

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

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Number of Tables: 6

Word Count abstract: 241

Word Count text: 4313

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 uni-dimensional, 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.

Keywords: Human papillomavirus (HPV); Papillomavirus vaccines; Papillomavirus Infections/prevention & control; Knowledge; Health Knowledge, Attitudes, Practice; Measure; Parents; Males; Acceptability

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 (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.

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, web 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 and colleagues (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. 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.

56 ***Study Participants and Design***

57 Parents who had a son aged 9-16 years old living in their household were recruited through a research
58 firm, Leger Marketing, which maintains a representative panel of 400,000 Canadian households. We targeted a
59 sample of 4,000 parents, weighted according to the population distribution of the ten Canadian provinces. In
60 February 2014, panel participants who met the inclusion criteria were sent an invitation email with a link to the
61 online study. Participants elected whether they preferred to answer the questionnaire in English or French.

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

71 ***Knowledge Items***

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

78 The present study included the identical Waller et al.'s 16-item GK scale with two minor semantic
79 changes (shown in italics): "HPV can be *transmitted* through general skin-to-skin contact" and "Using condoms
80 reduces the *chances* of HPV transmission¹." Our study also included the identical Waller et al.'s 7-item VK
81 scale with one semantic change: "Girls who have had the HPV vaccine do not need a Pap test (*cervical cancer*
82 *screening*) when they are older²". It was also necessary to slightly revise one of the VK items about dosing as
83 since Waller et al.'s (2013) publication, the WHO recommendation(WHO Report, 2015) had shifted from a

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

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

84 three to a two-dose policy for children under 15 years of age (“The HPV vaccine requires only *one dose*³”).
85 Response options were identical to Waller’s scale and used forced choice response categories of
86 True/False/Don’t know.

87 Based on our previous HPV research (Krawczyk et al., 2015; Krawczyk et al., 2013; Krawczyk et al.,
88 2012), consultation with an expert panel and a comprehensive literature search, we identified additional
89 knowledge items that were not included in Waller’s scale. These items reflected the most up-to-date emerging
90 scientific evidence and were frequently being measured in the HPV psychosocial/epidemiological literature
91 (Daley et al., 2009; Daley et al., 2010; Fisher, Personal communication; Gerend and Barley, 2009; Giede et al.,
92 2010; Gutierrez et al., 2013; Katz et al., 2011). The addition of the 9 GK (see Appendices A & B; items 17- 25
93 for the new added items) and 4 VK items (see Appendices A & B; items 8- 11 for the new added items) aimed
94 to measure: 1) the association of HPV with oral, penile, and anal cancers (items 17, 20, 24), 2) transmission
95 (items 19, 22, 25), 3) HPV-associated signs and symptoms (items 18, 21, 23), 4) prevention (items 8), 5)
96 treatment (item 9), 6) the recommendation for males and females in the Canadian context (items 10,11) (see
97 Appendices A & B).

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

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

109 **Analysis**

110 Analyses were performed on the T1 and T2 samples separately, which were also divided into two sub-
111 samples, English and French respondents. Analyses included internal consistency analysis (Cronbach’s alpha),
112 exploratory factor analysis (EFA) to investigate dimensionality and a CFA to investigate validity (model fit).
113 Results for the 16-item GK scale and the 7-item VK scale in French and English were compared with the results
114 obtained by Waller et al. (2013). The effects of adding nine new GK items and four new VK items on internal
115 consistency and dimensionality were then investigated by comparing the scale properties with and without the

³Waller’s item: HPV vaccines require three doses

116 additional items. Additionally, descriptive statistics and Welch two sample *t*-tests, $p < 0.05$ were used to explore
117 knowledge scores over time and across languages.

118 For the EFA, a PFA was used with varimax rotation. Similar to Waller's analysis, four criteria (Slocum-
119 Gori and Zumbo, 2010) were used to explore dimensionality; three criteria are presented in Table 2. Results for
120 the fourth criterion, examining items that did not load higher than 0.33 on a forced one-factor solution, are
121 presented in text. For the CFA, results are based on four indices (Hu and Bentler, 1999) (see Table 3 and Table
122 4). Differences in proportions were tested using Chi-square, $p < 0.05$. Statistical analysis was conducted using
123 SPSS v21, Stata 13 and R Studio v0.99.896.

124 **Results**

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

128 ***Internal Consistency Analysis***

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

133 Internal consistency values for the VK7 and VK11 subscales were higher than those found by Waller et
134 al. (Table 1). Item specific analysis suggested a slight misfit for the item "One of the HPV vaccines offers
135 protection against genital warts" but the effect was very small.
136

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) $\alpha = 0.561$

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>3xF2); 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 greater than .33 on a 1-factor solution for all subsamples and at both time points.

For the GK25, the criteria F1 > 3xF2 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 greater than 1 (Table 2). Similar to the GK16, the item “HPV usually doesn't need any treatment” failed to load greater than .33 on a 1-factor solution. The item “HPV can cause herpes” also failed to load greater than .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 > 3xF2 (Table 2). For both the VK7 and the VK11

158 and across all subsamples, the percentage of variance accounted for by a 1-factor solution was higher (22.17-
159 31.39) than the percentage of variance obtained by Waller et al. (21.65). Item level analysis indicated that for
160 both the VK7 and the VK11, most items loaded >0.33 on the one factor solution for all subsamples at both time
161 points. The item “One of the HPV vaccines offers protection against genital warts” frequently failed to load
162 >0.33 and the items “The HPV vaccines offer protection against most cervical cancers” and “The HPV vaccine
163 only requires one dose” occasionally failed to load >0.33 .

Table 2. Results of the Exploratory Factor Analysis on all subsamples

		GK16			GK25			VK7			VK11		
		EV>1	F1>3xF2	1FVar	EV>1	F1>3xF2	1FVar	EV>1	F1>3xF2	1FVar	EV>1	F1>3xF2	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>3xF2=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>3xF2=Yes; 1FVar=27.78. Waller's results for the 7-item VK scale were: EV>1=1; F1>3xF2=No; 1FVar=21.65.

185 ***Model fit (CFA)***

186 CFA analysis for the GK16 and the GK25 found that the Standardized Root Mean Square Residual
187 (SRMR) and the Coefficient of Determination (CD) values met the suggested model fit criteria (Hu and Bentler,
188 1999). The Comparative Fit Index (CFI) values were close to the cutoff criteria while the p value for Chi square
189 and Root Mean Square Error Approximation (RMSEA) criteria for model fit were not met (Table 3). For the
190 VK7 and the VK11, previous observations related to cut-off criteria for the GK scales apply (Table 4).

191 **Table 3.** Results of the Confirmatory Factor Analysis for the 16 and 25-item HPV General Knowledge (GK)
 192 scales

		GK16					GK25				
		χ^2	CFI	RMSEA	SRMR	CD	χ^2	CFI	RMSEA	SRMR	CD
T1	French (n =1000)	889.15 <i>p</i> <.001	.843	.087	.055	.900	2571.48 <i>p</i> <.001	.725	.091	.071	.916
	English (n =2117)	1311.88 <i>p</i> <.001	.905	.074	.042	.918	4807.88 <i>p</i> <.001	.784	.088	.066	.933
	Combined (n = 3117)	2054.54 <i>p</i> <.001	.889	.078	.045	.912	7185.70 <i>p</i> <.001	.764	.090	.068	.927
T2	French (n =554)	484.63 <i>p</i> <.001	.853	.081	.055	.895	1435.47 <i>p</i> <.001	.729	.087	.073	.911
	English (n =873)	588.96 <i>p</i> <.001	.904	.073	.045	.916	2308.79 <i>p</i> <.001	.766	.092	.070	.931
	Combined (n = 1427)	948.23 <i>p</i> <.001	.889	.075	.047	.908	3518.88 <i>p</i> <.001	.749	.091	.071	.923

193 *Note.* χ^2 =Chi square; CFI= comparative fit index; RMSEA= root mean square error approximation;
 194 SRMR= standardized root mean square residual; CD= coefficient of determination.
 195 Cut-off criteria: a) *p* for χ^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
 196 results: Chi square 1981.6, *p*<0.0001; CFI=.816; RMSEA=.087; SRMR=.063; NFI=.809

197 **Table 4.** Results of the Confirmatory Factor Analysis for the 7 and 11-item HPV Vaccination Knowledge (VK)

198 scales

		VK7					VK11				
		X ²	CFI	RMSEA	SRMR	CD	X ²	CFI	RMSEA	SRMR	CD
T1	French (n =1000)	128.21 p<.001	.908	.090	.052	.804	294.02 p<.001	.883	.075	.050	.832
	English (n =2117)	226.19 p<.001	.930	.085	.049	.822	576.73 p<.001	.909	.076	.048	.863
	Combined (n = 3117)	335.48 p<.001	.925	.086	.049	.815	834.75 p<.001	.901	.076	.048	.853
T2	French (n =554)	68.86 p<.001	.899	.084	.052	.767	174.02 p<.001	.870	.073	.053	.805
	English (n =873)	104.61 p<.001	.917	.086	.053	.799	275.40 p<.001	.896	.078	.051	.850
	Combined (n = 1427)	154.44 p<.001	.914	.084	.051	.786	409.95 p<.001	.886	.076	.050	.833

199 *Note.* χ^2 =Chi square; CFI= comparative fit index; RMSEA= root mean square error approximation;

200 SRMR= standardized root mean square residual; CD= coefficient of determination.

201 Cut-off criteria: a) p for χ^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

202 results: Chi square 428.9, p<0.0001; CFI=.793; RMSEA=.111; SRMR=.083; NFI=.789

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).

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 (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 (Mean_{EN}=5.21 and Mean_{FR}= 5.26 at T1) and (Mean_{EN}=6.38 and Mean_{FR}=6.17 at T2).

Knowledge Patterns of Change

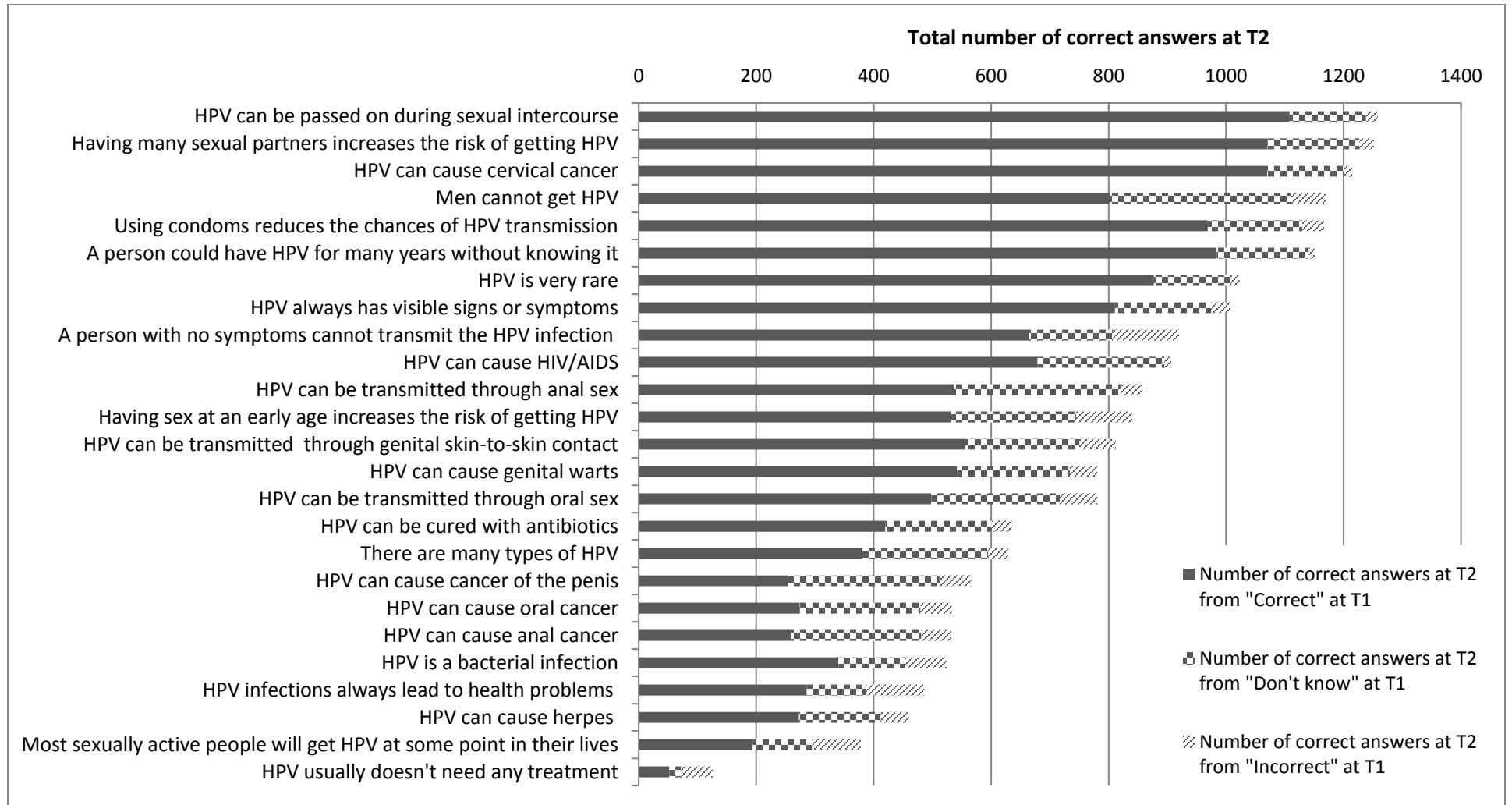
An examination of knowledge changes over time was conducted among those participants who answered the questionnaire at both T1 and T2 (n=1427). At T1, for the GK25, participants answered 49.1% of items correctly, 13.2% of items incorrectly and 37.7% of answers as “Don’t know”. At T2, at the item level, less than 50% of the sample achieved the correct answers for 10 out of 25 GK items (Figure 1). The mean

235 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]
236 $p<0.001$).

237 At T1 for the VK11, participants answered 49.9% of items correctly, 9.6% of items incorrectly and
238 40.5% of answers as “Don’t know”. At T2, at the item level, less than 50% of the sample got the correct answer
239 for 5 out of the 11 VK items (Figure 2). The mean knowledge score for the VK11 scale at T1 was 5.49 of 11
240 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
241 provided in Figure 1 and the most and least known VK items at T2 are provided in Figure 2.

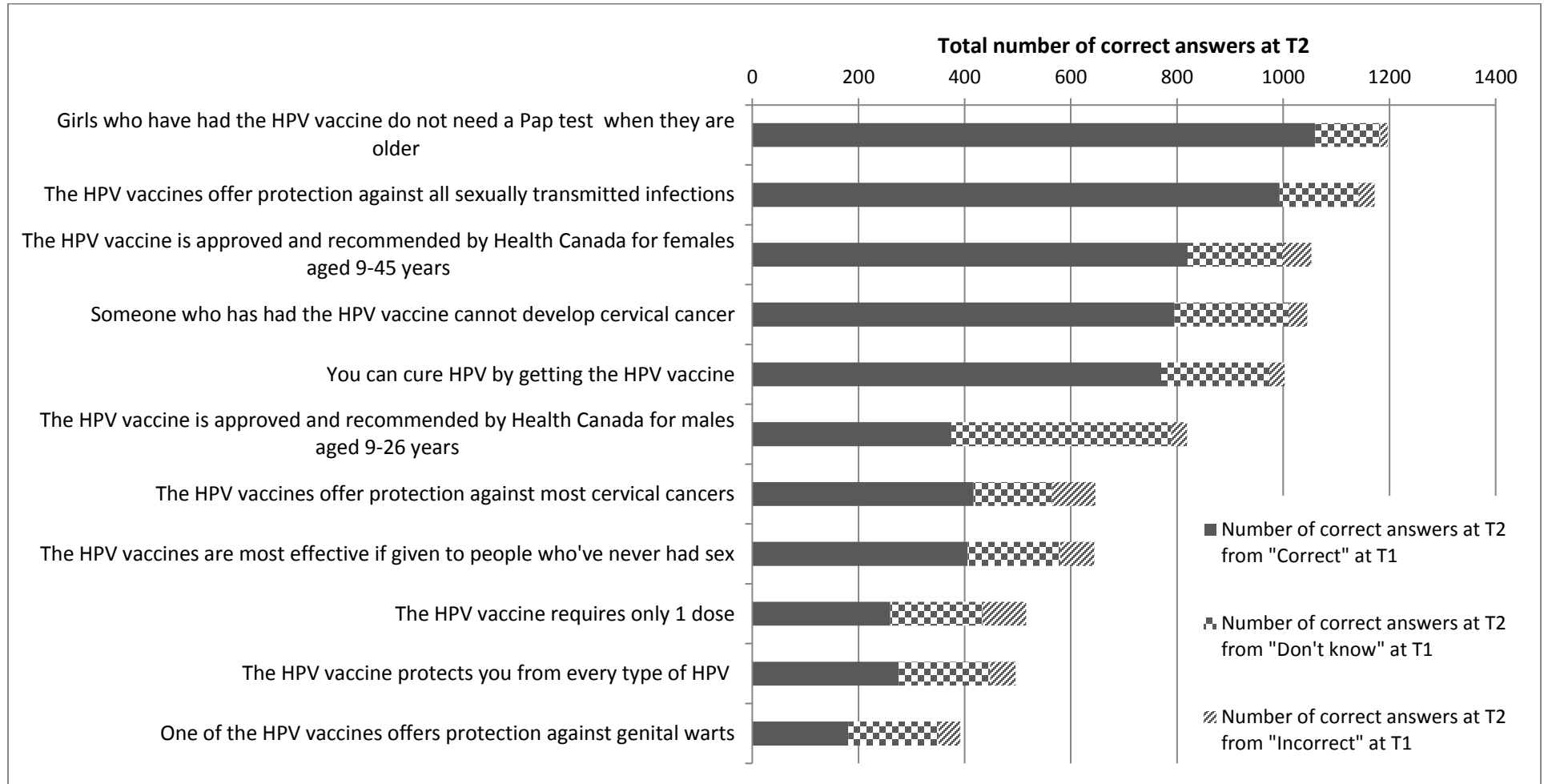
242 Item-level analysis of both the GK and VK scales revealed that for best known items, correct responses
243 at T2 can be best explained by correct responses at T1 (Figure 1 and Figure 2). For both GK and VK items, few
244 correct responses at T2 can be explained by changing from incorrect at T1Figure 1Figure 2. The number of
245 correct responses at T2 originating from “Don’t know” answers at T1 was relatively constant across items
246 (Figure 1). For GK, the largest increase was observed for parents who did not know at T1 that: a) men can get
247 HPV, b) HPV can cause cancer of penis and c) HPV can be transmitted through anal sex (Figure 1). For VK, the
248 largest increase was observed for parents who did not know at T1 that the vaccine is recommended for males
249 aged 9-26 (Figure 2).

Figure 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 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.

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

Discussion

250

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

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

266 Interestingly, knowledge of these items was very poor in our Canadian sample which is
267 in line with other populations (Blake et al., 2015; Bynum et al., 2011; Daley et al., 2010; Gerend
268 and Shepherd, 2011; Giambi et al., 2014; Holcomb et al., 2004; Kang and Kim, 2011; Marlow et
269 al., 2013; Mollers et al., 2014; Yacobi et al., 1999). Future consideration should be given to
270 excluding these items from the GK scales as perhaps they are not necessary to understanding
271 HPV and may be confusing (e.g., *HPV itself* does not require any treatment but *HPV-associated*
272 *diseases* do require treatment) and likely unnecessary (e.g., is it relevant to know that HPV does
273 not cause herpes). Post hoc, we explored the effect of removing these two items from the GK25
274 scale, and model fit remained largely unchanged and the change in internal consistency was
275 inconsequential. The decision then to include or exclude these items would thus be left to the
276 individual researcher, though it is our suggestion to exclude these 2 items, as it make more
277 substantive sense, leaving a 23-item solution, the GK23.

278 For the VK11 scale, two items failed to appropriately load: "One of the HPV vaccines
279 offers protection against genital warts" and "The HPV vaccine only requires one dose", which

280 was similarly found by Waller and colleagues (2013). These items require further attention as
281 they are conceptually valuable for measuring HPV vaccine knowledge as the protection against
282 genital warts may be an additional benefit to some individuals to prompt vaccination and dosage
283 is important as we know that many parents do not complete the full vaccination series. As most
284 countries are now only using vaccines that prevent both cancers and warts (i.e., 4vHPV and
285 9vHPV), and as most countries transition to the WHO recommended 2-dose schedule, it may
286 have confused parents to inter-change HPV vaccine with ('one of the') HPV vaccines (*plural*).
287 We hypothesize that a slight change in wording/semantics for all VK could potentially improve
288 model fit, e.g., “The HPV vaccine offers protection against genital warts” and “The HPV vaccine
289 requires at least 2 doses”.

290 The mean GK and VK in our sample was poor at both time points i.e. on average, parents
291 answered around only half the items for both scales correctly, which is consistent with Waller’s
292 (2013) and most study results (Davlin et al., 2015; Holcomb et al., 2004; Joseph et al., 2015;
293 Klug et al., 2008). Item-level analysis showed a similar ranking of knowledge items compared to
294 Marlow et al.’s study (n =2409 participants living in the UK, US, and Australia, $M_{age}= 41-48$,
295 with 12-14% of them having daughters aged 9-17 (2013). This may suggest a pattern among the
296 general population where most individuals, regardless of parental status, know about the
297 association between HPV and cervical cancer and that increasing the number of partners
298 increases the risk of HPV. In both our and Marlow et al.’s sample, most individuals did not know
299 that “Most sexually active people will get HPV at some point in their lives”. These results
300 suggest that there may be knowledge gaps that are widespread among different subsamples (e.g.,
301 parents, young adults), and that parents are not acquiring any additional knowledge beyond the
302 general population. Educational interventions, dispersed in many widespread channels could
303 target these specific knowledge gaps.

304 Both GK and VK total scores increased statistically significant over time but the effect
305 size was small (Cohen’s $d < 0.3$ for the 1427 sample). At Time 1, we provided a brief informative
306 statement about HPV after the knowledge section, but we estimate that the impact on knowledge
307 at follow-up was very small, considering the nine months’ time interval between baseline and
308 follow-up. A closer examination at the item level reveals that correct responses remained
309 consistent for at least nine months. Moreover, at T2, only a tiny proportion (between 0.8 and
310 12%) of correct responses can be attributed to a change from incorrect at T1 to correct at T2 and

311 a small proportion (10%-51%) can be attributed to a change from ‘Don’t know’ at T1 to correct
312 at T2. Therefore, we suggest providing both general HPV and HPV vaccine information/facts,
313 with emphasis on the items that parents do not know, rather than correcting misconceptions. As
314 an example, specifying the age and gender recommendation in one’s country is advisable. This is
315 further substantiated by our results which showed an overall pattern across both GK and VK
316 items where few individuals answered items *incorrectly* as compared to an often higher
317 proportion of participants who answered ‘Don’t know’, indicating *a lack of HPV knowledge*
318 rather than *wrong/misinformation*.

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

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

340 **Conclusions**

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

350

351 **Acknowledgements:**

352 This study was supported by: Grant #288295 from the Canadian Institute of Health Research
353 (CIHR). SP and GS are Vanier CIHR Canada Graduate Scholars. GS is a Queen Elizabeth II
354 Diamond Jubilee Scholar. Jo Waller is supported by Cancer Research UK. The authors thank
355 Eve Dubé, Eduardo Franco, Vladimir Gilca, Juliet Guichon, Keven Joyal-Desmarais,
356 Christopher Brown, and Gina Ogilvie, for their help in the development of the questionnaire.

357

358 **Conflict of Interest:**

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

Supplemental file: Appendix A – English HPV General Knowledge (GK) Items¹

Please answer the following questions to the best of your ability:	
1.	HPV is very rare (F)
2.	HPV always has visible signs or symptoms (F)
3.	HPV can cause cervical cancer (T)
4.	HPV can be transmitted through genital skin-to-skin contact (T)
5.	There are many types of HPV (T)
6.	HPV can cause HIV/AIDS (F)
7.	HPV can be passed on during sexual intercourse (T)
8.	HPV can cause genital warts (T)
9.	Men cannot get HPV (F)
10.	Using condoms reduces the chances of HPV transmission (T)
11.	HPV can be cured with antibiotics (F)
12.	Having many sexual partners increases the risk of getting HPV (T)
13.	HPV usually doesn't need any treatment (T)
14.	Most sexually active people will get HPV at some point in their lives (T)
15.	A person could have HPV for many years without knowing it (T)
16.	Having sex at an early age increases the risk of getting HPV (T)
17.	HPV can cause anal cancer (T)
18.	HPV is a bacterial infection (F)
19.	HPV can be transmitted through oral sex (T)
20.	HPV can cause cancer of the penis (T)
21.	HPV can cause herpes (F)
22.	HPV can be transmitted through anal sex (T)
23.	HPV infections always lead to health problems (F)
24.	HPV can cause oral cancer (T)
25.	A person with no symptoms cannot transmit the HPV infection (F)

¹ Items 1-16 are from Waller et al.'s scale. Items 17- 25 were added in this study. Items 13 and 21 could ideally be removed, leaving a 23-item solution (GK23). We leave this to the discretion of the researchers. Response options are: *True, False, Don't know*.

Supplemental file: Appendix A – English HPV Vaccination Knowledge (VK) Items²

Please answer the following questions to the best of your ability:	
1.	The HPV vaccine ³ requires only 1 dose (F)
2.	The HPV vaccines ⁴ offer protection against all sexually transmitted infections (F)
3.	The HPV vaccines ⁴ are most effective if given to people who've never had sex (T)
4.	Someone who has had the HPV vaccine cannot develop cervical cancer (F)
5.	The HPV vaccines ⁴ offer protection against most cervical cancers (T)
6.	One of the HPV vaccines ⁴ offers protection against genital warts (T)
7.	Girls who have had the HPV vaccine do not need a Pap test when they are older (F)
8.	The HPV vaccine protects you from every type of HPV (F)
9.	You can cure HPV by getting the HPV vaccine (F)
10.	The HPV vaccine is approved and recommended by Health Canada for females aged 9-45 years (T)
11.	The HPV vaccine is approved and recommended by Health Canada for males aged 9-26 years (T)

² Items 1-7 are from Waller et al.'s scale. Items 8-11 were added in this study. Items 10 and 11 can be adapted to each specific country or regions policy/recommendation. Response options are: *True, False, Don't know*.

³ We recommend modifying this item to: *The HPV vaccine requires at least 2 doses* (T).

⁴ We recommend using *HPV vaccine* (singular) throughout the VK items instead of *HPV vaccines* (plural) as this can be confusing to the reader. For item 6, we recommend the item be asked as follows: *The HPV vaccine offers protection against genital warts*.

Veillez répondre aux questions suivantes du mieux que vous le pouvez:	
1.	Le VPH est très rare (F)
2.	Le VPH présente toujours des signes ou symptômes visibles (F)
3.	Le VPH peut causer le cancer du col de l'utérus (V)
4.	Le VPH peut se transmettre par contact génital peau à peau (V)
5.	Il existe plusieurs types de VPH (V)
6.	Le VPH peut causer le VIH ou le sida (F)
7.	Le VPH peut être transmis au cours de relations sexuelles (V)
8.	Le VPH peut causer des verrues génitales (V)
9.	Les hommes ne peuvent pas contracter le VPH (F)
10.	L'utilisation d'un condom réduit les chances de transmission du VPH (V)
11.	Le VPH peut être guéri avec des antibiotiques (F)
12.	Avoir de nombreux partenaires sexuels augmente les risques de contracter le VPH (V)
13.	Le VPH ne nécessite habituellement pas de traitement (V)
14.	La plupart des personnes sexuellement actives contracteront le VPH à un moment ou à un autre de leur vie (V)
15.	Une personne pourrait être atteinte du VPH pendant de nombreuses années sans le savoir (V)
16.	Avoir des relations sexuelles à un jeune âge augmente les chances d'attraper le VPH (V)
17.	Le VPH peut causer le cancer de l'anus (V)
18.	Le VPH est une infection bactérienne (F)
19.	Le VPH peut être transmis par sexe oral (V)
20.	Le VPH peut causer le cancer du pénis (V)
21.	Le VPH peut causer l'herpès (F)
22.	Le VPH peut être transmis par sexe anal (V)
23.	Les infections au VPH entraînent toujours des problèmes de santé (F)
24.	Le VPH peut causer le cancer de la bouche (V)
25.	Une personne ne présentant pas de symptômes ne peut pas transmettre le VPH (F)

Supplemental File: Appendix B – French HPV General Knowledge Items⁵

Supplemental File: Appendix B – French HPV Vaccination Knowledge (VK) Items⁶

Veillez répondre aux questions suivantes du mieux que vous le pouvez:	
1.	Le vaccin ⁷ contre le VPH ne nécessite qu'une seule dose (F)
2.	Les vaccins ⁸ contre le VPH protègent contre toutes les infections transmises sexuellement (F)
3.	Les vaccins ⁴ contre le VPH sont les plus efficaces lorsqu'ils sont administrés à des personnes n'ayant jamais eu de rapports sexuels (V)
4.	Une personne ayant été vaccinée contre le VPH ne peut pas développer le cancer du col de l'utérus (F)
5.	Les vaccins ⁴ contre le VPH protègent contre la plupart des cancers du col de l'utérus (V)
6.	L'un des vaccins ⁴ contre le VPH protège contre les verrues génitales (V)
7.	Les filles ayant été vaccinées contre le VPH n'ont pas besoin de passer de test Pap lorsqu'elles sont plus âgées (F)
8.	Le vaccin contre le VPH vous protège contre tous les types de VPH (F)
9.	Vous pouvez guérir le VPH en recevant le vaccin contre le VPH (F)
10.	Le vaccin contre le VPH est approuvé et recommandé par Santé Canada pour les filles/femmes de 9 à 45 ans (V)
11.	Le vaccin contre le VPH est approuvé et recommandé par Santé Canada pour les garçons/hommes de 9 à 26 ans (V)

⁵ Items 1-16 are from Waller et al.'s scale. Items 17- 25 were added in this study. Items 13 and 21 could ideally be dropped, leaving a 23-item solution (GK23). We leave this to the discretion of the researchers. Response options are: *Vrai, Faux, Je ne sais pas*.

⁶Items 1-7 are from Waller et al.'s scale. Items 8-11 were added in this study. Items 10 and 11 can be adapted to each specific country or regions policy/recommendation. Response options are: *Vrai, Faux, Je ne sais pas*.

⁷ We recommend modifying this item to: *Le vaccin contre le VPH nécessite au moins deux doses* (T).

⁸We recommend using *Le vaccin contre le VPH* (singular) throughout the VK items instead of *les vaccins contre le VPH* (plural) as this can be confusing to the reader. For item 6, we recommend the item be asked as follows: *Le vaccin contre le VPH protège contre les verrues génitales*.

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