowledge scales are valid, reliable and comprehensive, and could be used among parents of boys, in both English and French. Educational interventions could target specific knowledge gaps and focus on providing information rather than correcting misconceptions.

1. Introduction

Strong empirical evidence supports the causal role of the human papillomavirus (HPV) in the development of cervical, vaginal, penile, anal and oropharyngeal cancers and genital warts (Forman et al., 2012; Vardas et al., 2011). In Canada, all provinces and territories vaccinate females against HPV as part of provincial school-based immunization programs i.e., grades 4 through 8 (~10–14 years old), dependent on location (Public Health Agency of Canada, 2016; Shapiro et al., 2016). Most organizations now also recommend HPV immunization for males (Centers for Disease Control and Prevention, 2015; Public Health Agency of Canada, 2015; WHO Report, 2015). In Canada, the HPV vaccine has been included for boys in school-based provincial immunization programs, with other provinces due to follow in the autumn 2016 e.g. Alberta (autumn 2014), Prince Edward Island (PEI) (autumn 2013), and Nova Scotia (autumn 2015) for grade 5, 6 and 7 (~11–13 years old), respectively. Quebec and Manitoba are set to begin programs (autumn 2016) for boys in grades 4 and 6 respectively (Public Health Agency of Canada, 2016; Shapiro et al., 2016). Across many parts of Canada, HPV vaccination uptake for girls is not reaching the ~70% needed to provide herd protection (Brisson et al., 2011; Public Health Agency of Canada, 2014). Data from the first male HPV immunization program in PEI indicates that although HPV vaccination uptake was high (79% for males and 85% for females), grade six girls had a 1.5 higher likelihood of being vaccinated compared to boys of the same age (McClure et al., 2015). In this early period where male HPV vaccination programs are being initiated, there is a need to understand what influences parental decision-making concerning HPV vaccination for their sons.

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Psychosocial research examining the factors that influence HPV vaccination acceptance suggests a direct relationship exists between parents' HPV and HPV vaccine knowledge and intentions to vaccinate against HPV (Allen et al., 2010; Giambi et al., 2014; Pelucchi et al., 2010). A comprehensive measurement of parents' HPV knowledge is important to target HPV vaccine specific knowledge gaps, when designing and implementing educational interventions, aimed at increasing HPV vaccine uptake. A reliable HPV general knowledge and HPV vaccination specific knowledge scale was developed and validated by Waller et al. (2013). While the scales were extensively psychometrically tested and found to be structurally cohesive and reliable, they do not capture knowledge items relevant to males (e.g., did not assess knowledge about HPV-associated diseases *beyond* cervical cancer) and were only validated among English speakers. Waller et al. (2013) concluded with the recommendation to validate the measure in other settings and languages and to examine the addition of new items particularly when the HPV vaccine becomes readily available for males.

The present study's objectives were 1) to replicate the validation of the general HPV and HPV vaccine knowledge scales proposed by Waller and colleagues among a national sample of both English and French-speaking Canadian parents of boys; 2) to examine whether our additional items add to the comprehensiveness and cohesiveness of the existing general HPV knowledge and HPV vaccine scales and; 3) to measure and describe general HPV and HPV vaccine knowledge patterns of change over time.

2. Methods

2.1. Study participants and design

Parents who had a son aged 9–16 years old living in their household were recruited through a research firm, Leger Marketing, which maintains a representative panel of 400,000 Canadian households. We targeted a sample of 4000 parents, weighted according to the population distribution of the ten Canadian provinces. In February 2014, panel participants who met the inclusion criteria were sent an invitation email with a link to the online study. Participants elected whether they preferred to answer the questionnaire in English or French.

Data were collected using an online questionnaire that took approximately 20 minutes to complete and contained a variety of quantitative and qualitative items including: socio-demographics, knowledge, HPV vaccination attitudes, and health behaviors. The focus of this study is on the HPV and HPV vaccine knowledge items. Participants who completed the questionnaire at Time 1 (T1) and deemed eligible respondents were invited to re-complete the questionnaire at 9-months follow up (November 2014, Time 2, (T2)). The study was approved by the Research Ethics Board at the Jewish General Hospital, Montreal, Canada. A detailed methodology of the study protocol and sample characteristics is provided elsewhere (Perez, S. et al., Determinants of parental human papillomavirus (HPV) vaccine decision-making for sons: Methodological challenges and initial results of a pan-Canadian longitudinal study, under review).

2.2. Knowledge items

The authors expanded upon the HPV-general knowledge (herein referred to as GK) and the HPV-vaccine knowledge (herein referred to as VK) scales published by Waller et al. (2013), who, using a Principal Axis Factor Analysis (PFA), found that both a 16-item HPV knowledge subscale, GK ($\alpha = 0.849$) and the 7-item HPV vaccination knowledge subscale, VK ($\alpha = 0.561$) were reliable and unidimensional (2013). Results of the Confirmatory Factor Analysis (CFA) suggested a better fit for the 16-item GK scale than for the 7-item VK scale.

The present study included the identical Waller et al.'s 16-item GK scale with two minor semantic changes (shown in italics): "HPV can be *transmitted* through general skin-to-skin contact" and "Using condoms reduces the *chances* of HPV transmission.[1]" Our study also included the identical Waller et al.'s 7-item VK scale with one semantic change: "Girls who have had the HPV vaccine do not need a Pap test (*cervical cancer screening*) when they are older[2]". It was also necessary to slightly revise one of the VK items about dosing as since Waller et al.'s (2013) publication, the WHO recommendation (WHO Report, 2015) had shifted from a three to a two-dose policy for children under 15 years of age ("The HPV vaccine requires only *one dose*[3]"). Response options were identical to Waller's scale and used forced choice response categories of True/False/Don't know.

Based on our previous HPV research (Krawczyk et al., 2015; Krawczyk et al., 2013; Krawczyk et al., 2012), consultation with an expert panel and a comprehensive literature search, we identified additional knowledge items that were not included in Waller's scale. These items reflected the most up-to-date emerging scientific evidence and were frequently being measured in the HPV psychosocial/epidemiological literature (Daley et al., 2009; Daley et al., 2010; Fisher, 2016; Gerend and Barley, 2009; Giede et al., 2010; Gutierrez et al., 2013; Katz et al., 2011). The addition of the 9 GK (see Appendices A & B; items 17–25 for the new added items) and 4 VK items (see Appendices A & B; items 8–11 for the new added items) aimed to measure: 1) the association of HPV with oral, penile, and anal cancers (items 17, 20, 24), 2) transmission (items 19, 22, 25), 3) HPV-associated signs and symptoms (items 18, 21, 23), 4) prevention (items 8), 5) treatment (item 9), 6) the recommendation for males and females in the Canadian context (items 10,11) (see Appendices A & B).

Questionnaire development took into account language and literacy levels. The entire questionnaire was pilot tested for readability and validity with 20 parents of 9–16-year-old boys. The reading level of the survey was measured using the Flesch-Kincaid scale available through Microsoft Word (Microsoft Corp., Redmond, WA) and found to be appropriate for a grade 8 reading level. The English survey was translated into French by a specialized translation firm with expertise in health literacy and reviewed for accuracy by an independent bilingual group of professionals ($n = 5$) working in the healthcare field. Questionnaire development and translation was reviewed by a bilingual panel of seven highly experienced HPV researchers.

GK and VK scores were calculated by assigning 1 point to each correct answer and zero points for incorrect or 'Don't know' answers (Range = 0–25 for GK and range = 0–11 for VK). A GK and VK total score were calculated at baseline (Time 1, T1) and at 9-months follow up (Time 2, T2) for the English and French sub-samples.

2.3. Analysis

Analyses were performed on the T1 and T2 samples separately, which were also divided into two sub-samples, English and French respondents. Analyses included internal consistency analysis (Cronbach's alpha), exploratory factor analysis (EFA) to investigate dimensionality and a CFA to investigate validity (model fit). Results for the 16-item GK scale and the 7-item VK scale in French and English were compared with the results obtained by Waller et al. (2013). The effects of adding nine new GK items and four new VK items on internal consistency and dimensionality were then investigated by comparing the scale properties with and without the additional items. Additionally, descriptive statistics and Welch two sample *t*-tests, $p < 0.05$ were used to explore knowledge scores over time and across languages.

For the EFA, a PFA was used with varimax rotation. Similar to Waller's analysis, four criteria (Slocum-Gori and Zumbo, 2010) were used to explore dimensionality; three criteria are presented in Table 2.

[1] Waller's items: HPV can be *passed* on during sexual intercourse; using condoms reduces the *risk* of getting HPV.

[2] Waller's items: Girls who have had the HPV vaccine do not need a [Pap test/Smear test/Pap smear test] when they are older.

[3] Waller's item: HPV vaccines require three doses.

Results for the fourth criterion, examining items that did not load higher than 0.33 on a forced one-factor solution, are presented in text. For the CFA, results are based on four indices (Hu and Bentler, 1999) (see Table 3 and Table 4). Differences in proportions were tested using Chi-square, $p < 0.05$. Statistical analysis was conducted using SPSS v21, Stata 13 and R Studio v0.99.896.

3. Results

At T1 $n = 3117$ respondents and at T2, $n = 1427$ respondents were included in the analysis. At T1, 2117 participants from T1 completed the questionnaire in English and 1000 in French. At T2, 873 participants completed the questionnaire in English and 554 completed it in French.

3.1. Internal consistency analysis

The internal consistency results for the GK16 compared favorably with the results obtained by Waller et al. The internal consistency of the GK25 was higher than GK16 across all subsamples (Table 1). Item level analysis indicated that the item "HPV usually doesn't need any treatment" sometimes had a slightly negative effect (in the third decimal place) on scales' internal consistency.

Internal consistency values for the VK7 and VK11 subscales were higher than those found by Waller et al. (Table 1). Item specific analysis suggested a slight misfit for the item "One of the HPV vaccines offers protection against genital warts" but the effect was very small.

3.2. Dimensionality analysis (EFA)

For the GK16, on all subsamples and at both time points, we obtained only one factor with Eigenvalue (EV) > 1; the extracted loading of factor one was more than three times larger than factor two ($F1 > 3 \times F2$); and the one factor percentage of common variance (1FVar) was higher than the reference value (27.78) from Wallers' scale (2013), with one exception. Item level analysis found that the item "HPV usually doesn't need any treatment" failed to load >0.33 on a 1-factor solution for all subsamples and at both time points.

For the GK25, the criteria $F1 > 3 \times F2$ and 1FVar were met (Table 2) for all subsamples and at both time points. At T1 and T2, the percentage of common variance accounted for in the French language sample was lower than that of the English sample (Table 2). A consistent finding, with the exception of the T1 combined sample, was that the addition of the nine new items (GK25) resulted in three factors with EV >1 (Table 2). Similar to the GK16, the item "HPV usually doesn't need any treatment" failed to load >0.33 on a 1-factor solution. The item "HPV can cause herpes" also failed to load >0.33 on a 1-factor solution for the French language at the second time point.

EFA results for VK7 and VK11 across both language subsamples and at both time points found only one factor with an EV > 1 (Table 2). In almost all cases, F1 was $>3 \times$ F2 (Table 2). For both the VK7 and the VK11 and across all subsamples, the percentage of variance accounted for by a 1-factor solution was higher (22.17–31.39) than the percentage of variance obtained by Waller et al. (21.65). Item level analysis indicated that for both the VK7 and the VK11, most items loaded >0.33 on the one factor solution for all subsamples at both time points. The item "One of the HPV vaccines offers protection against genital warts" frequently failed to load >0.33 and the items "The HPV vaccines offer protection against most cervical cancers" and "The HPV vaccine only requires one dose" occasionally failed to load >0.33.

3.3. Model fit (CFA)

CFA analysis for the GK16 and the GK25 found that the Standardized Root Mean Square Residual (SRMR) and the Coefficient of Determination (CD) values met the suggested model fit criteria (Hu and Bentler, 1999). The Comparative Fit Index (CFI) values were close to the cutoff criteria while the p value for Chi square and Root Mean Square Error Approximation (RMSEA) criteria for model fit were not met (Table 3). For the VK7 and the VK11, previous observations related to cut-off criteria for the GK scales apply (Table 4).

3.4. GK across time and language

Consistently, for every single item for both the English and French subsamples, there was an increase in the proportion of correct responses from T1 ($n = 3117$) to T2 ($n = 1427$). This increase was significant for 24 from 25 items for the English sample and 21 from 25 items for the French sample. For example, two items with the largest significant increase (12–25%) over time in both English and French were "Men cannot get HPV" and "HPV can cause cancer of the penis". Importantly, the overall mean GK25 score significantly increased for both languages across time: $Mean_{EN}$ at T1 = 11.76; $Mean_{EN}$ at T2 = 14.23, t = 9.78, CI [1.97; 2.95] and $Mean_{FR}$ at T1 = 11.47; $Mean_{FR}$ at T2 = 13.69, t = 7.35, CI [1.63; 2.82].

There were differences in the proportion of correct answers at the item level between English and French samples at both time points i.e., 18 from 25 items significantly differed between French and English samples at T1 and 15 from 25 significantly differed between French and English samples at T2. Importantly, there was no significant difference between the overall mean GK25 score for the two languages at either time point: $Mean_{EN} = 11.76$ and $Mean_{FR} = 11.47$ at T1; and $Mean_{EN} = 14.23$ and $Mean_{FR} = 13.69$ at T2.

3.5. VK across time and language

An identical pattern as GK25 was found for VK11. There was an increase in the proportion of correct responses for every single item for both the English and French subsamples from T1 ($n = 3117$) to T2

Table 1
Internal consistency (Cronbach's alpha) of HPV general knowledge (GK) and HPV vaccine knowledge (VK) across subsamples at Time 1 (T1) and Time 2 (T2).

		HPV general knowledge (GK)		HPV vaccine knowledge (VK)	
		GK16	GK25	VK7	VK11
T1	French ($n = 1000$)	0.869	0.902	0.699	0.778
	English ($n = 2117$)	0.898	0.922	0.733	0.819
	Combined ($n = 3117$)	0.889	0.916	0.722	0.807
T2	French ($n = 554$)	0.828	0.874	0.651	0.737
	English ($n = 873$)	0.855	0.894	0.619	0.742
	Combined ($n = 1427$)	0.844	0.887	0.629	0.739

Note. Waller et al. GK (16 items) $\alpha = 0.849$; Waller et al. VK (7 items) $\alpha = 0.561$.

Table 2
Results of the exploratory factor analysis for the 16 and 25-item HPV general knowledge (GK) and the 7 and 11-item HPV vaccine knowledge (VK) scales at Time 1 (T1) and Time 2 (T2).

		GK16			GK25			VK7			VK11		
		EV > 1	F1 > 3 × F2	1FVar	EV > 1	F1 > 3 × F2	1FVar	EV > 1	F1 > 3 × F2	1FVar	EV > 1	F1 > 3 × F2	1FVar
T1	French ($n = 1000$)	One	Yes	31.35	Three	Yes	27.9	One	Yes	26.61	One	Yes	26.32
	English ($n = 2117$)	One	Yes	37.18	Three	Yes	33.09	One	Yes	31.39	One	Yes	31.12
	Combined ($n = 3117$)	One	Yes	35.26	Two	Yes	31.32	One	Yes	30.38	One	Yes	29.48
T2	French ($n = 554$)	One	Yes	26.03	Three	Yes	23.26	One	No*	25.26	One	Yes	22.85
	English ($n = 873$)	One	Yes	29.72	Three	Yes	27.04	One	No*	–	One	Yes	22.28
	Combined ($n = 1427$)	One	Yes	28.13	Three	Yes	25.38	One	No*	–	One	Yes	22.17

Note. EV = Eigenvalue; EV > 1 = number of factors with EV > 1; F1 > 3 × F2 = extracted loadings of factor1 three times bigger than factor 2; 1FVar = 1 factor % common variance.
* Very close to yes.
Waller's results for the 16-item GK scale were: EV > 1 = one; F1 > 3 × F2 = Yes; 1FVar = 27.78.
Waller's results for the 7-item VK scale were: EV > 1 = 1; F1 > 3 × F2 = No; 1FVar = 21.65.

($n = 1427$). This increase was significant for 11 of 11 items for the English sample and 9 of 11 items for the French sample. For example, two items with the largest significant increase (11–27%) over time were "The HPV vaccine is approved and recommended by Health Canada for males aged 9–26 years" and "Someone who has had the HPV vaccine cannot develop cervical cancer". Importantly, the mean VK11 score significantly increased for both languages across time: Mean_{EN} at T1 = 5.21; Mean_{EN} at T2 = 6.38, t = 10.4, CI [0.94;1.39] and Mean_{FR} at T1 = 5.26 and Mean_{FR} at T2 = 6.17, t = 6.52, CI [0.63;1.18].

There were differences in the proportion of correct answers at the item level between English and French samples at both time points i.e., 7 of 11 items significantly differed between French and English at T1 and 4 of 11 significantly differed between FR and EN at T2. Importantly, there was no significant difference between the overall mean VK11 score for the two languages at either time point: $\text{Mean}_{EN} = 5.21$ and $\text{Mean}_{FR} = 5.26$ at T1; and $\text{Mean}_{EN} = 6.38$ and $\text{Mean}_{FR} = 6.17$ at T2.

3.6. Knowledge patterns of change

An examination of knowledge changes over time was conducted among those participants who answered the questionnaire at both T1 and T2 ($n = 1427$). At T1, for the GK25, participants answered 49.1% of items correctly, 13.2% of items incorrectly and 37.7% of answers as "Don't know". At T2, at the item level, <50% of the sample achieved the correct answers for 10 out of 25 GK items (Fig. 1). The mean knowledge score for the GK25 scale at T1 was 12.28/25 and 14.02/25 at T2, (t = 7.56, 95% CI [1.29; 2.19] $p < 0.001$).

At T1 for the VK11, participants answered 49.9% of items correctly, 9.6% of items incorrectly and 40.5% of answers as "Don't know". At T2, at the item level, <50% of the sample got the correct answer for 5 out of the 11 VK items (Fig. 2). The mean knowledge score for the VK11 scale at T1 was 5.49 of 11 and 6.3 of 11 at T2, (t = 7.86, 95% CI [0.6; 1.0], $p < 0.001$). The most and least known GK items at T2 are provided in Fig. 1 and the most and least known VK items at T2 are provided in Fig. 2.

Item-level analysis of both the GK and VK scales revealed that for best known items, correct responses at T2 can be best explained by correct responses at T1 (Fig. 1 and Fig. 2). For both GK and VK items, few correct responses at T2 can be explained by changing from incorrect at T1 (Figs. 1 and 2). The number of correct responses at T2 originating from "Don't know" answers at T1 was relatively constant across items (Fig. 1). For GK, the largest increase was observed for parents who did not know at T1 that: a) men can get HPV, b) HPV can cause cancer of penis and c) HPV can be transmitted through anal sex (Fig. 1). For VK, the largest increase was observed for parents who did not know at T1 that the vaccine is recommended for males aged 9–26 (Fig. 2).

4. Discussion

As a replication analysis, our results support the conclusion that Waller's HPV general (GK) and HPV vaccine (VK) knowledge subscales operate as structurally coherent and reliable measures that can continue to be used in English and now in French. Investigation of the addition of the 9 new items and the 4 items to the GK and VK subscales respectively, found improved internal consistency compared to Waller et al.'s (2013), scale. The exception to this was "HPV usually doesn't need any treatment", which when removed improved reliability (although not substantially) and was by far the item which the fewest participants were able to answer correctly.

Similar to Waller et al., our hypothesis of unidimensionality holds for both the GK25 and the VK11 scales. Of note, for the GK25 scale, obtaining three factors with Eigenvalues greater than one is not of concern because the first factor was typically a very dominant factor such that subsequent rotated factors often involved cross-loaded items and rarely led to meaningful factors in item content terms. Item loading results for the GK25 were similar to the Waller et al.'s results. The item "HPV can cause herpes" and the item "HPV usually doesn't need any treatment" loaded poorly in both our and Waller's study.

Interestingly, knowledge of these items was very poor in our Canadian sample which is in line with other populations (Blake et al., 2015; Bynum et al., 2011; Daley et al., 2010; Gerend and Shepherd, 2011; Giambi et al., 2014; Holcomb et al., 2004; Kang and Kim, 2011; Marlow et al., 2013; Mollers et al., 2014; Yacobi et al., 1999). Future consideration should be given to excluding these items from the GK scales

Table 3
Results of the confirmatory factor analysis for the 16 and 25-item HPV general knowledge (GK) scales across subsamples at Time 1 (T1) and Time 2 (T2).

		GK16					GK25				
		χ^2	CFI	RMSEA	SRMR	CD	χ^2	CFI	RMSEA	SRMR	CD
T1	French ($n = 1000$)	889.15 $p < 0.001$	0.843	0.087	0.055	0.900	2571.48 $p < 0.001$	0.725	0.091	0.071	0.916
	English ($n = 2117$)	1311.88 $p < 0.001$	0.905	0.074	0.042	0.918	4807.88 $p < 0.001$	0.784	0.088	0.066	0.933
	Combined ($n = 3117$)	2054.54 $p < 0.001$	0.889	0.078	0.045	0.912	7185.70 $p < 0.001$	0.764	0.090	0.068	0.927
T2	French ($n = 554$)	484.63 $p < 0.001$	0.853	0.081	0.055	0.895	1435.47 $p < 0.001$	0.729	0.087	0.073	0.911
	English ($n = 873$)	588.96 $p < 0.001$	0.904	0.073	0.045	0.916	2308.79 $p < 0.001$	0.766	0.092	0.070	0.931
	Combined ($n = 1427$)	948.23 $p < 0.001$	0.889	0.075	0.047	0.908	3518.88 $p < 0.001$	0.749	0.091	0.071	0.923

Note. χ^2 = Chi square; CFI = comparative fit index; RMSEA = root mean square error approximation; SRMR = standardized root mean square residual; CD = coefficient of determination. Cut-off criteria: a) p for $\chi^2 > 0.05$, b) CFI > 0.9, c) RMSEA < 0.06, d) SRMR < 0.08 and e) CD as close as possible to 1. Waller et al. results: Chi square 1981.6, $p < 0.0001$; CFI = 0.816; RMSEA = 0.087; SRMR = 0.063; NFI = 0.809.

Table 4
Results of the confirmatory factor analysis for the 7 and 11-item HPV vaccination knowledge (VK) scales across subsamples at Time 1 (T1) and Time 2 (T2).

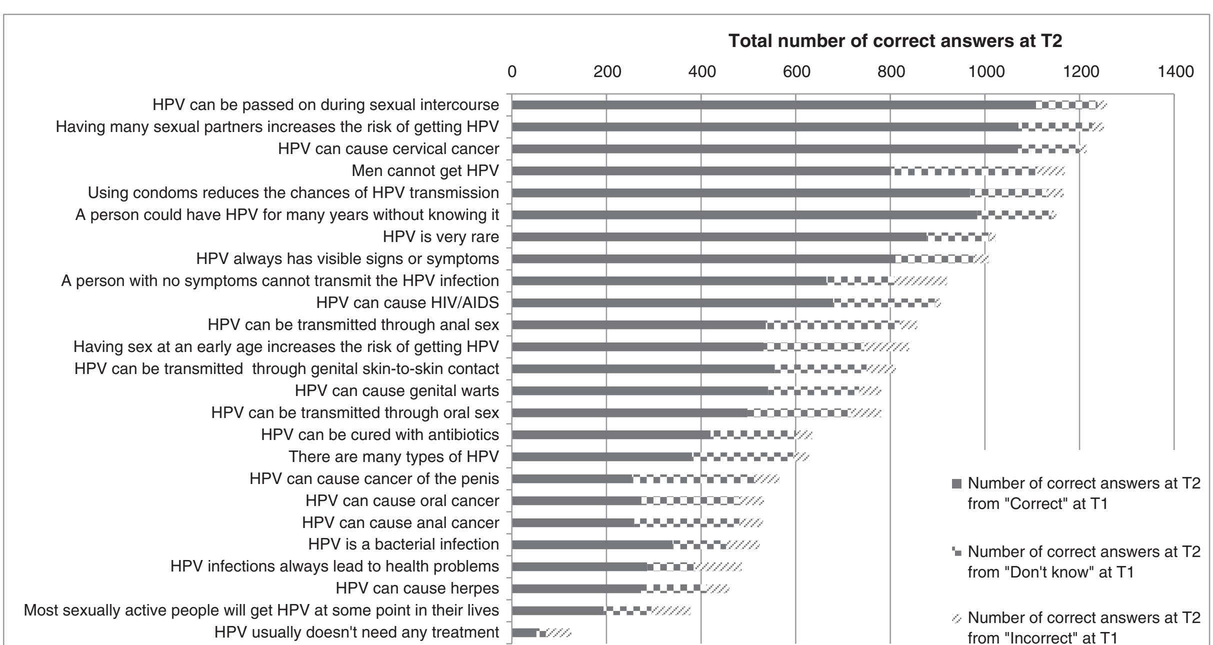
		VK7					VK11				
		χ2	CFI	RMSEA	SRMR	CD	χ2	CFI	RMSEA	SRMR	CD
T1	French ($n = 1000$)	128.21 $p < 0.001$	0.908	0.090	0.052	0.804	294.02 $p < 0.001$	0.883	0.075	0.050	0.832
	English ($n = 2117$)	226.19 $p < 0.001$	0.930	0.085	0.049	0.822	576.73 $p < 0.001$	0.909	0.076	0.048	0.863
	Combined ($n = 3117$)	335.48 $p < 0.001$	0.925	0.086	0.049	0.815	834.75 $p < 0.001$	0.901	0.076	0.048	0.853
T2	French ($n = 554$)	68.86 $p < 0.001$	0.899	0.084	0.052	0.767	174.02 $p < 0.001$	0.870	0.073	0.053	0.805
	English ($n = 873$)	104.61 $p < 0.001$	0.917	0.086	0.053	0.799	275.40 $p < 0.001$	0.896	0.078	0.051	0.850
	Combined ($n = 1427$)	154.44 $p < 0.001$	0.914	0.084	0.051	0.786	409.95 $p < 0.001$	0.886	0.076	0.050	0.833

Note. χ^2 = Chi square; CFI = comparative fit index; RMSEA = root mean square error approximation; SRMR = standardized root mean square residual; CD = coefficient of determination. Cut-off criteria: a) p for $\chi^2 > 0.05$, b) CFI > 0.9, c) RMSEA < 0.06, d) SRMR < 0.08 and e) CD as close as possible to 1. Waller et al. results: Chi square 428.9, $p < 0.0001$; CFI = 0.793; RMSEA = 0.111; SRMR = 0.083; NFI = 0.789.

as perhaps they are not necessary to understanding HPV and may be confusing (e.g., *HPV itself* does not require any treatment but *HPV-associated diseases* do require treatment) and likely unnecessary (e.g., is it relevant to know that HPV does not cause herpes). Post hoc, we explored the effect of removing these two items from the GK25 scale, and model fit remained largely unchanged and the change in internal consistency was inconsequential. The decision then to include or exclude these items would thus be left to the individual researcher, though it is our suggestion to exclude these two items, as it make more substantive sense, leaving a 23-item solution, the GK23.

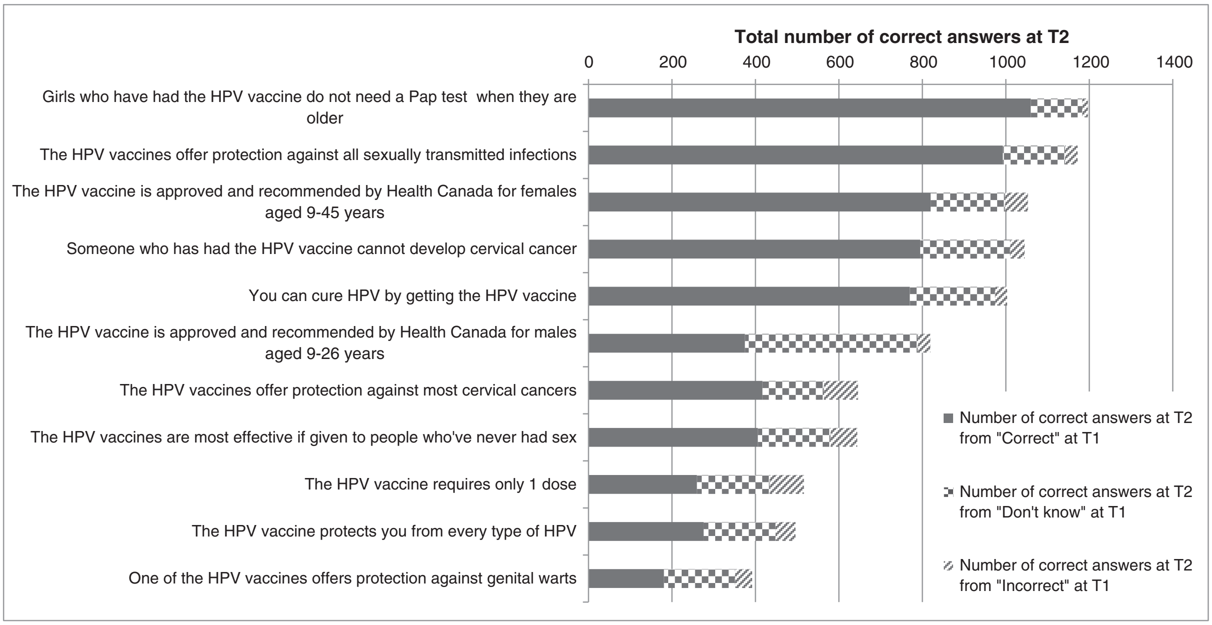
For the VK11 scale, two items failed to appropriately load: "One of the HPV vaccines offers protection against genital warts" and "The HPV vaccine only requires one dose", which was similarly found by Waller et al. (2013). These items require further attention as they are conceptually valuable for measuring HPV vaccine knowledge as the protection against genital warts may be an additional benefit to some individuals to prompt vaccination and dosage is important as we know that many parents do not complete the full vaccination series. As most countries are now only using vaccines that prevent both cancers and warts (i.e., 4vHPV and 9vHPV), and as most countries transition to the WHO recommended 2-dose schedule, it may have confused parents to interchange HPV vaccine with ('one of the') HPV vaccines (*plural*). We hypothesize that a slight change in wording/semantics for all VK items that could potentially improve model fit, e.g., "The HPV vaccine offers protection against genital warts" and "The HPV vaccine requires at least 2 doses".

The mean GK and VK in our sample was poor at both time points i.e. on average, parents answered around only half the items for both scales correctly, which is consistent with Waller's (2013) and most study results (Davlin et al., 2015; Holcomb et al., 2004; Joseph et al., 2015; Klug et al., 2008). Item-level analysis showed a similar ranking of knowledge items compared to Marlow et al.'s study ($n = 2409$ participants living in the UK, US, and Australia, $M_{age} = 41–48$, with 12–14% of them having daughters aged 9–17 (2013)). This may suggest a pattern among the general population where most individuals, regardless of parental status, know about the association between HPV and cervical cancer and that increasing the number of partners increases the risk of HPV. In both our and Marlow et al.'s sample, most individuals did not know that "Most sexually active people will get HPV at some point in their lives". These results suggest that there may be similiar knowledge gaps that are widespread among different subsamples (e.g., parents, young adults), and that parents are not acquiring any additional



Note. Data is presented for *n*=1427 at T1 and *n*=1427 at T2. For each item, the entire bar represents the number of correct answers at T2. Shading represents the way in which these participants remained correct or changed to correct from their initial response at T1. For example, for the item "*HPV can be passed on during sexual intercourse*", 1108 correct answers at T1 remained correct at T2; 130 'Don't Know' answers at T1 and 20 incorrect answers at T1 changed to correct at T2.

Fig. 1. Number of correct answers to each item at Time 2, by their answer at Time 1 for HPV General Knowledge (GK) items.



Note. Data is presented for *n*=1427 at T1 and *n*=1427 at T2. For each item, the entire bar represents the correct number of answers at T2. Shading represents the way in which these participants remained correct or changed to correct from their initial response at T1. For example, for the item "Girls who have had the HPV vaccine do not need a Pap test when they are older", 1060 correct answers at T1 remained correct at T2; 123 'Don't Know' answers at T1 and 14 incorrect answers at T1 changed to correct at T2

Fig. 2. Number of correct answers to each item at Time 2, by their initial answer at Time 1 for HPV Vaccination Knowledge (VK) items.

knowledge beyond the general population. Educational interventions, dispersed in many widespread channels could target these specific knowledge gaps.

Both GK and VK total scores increased statistically significant over time but the effect size was small (Cohen's d < 0.3 for the 1427 sample). At T1, we provided a brief informative statement about HPV after the knowledge section, but we estimate that the impact on knowledge at follow-up was very small, considering the nine months' time interval between baseline and follow-up. A closer examination at the item level reveals that correct responses remained consistent for at least nine months. Moreover, at T2, only a tiny proportion (between 0.8 and 12%) of correct responses can be attributed to a change from incorrect at T1 to correct at T2 and a small proportion (10%–51%) can be attributed to a change from 'Don't know' at T1 to correct at T2. Therefore, we suggest providing both general HPV and HPV vaccine information/facts, with emphasis on the items that parents do not know, rather than correcting misconceptions. As an example, specifying the age and gender recommendation in one's country is advisable. This is further substantiated by our results which showed an overall pattern across both GK and VK items where few individuals answered items *incorrectly* as compared to an often higher proportion of participants who answered 'Don't know', indicating *a lack of HPV knowledge* rather than *wrong/mis*information.

Our study is not without limitations. Firstly, our response rate, calculated based on completion by participants who began the questionnaire ($n = 5733$ at T1 and $n = 1999$ at T2), was modest (66% at T1 and 80.4% at T2) but superior to other studies (Blake et al., 2015; Gowda et al., 2012). Secondly, a high attrition (49.9%) can be expected in online surveys, but we believe that the effect on our results was minimal due to very few significant changes between the baseline and follow-up sample (see Perez et al., Study Protocol. Under review), and a fairly large sample at T2. Third, although Leger aimed to maintain a nationally representative panel of Canadians, there may be differences between panel members and the general Canadian population (see Perez et al., Study Protocol. Under review). Fourth, we made a few semantic changes to Waller et al.'s scale, which though minimal, result in an imperfect replication. Lastly, the internal consistency was lower among French speakers compared to English, and the reason for this requires further exploration.

It remains challenging to compare HPV and HPV vaccine knowledge across studies as researchers vary extensively in the number of items used (e.g., some use as few as three items) (Allen et al., 2010; Pelucchi et al., 2010), different response options (e.g., multiple choice, true-false, yes/no/not sure, Likert scale, open-ended) and differing content (Davlin et al., 2015; Giede et al., 2010; Klug et al., 2008). We strongly encourage researchers to utilize the extended GK23 scale to measure HPV knowledge and the VK11 to measure HPV vaccine knowledge, which could allow for comparisons on the overall knowledge level as well as the item level. Additionally, beyond English and French, future researchers could translate these scales to other languages and evaluate the validity among different languages and populations.

5. Conclusions

Our extended HPV general knowledge and HPV vaccine knowledge scales are reliable and unidimensional in both English and French, and capture issues related to both genders. Interestingly, the added items tended to be least known, which suggests parents may know specific facts about HPV better (e.g. the link with cervical cancer; that HPV is an STD) than others (e.g., the link with oral/anal cancers). We suggest educational interventions to inform about the updated points about HPV and the HPV vaccine that are least known and to focus on providing information rather than correcting misconceptions. In our opinion, our comprehensive HPV knowledge scales can significantly contribute to the understanding of how knowledge can influence vaccine decision-making, and in turn improve, HPV vaccination uptake.

Conflict of interest

Zeev Rosberger reports personal fees from Merck outside the submitted work at a consultation meeting in November 2015; and speaker to family physicians in April 2015. Gregory Zimet reports grants from Merck, grants from Roche, personal fees from Merck, outside the submitted work.

Transparency document

The Transparency document associated with this article can be found, in online version.

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Appendix A and B. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.ypmed.2016.07.017.

References

Allen, J.D., Othus, M.K., Shelton, R.C., Li, Y., Norman, N., Tom, L., del Carmen, M.G., 2010. Parental decision making about the HPV vaccine. Cancer Epidemiol. Biomark. Prev. 19, 2187–2198. http://dx.doi.org/10.1158/1055-9965.EPI-10-0217.

Blake, K.D., Ottenbacher, A.J., Finney Rutten, L.J., Grady, M.A., Kobrin, S.C., Jacobson, R.M., Hesse, B.W., 2015. Predictors of human papillomavirus awareness and knowledge in 2013: gaps and opportunities for targeted communication strategies. Am. J. Prev. Med. 48, 402–410. http://dx.doi.org/10.1016/j.amepre.2014.10.024.

Brisson, M., van de Velde, N., Franco, E.L., Drolet, M., Boily, M.C., 2011. Incremental impact of adding boys to current human papillomavirus vaccination programs: role of herd immunity. J. Infect. Dis. 204, 372–376. http://dx.doi.org/10.1093/infdis/jir285.

Bynum, S.A., Brandt, H.M., Friedman, D.B., Annang, L., Tanner, A., 2011. Knowledge, beliefs, and behaviors: examining human papillomavirus-related gender differences among African American college students. J. Am. Coll. Heal. 59, 296–302. http://dx.doi.org/10.1080/07448481.2010.503725.

Centers for Disease Control and Prevention, 2015. HPV vaccines: vaccinating your preteen or teen. Internet; January 26, 2015. Available at http://www.cdc.gov/hpv/parents/vaccine.html Accessed July, 19 2016.

Daley, E.M., Buhi, E.R., Baldwin, J., Lee, J.H., Vadaparampil, S., Abrahamsen, M., Vamos, C.A., Kolar, S., Chandler, R., et al., 2009. Men's responses to HPV test results: development of a theory-based survey. Am. J. Health Behav. 33, 728–744. http://dx.doi.org/10.5993/AJHB.33.6.10.

Daley, E.M., Vamos, C.A., Buhi, E.R., Kolar, S.K., McDermott, R.J., Hernandez, N., Fuhrmann, H.J., 2010. Influences on human papillomavirus vaccination status among female college students. J. Women's Health (Larchmt) 19, 1885–1891. http://dx.doi.org/10.1089/jwh.2009.1861.

Davlin, S.L., Berenson, A.B., Rahman, M., 2015. Correlates of HPV knowledge among low-income minority mothers with a child 9–17 years of age. J. Pediatr. Adolesc. Gynecol. 28, 19–23. http://dx.doi.org/10.1016/j.jpag.2014.01.109.

Fisher, B., 2016. HPV Vaccination: Knowledge, Attitudes, and Practice of Undergraduates (Questionnaire unpublished). Department of Psychology, The University of Western Ontario, Canada.

Forman, D., de Martel, C., Lacey, C.J., Soerjomataram, I., Lortet-Tieulent, J., Bruni, L., Vignat, J., Ferlay, J., Bray, F., et al., 2012. Global burden of human papillomavirus and related diseases. Vaccine 30 (Suppl. 5), F12–F23. http://dx.doi.org/10.1016/j.vaccine.2012.07.055.

Gerend, M.A., Barley, J., 2009. Human papillomavirus vaccine acceptability among young adult men. Sex. Transm. Dis. 36, 58–62. http://dx.doi.org/10.1097/OLQ.0b013e31818606fc.

Gerend, M.A., Shepherd, J.E., 2011. Correlates of HPV knowledge in the era of HPV vaccination: a study of unvaccinated young adult women. Women Health 51, 25–40. http://dx.doi.org/10.1080/03630242.2011.540744.

Giambi, C., D'Ancona, F., Del Manso, M., De Mei, B., Giovannelli, I., Cattaneo, C., Possenti, V., Declich, S., Local Representatives for, V., 2014. Exploring reasons for non-vaccination against human papillomavirus in Italy. BMC Infect. Dis. 14, 545. http://dx.doi.org/10.1186/s12879-014-0545-9.

Giede, C., McFadden, L.L., Komonoski, P., Agrawal, A., Stauffer, A., Pierson, R., 2010. The acceptability of HPV vaccination among women attending the University of Saskatchewan Student Health services. J. Obstet. Gynaecol. Can. (JOGC) 32, 679–686http://www.scopus.com/inward/record.url?eid=2-s2.0-77957256407&partnerID=40&md5=51c25866b2be1dec712e30c672ee5d5a.

Gowda, C., Carlos, R.C., Butchart, A.T., Singer, D.C., Davis, M.M., Clark, S.J., Dempsey, A.F., 2012. CHIAS: a standardized measure of parental HPV immunization attitudes and beliefs and its associations with vaccine uptake. Sex. Transm. Dis. 39, 475–481. http://dx.doi.org/10.1097/OLQ.0b013e318248a6d5.

Gutierrez Jr., B., Leung, A., Jones, K.T., Smith, P., Silverman, R., Frank, I., Leader, A.E., 2013. Acceptability of the human papillomavirus vaccine among urban adolescent males. Am. J. Mens Health 7, 27–36. http://dx.doi.org/10.1177/1557988312456697.

Holcomb, B., Bailey, J.M., Crawford, K., Ruffin, M.T., 2004. Adults' knowledge and behaviors related to human papillomavirus infection. J. Am. Board Fam. Med. 17, 26–31. http://dx.doi.org/10.3122/jabfm.17.1.26.

Hu, L.T., Bentler, P.M., 1999. Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. Struct. Equ. Model.: A Multidisciplinary Journal 6, 1–55. http://dx.doi.org/10.1080/10705519909540118.

Joseph, N.P., Shea, K., Porter, C.L., Walsh, J.P., Belizaire, M., Estervine, G., Perkins, R., 2015. Factors associated with human papillomavirus vaccine acceptance among Haitian and African-American parents of adolescent sons. J. Natl. Med. Assoc. 107, 80–88. http://dx.doi.org/10.1016/s0027-9684(15)30028-6.

Kang, H.Y., Kim, J.S., 2011. Knowledge, attitudes of human papillomavirus vaccine, and intention to obtain vaccine among Korean female undergraduate students. Women Health 51, 759–776. http://dx.doi.org/10.1080/03630242.2011.627091.

Katz, M.L., Krieger, J.L., Roberto, A.J., 2011. Human papillomavirus (HPV): college male's knowledge, perceived risk, sources of information, vaccine barriers and communication. J. Mens Health 8, 175–184. http://dx.doi.org/10.1016/j.jomh.2011.04.002.

Klug, S.J., Hukelmann, M., Blettner, M., 2008. Knowledge about infection with human papillomavirus: a systematic review. Prev. Med. 46, 87–98. http://dx.doi.org/10.1016/j.ypmed.2007.09.003.

Krawczyk, A.L., Perez, S., Lau, E., Holcroft, C.A., Amsel, R., Knauper, B., Rosberger, Z., 2012. Human papillomavirus vaccination intentions and uptake in college women. Health Psychol. 31, 685–693. http://dx.doi.org/10.1037/a0027012.

Krawczyk, A., Stephenson, E., Perez, S., Lau, E., Rosberger, Z., 2013. Deconstructing human papillomavirus (HPV) knowledge: objective and perceived knowledge in males' intentions to receive the HPV vaccine. Am. J. Health Educ. 44, 26–31. http://dx.doi.org/10.1080/19325037.2012.749714.

Krawczyk, A., Knauper, B., Gilca, V., Dube, E., Perez, S., Joyal-Desmarais, K., Rosberger, Z., 2015. Parents' decision-making about the human papillomavirus vaccine for their daughters: I. Quantitative results. Hum. Vaccin. Immunother. 11, 322–329. http://dx.doi.org/10.1080/21645515.2014.1004030.

Marlow, L.A., Zimet, G.D., McCaffery, K.J., Ostini, R., Waller, J., 2013. Knowledge of human papillomavirus (HPV) and HPV vaccination: an international comparison. Vaccine 31, 763–769. http://dx.doi.org/10.1016/j.vaccine.2012.11.083.

McClure, C.A., MacSwain, M.A., Morrison, H., Sanford, C.J., 2015. Human papillomavirus vaccine uptake in boys and girls in a school-based vaccine delivery program in Prince Edward Island, Canada. Vaccine 33, 1786–1790. http://dx.doi.org/10.1016/j.vaccine.2015.02.047.

Mollers, M., Lubbers, K., Spoelstra, S.K., Weijmar-Schultz, W.C., Daemen, T., Westra, T.A., van der Sande, M.A., Nijman, H.W., de Melker, H.E., et al., 2014. Equity in human papilloma virus vaccination uptake?: sexual behaviour, knowledge and demographics in a cross-sectional study in (un)vaccinated girls in the Netherlands. BMC Public Health 14 (288). http://dx.doi.org/10.1186/1471-2458-14-288.

Pelucchi, C., Esposito, S., Galeone, C., Semino, M., Sabatini, C., Picciolli, I., Consolo, S., Milani, G., Principi, N., 2010. Knowledge of human papillomavirus infection and its prevention among adolescents and parents in the greater Milan area, northern Italy. BMC Public Health 10 (378). http://dx.doi.org/10.1186/1471-2458-10-378.

Public Health Agency of Canada, 2014. Recommendations for human papillomavirus immunization programs-Canadian Immunization Committee. Internet; April 2014. Available at http://publications.gc.ca/collections/collection_2014/aspc-phac/HP40-107-2014-eng.pdf Accessed July, 19 2016.

Public Health Agency of Canada, 2015. An Advisory Committee Statement (ACS) National Advisory Committee on Immunization (NACI). Update on the recommended Human Papillomavirus vaccine immunization schedule. Internet; February 2015. Available at http://publications.gc.ca/collections/collection_2015/aspc-phac/HP40-128-2014-eng.pdf Accessed July 19, 2016.

Public Health Agency of Canada, 2016. Canada's provincial and territorial routine (and catch-up) vaccination programs for infants and children. Internet; January 2016. Available at http://healthycanadians.gc.ca/healthy-living-vie-saine/immunization-immunisation/schedule-calendrier/alt/infants-children-vaccination-enfants-nourrissons-eng.pdf Accessed July 19, 2016.

Shapiro, G.K., Perez, S., Rosberger, Z., 2016. Including males in Canadian human papillomavirus vaccination programs: a policy analysis. CMAJ http://dx.doi.org/10.1503/cmaj.150451 Published ahead of print April 25, 2016.

Slocum-Gori, S.L., Zumbo, B.D., 2010. Assessing the unidimensionality of psychological scales: using multiple criteria from factor analysis. Soc. Indic. Res. 102, 443–461. http://dx.doi.org/10.1007/s11205-010-9682-8.

Vardas, E., Giuliano, A.R., Goldstone, S., Palefsky, J.M., Moreira Jr., E.D., Penny, M.E., Aranda, C., Jessen, H., Moi, H., et al., 2011. External genital human papillomavirus prevalence and associated factors among heterosexual men on 5 continents. J. Infect. Dis. 203, 58–65. http://dx.doi.org/10.1093/infdis/jiq015.

Waller, J., Ostini, R., Marlow, L.A., McCaffery, K., Zimet, G., 2013. Validation of a measure of knowledge about human papillomavirus (HPV) using item response theory and classical test theory. Prev. Med. 56, 35–40. http://dx.doi.org/10.1016/j.ypmed.2012.10.028.

WHO Report, 2015. Human papillomavirus vaccines: WHO position paper, October 2014-recommendations. Vaccine 33, 4383–4384. http://dx.doi.org/10.1016/j.vaccine.2014.12.002.

Yacobi, E., Tennant, C., Ferrante, J., Pal, N., Roetzheim, R., 1999. University students' knowledge and awareness of HPV. Prev. Med. 28, 535–541. http://dx.doi.org/10.1006/pmed.1999.0486.