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Using an integrated conceptual framework to investigate parents' HPV vaccine decision for their daughters and sons

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ABSTRACT

Despite being an effective cancer prevention strategy, human papillomavirus (HPV) vaccination in Canada remain suboptimal. This study is the first to concurrently evaluate HPV vaccine knowledge, attitudes, and the decision-making stage of Canadian parents for their school-aged daughters and sons. Data were collected through an online survey from a nationally representative sample of Canadian parents of 9–16 year old children from August to September 2016. Measures included socio-demographics, validated scales to assess HPV vaccine knowledge and attitudes (using the Health Belief Model), and parents' HPV vaccination adoption stage using the Precaution Adoption Process Model (PAPM; six stages: unaware, unengaged, undecided, decided not, decided to, or vaccinated). 3779 parents' survey responses were analyzed (1826 parents of sons and 1953 parents of daughters). There was a significant association between child's gender and PAPM stage of decision-making, with parents of boys more likely to report being in earlier PAPM stages. In multinomial logistic regression analyses parents of daughters (compared to sons), parents of older children, and parents with a health care provider recommendation had decreased odds of being in any earlier PAPM stage as compared to the last PAPM stage (i.e. vaccinated). Parents who were in the 'decided not to vaccinate' stage had significantly greater odds of reporting perceived vaccine harms, lack of confidence, risks, and vaccine conspiracy beliefs. Future research could use these findings to investigate theoretically informed interventions to specifically target subsets of the population with particular attention towards addressing knowledge gaps, perceived barriers, and concerns of parents.

1. Introduction

Human papillomavirus (HPV) can cause a number of anogenital and oropharyngeal cancers in men and women (Brotherton et al., 2016; Canadian Cancer Society, 2016). To prevent morbidity and mortality, three vaccines have been licensed and recommended for use (Shapiro et al., 2017a; Blake and Middleman, 2017). Currently, over 80 countries have implemented national HPV vaccination programs (Brotherton et al., 2016; Brotherton and Bloem, 2015; Cervical Cancer Action. Global Progress in HPV Vaccination, 2017). In Canada, provinces and territories have implemented publicly funded school-based HPV vaccine programs. All Canadian jurisdictions implemented programs for girls, from 2007 to 2010 (Shapiro et al., 2016a, 2017b). As of 2018, all jurisdictions also offer programs for boys in schools (Public Health Agency of Canada, 2017); however, the roll out of these programs (since 2013) has been staggered and HPV vaccination rates in Canada remain suboptimal (Shapiro et al., 2017a, 2017b, 2015).

Because HPV vaccination targets children (Shapiro et al., 2017a), parental acceptance is critical to ensuring uptake. Previous research has indicated common themes associated with uptake, such as the importance of parents believing in the benefits of vaccination and perceiving few barriers (Holman et al., 2014; Radisic et al., 2017). Unsurprisingly, parents are less likely to vaccinate their child if they are not aware of, or do not know enough about, HPV vaccination. Parents are also less likely to vaccinate their child if they believe that HPV vaccination can cause harm, or that vaccination is not accessible or

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affordable (Gerend and Shepherd, 2012). Furthermore, positive attitudes towards vaccines in general are related to HPV vaccine acceptance (Shapiro et al., 2016b, 2018). Notably, a strong health care provider (HCP) recommendation significantly improves parental vaccine acceptance (Blake and Middleman, 2017; Holman et al., 2014; Perez et al., 2017). Other social influences, including by a partner, family, friends, or online social network, can also influence parents' decision (Gerend and Shepherd, 2012; Perez et al., 2017, 2016a; Shapiro et al., 2017c).

It is likely that these factors have varying impact on parents depending on where they are in the decision-making process, which is obscured in much previous research investigating vaccination as a binary outcome (vaccinated or not). Literature on vaccine hesitancy highlights many reasons a parent may delay or refuse vaccination for their child (Dube et al., 2013). A theoretical stage-based model, the Precaution Adoption Process Model (PAPM), allows for a nuanced examination of which modifying factors and individual health beliefs are important for each stage of decision-making (Fig. 1) (Shapiro et al., 2017d; Weinstein, 1988; Prue and Santin, 2015). The PAPM identifies six stages involved in making a health decision and clarifies what factors lead individuals to move from one health behaviour decision-making stage to the next (Weinstein and Sandman, 1992). A stage-based understanding of HPV vaccine decision-making is important for identifying the psychosocial correlates for each stage and how to best intervene for parents at different stages. Nevertheless, few studies have examined the stages of HPV vaccine decision-making in college students and parents of only boys (Perez et al., 2017; Barnard et al., 2017; Perez et al., 2016b; Tatar et al., 2017), and no study has compared the stages of decision-making of parents of girls to parents of boys. Previous studies have found that college students and parents of boys were in the earliest stages of HPV vaccine decision-making (Perez et al., 2017; Barnard et al., 2017; Perez et al., 2016b; Tatar et al., 2017). Given HPV vaccine programs and policies have differentially targeted boys and girls, it is important to examine differences in decision-making stage between parents of girls and boys.

This study will identify and compare parents' stage of decision-making by gender for their school-aged daughters and sons, examine differences in parents' HPV vaccine knowledge and attitudes by PAPM stage, and investigate the psychosocial correlates of parents' PAPM stages.

2. Methods

2.1. Survey design and participants

Details of the methodology are presented in the protocol paper (Shapiro et al., 2017d). This study used a cross-sectional design to collect self-reported online survey data from a national sample of Canadian parents. Data presented here were part of a larger two-wave protocol and were collected from August 17 to September 11, 2016 (i.e. Time one). All Canadian jurisdictions at this time had publicly funded, school-based HPV vaccination programs for girls but only three provinces (i.e. Alberta, Prince Edward Island, and Nova Scotia) had programs for boys.

This study targeted parents and/or guardians (hereafter referred to as parents) of 9–16 year-old boys and girls. Parents with more than one child were asked to answer the questionnaire in reference to the child who had the most recent birthday to ensure randomization. The online survey was offered in English and French (i.e. Canada's two official languages). Participants were recruited using Leger-*The Research Intelligence Group*, which maintains a nationally representative panel of 400,000 Canadians (Leger, 2018). This study received Research Ethics Board approval from the Research Review Office, Integrated Health and Social Services University Network for West-Central Montreal (CODIM-FLP-16-219) (Shapiro et al., 2017d).

2.2. Measures

The dependent variable was parents' PAPM stage, which categorizes parents' stage of decision-making regarding HPV vaccination into six stages (Fig. 1) (Weinstein, 1988).

Potential psychosocial predictors of HPV vaccine decision-making included socio-demographics, HCP recommendation, as well as validated scales to assess HPV and HPV vaccine knowledge, HPV vaccine attitudes, and general vaccine attitudes. HCP recommendation was assessed by asking parents, 'did a health care provider (e.g. a doctor, pediatrician, or nurse) recommend that [child's name] receive the HPV vaccine within the last 12 months?'. Parents were only administered this question if they had answered affirmatively that they had seen a HCP and discussed their child receiving the HPV vaccine with a HCP.

Two validated scales were used to measure parents' knowledge of HPV and the HPV vaccine (Waller et al., 2013; Perez et al., 2016c). Specifically, the 23-item HPV General Knowledge Scale ($\alpha = 0.94$) and the 11-item HPV Vaccine Knowledge (VK) Scale ($\alpha = 0.88$) were used (Appendix A). To each item, respondents answered 'true', 'false', or 'don't know', for which a total score was calculated based on correct answers (higher scores indicate greater knowledge on both scales).

HPV vaccine attitudes were assessed using constructs from the Health Belief Model (HBM) including perceived benefits of, and barriers to, HPV vaccination; perceived severity of, and susceptibility to, HPV infection and disease; external influences prompting HPV vaccine uptake (i.e. cues to action), and the ability to exert change (i.e. self-efficacy). Sub-scales from the psychometrically validated HPV vaccination Attitudes and Beliefs Scale (HABS) were used to evaluate constructs from the HBM using a 7-point Likert-type rating scale ranging from 1 (strongly disagree) to 7 (strongly agree) (Perez et al., 2016c). Sub-scales were evaluated for internal consistency using Cronbach's α. HBM constructs, predominantly assessed using HABS subscales, included perceived susceptibility of child to HPV and its consequences (3 items, $\alpha = 0.92$), perceived severity of HPV and its consequence (3 items, $\alpha = 0.84$), perceived benefits of HPV vaccine (10 items, $\alpha = 0.94$), perceived barriers to HPV vaccine (6 items to measure harms, $\alpha = 0.93$; 4 items to measure accessibility, $\alpha = 0.79$; and 3 items to measure affordability, $\alpha = 0.87$), cues to action (8 items, $\alpha = 0.91$), and self-efficacy (4 items $\alpha = 0.89$) (Appendix A).[1]

General vaccine attitudes were assessed using two psychometrically validated scales: the Vaccine Conspiracy Beliefs Scale (VCBS) and the Vaccine Hesitancy Scale (VHS) (Shapiro et al., 2016b, 2018). The VCBS has seven items assessed on a 7-point Likert-type rating scale ($\alpha = 0.95$). The VHS was developed by the World Health Organization Sage Working Group on Vaccine Hesitancy (Larson et al., 2015), and psychometrically validated by our research group (Shapiro et al., 2018). The VHS was found to have two underlying factors (i.e. 'lack of confidence', $\alpha = 0.92$; and 'risks', $\alpha = 0.64$) and items are assessed on a 5-point Likert-type rating scale (Appendix A).

2.3. Analysis

This study reports parents' HPV vaccine decision-making in percentages based on the six PAPM stages. For assessing significant differences in PAPM stage based on child's gender, a chi-square test was used.

To examine differences between reported vaccine knowledge and attitudes by PAPM stage, one-way ANOVA and Tukey Honest Significant Difference (HSD) post-hoc tests were conducted.

Multinomial logistic regression analyses were used to calculate the odds ratios of being in one of the first five PAPM stages compared to PAPM stage 6 (i.e. vaccinated, reference category). PAPM stage was the

[1] All scales are subscales the HABS except self-efficacy, which is a construct of the HBM but was not included as a subscale in the HABS.

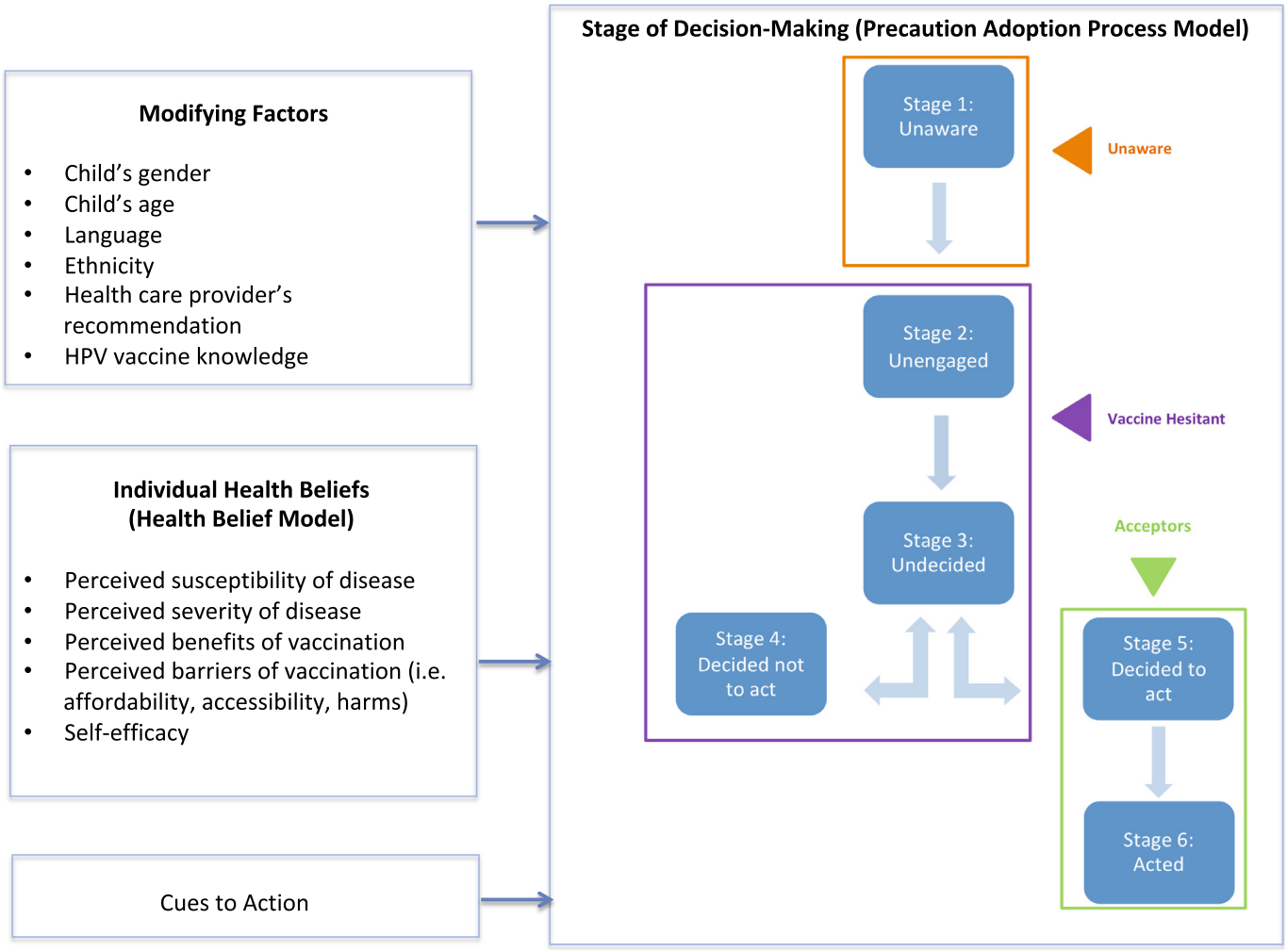

Fig. 1. An integrated conceptual framework of HPV vaccination.
Note. The PAPM, as applied to HPV vaccination, identifies individuals along six stages of decision-making: 1) *unaware* of the vaccine ("I was unaware that the HPV vaccine could be given to CHILD*"); 2) *unengaged* in the decision to vaccinate their child ("I have never thought about vaccinating CHILD* against HPV"); 3) *undecided* about whether to vaccinate their child ("I am undecided about vaccinating CHILD* against HPV"); 4) *decided not to act* (i.e. decided not to vaccinate their child, "I have decided I DO NOT want to vaccinate CHILD* against HPV"); 5) *decided to act* (i.e. decided to vaccinate their child, "I have decided I DO want to vaccinate CHILD* against HPV"); and 6) *acted* (i.e. vaccinated their child, "CHILD* has already received the HPV vaccine"). *To increase the personalization of this questionnaire, intelligent programming allowed for each question with "CHILD" to specifically include their child's name.

dependent variable. First, we conducted bivariate multinomial logistic regression analyses and estimated the associations for each independent variable individually. Subsequently, we performed multivariate multinomial logistic regression analyses by including 14 independent variables in a single model. In order to select variables that would ensure the most parsimonious and theory-driven multivariate model, variables were included based on attitudes predicted to be associated with behavioural change (according to the HBM) and significant modifying factors in the literature (see Fig. 1) (Perez et al., 2017; Krawczyk et al., 2015). Odds ratios and 95% confidence intervals (CI) were calculated. To assess multicollinearity of the multivariate multinomial logistic regression models, the Variation Inflation Factor (VIF) was calculated for all predictors. Model fit diagnostics were reported based on following criteria: (a) Cox-Snell R^2, (b) Cragg-Uhler R^2, and (c) McFadden R^2.

Statistical analyses were performed using IBM SPSS V.23 and R 3.3.2.

3. Results

3.1. Sample demographics

A total of 4606 parents completed the survey. The response rate, calculated based on completion by participants who initiated the questionnaire ($N = 6789$) was 67.9%. Overall, 827 (18.0%) participants were excluded as these participants were detected to be inattentive or unmotivated respondents based on data cleaning (i.e. the use of two bogus items and index of psychometric synonyms) (Shapiro et al., 2017d). Sociodemographic characteristics for the final sample ($N = 3779$) are presented in Table 1. At the time of data collection, only 7% were parents of boys living in provinces where there was a publicly funded HPV vaccine program for boys available ($n = 252$) and fewer still would have been eligible for the program depending upon their child's age.

3.2. Identifying Canadian parents' stage of decision-making by child's gender

Table 2 shows the proportion of parents of boys and parents of girls

Table 1
Sample characteristic (N = 3779).

Participant characteristics	*N* (%)
Parent's gender	
Men	1311 (34.69)
Women	2468 (65.31)
Parent's age	
Range (years)	18–81
Mean (*SD*)	43.51 (6.86)
Language in which parents answered the survey	
English	2801 (74.12)
French	978 (25.88)
Marital status	
Single/separated/divorced/widowed	760 (20.11)
Married/common law	3019 (79.89)
Parent's level of education	
Elementary or high school	659 (17.44)
Trade technical or university	3120 (82.56)
Parent's employment status	
Employed	3057 (80.89)
Not employed	722 (19.11)
Born in Canada	
Yes	3214 (85.05)
No	565 (14.95)
Parent's ethnicity	
White	3224 (85.31)
Other	555 (14.69)
Parent's religion	
Any religious affiliation	2493 (65.97)
No religious affiliation	1286 (34.03)
Household income	
< 100 K	1973 (52.21)
≥100 K	1409 (37.28)
Prefer not to answer	397 (10.51)
Child's gender	
Boys (sons)	1826 (48.32)
Girls (daughters)	1953 (51.68)
Child's age	
Range (years)	9–16
Mean (*SD*)	12.58 (2.31)
Child's school's religion	
No affiliation	2821 (74.65)
Any religious affiliation	958 (25.35)
Child's school's language	
English	2647 (70.04)
French and other	1132 (29.96)
Province with funded HPV vaccination for boys	
No	3225 (85.34)
Yes	554 (14.66)
Size of city	
< 100 K	1799 (47.61)
≥100 K	1980 (52.39)
Number of children in the family	
1	868 (22.97)
2	1747 (46.23)
≥3	1164 (30.80)
Child's sexual orientation	
Heterosexual	3301 (87.35)
Other	478 (12.65)
HCP recommendation	
No	3346 (88.54)
Yes	433 (11.46)

across the six PAPM stages. HPV vaccine uptake of Canadian children was low, with only 801 (41.0%) parents of girls reporting that their daughters were vaccinated and only 160 (8.8%) parents of boys reporting that their sons were vaccinated. There was a significant and large association between child's gender and PAPM stage of decision making ($\chi^2(5) = 735.25$, $p < .001$, $\varphi_c = 0.44$) with parents of boys more likely to be in earlier stages.

3.3. Comparison of knowledge and attitudes for HPV vaccine PAPM stages

One-way ANOVA found that there was a significant effect of PAPM stage on all vaccine knowledge and attitude scales (Table 3). The greatest effect sizes were for cues to action, benefits, and barriers-harms.

Post hoc analyses found that knowledge (both HPV vaccine knowledge and HPV general knowledge) was significantly lower for PAPM stages 1–3 (unaware, unengaged, and undecided) compared to later PAPM stages. In addition, parents who were unaware reported significantly lower perceived vaccine affordability compared to parents who were unengaged and undecided, while parents who were unaware and unengaged reported significantly lower perceived harms and VHS-risk compared to parents who were undecided.

Parents who decided not to vaccinate (Stage 4) significantly differed from all other PAPM stages on all scales except barriers-not accessible, self-efficacy, and knowledge scales (VK and GK); however, on these four scales, parents who decided not to vaccinate responded similarly to parents who decided to vaccinate or already vaccinated their child (Stages 5 and 6).

Parents who decided to vaccinate their child (Stage 5) reported significantly higher perceived benefits, greater perceived barriers of accessibility and affordability, and fewer cues to action compared to those who already vaccinated their child (Stage 6).

3.4. Examination of correlates of PAPM stage

The bivariate and multivariate multinomial logistic regression analyses of parents' PAPM stage can be found in Tables 4 and 5, respectively. Appendix B contains exploratory analyses of additional variables as well as all analyses conducted separately for parents of boys and girls. All earlier stages of PAPM were compared to the reference group (Stage 6-Vaccinated).

3.4.1. Bivariate multinomial logistic regression

Parents of daughters, older children, and parents with a HCP recommendation had decreased odds of being in any earlier PAPM stage as compared to the last PAPM stage (i.e. vaccinated). Higher HPV vaccine knowledge was significantly associated with decreased odds of being unaware, unengaged, undecided, or decided to vaccinate.

Parents who had decided not to vaccinate their child had significantly stronger vaccine conspiracy beliefs (OR = 3.10; 95% CI 2.78; 3.46), lack of confidence in vaccines (OR = 9.21; 95% CI 7.50; 11.31), and higher perception of vaccine risks (OR = 5.19; 95% CI 4.38; 6.16) compared to parents who vaccinated their child.

Parents living in provinces with HPV vaccination programs for boys had significantly lower odds of being unaware (OR = 0.34; 95% CI 0.24; 0.48), unengaged (OR = 0.49; 95% CI 0.34; 0.70), or undecided (OR = 0.50; 95% CI 0.37; 0.67). Further analysis by child's gender indicated that this effect was not significant in the model examining parents of girls; however, parents of boys living in provinces with HPV vaccine funding for boys had significantly lower odds of being in any earlier PAPM stage compared to vaccinated (Tables B4 and B7).

3.4.2. Multivariate multinomial logistic regression

Parents of daughters and older children had significantly decreased odds of reporting that their child was in any earlier PAPM stage compared to vaccinated. Parents answering the survey in French had lower odds of being unengaged (AOR = 0.67; 95% CI 0.47; 0.97), undecided (AOR = 0.61; 95% CI 0.44; 0.84) and decided to vaccinate (AOR = 0.51; 95% CI 0.38; 0.67).

Parents who received a HCP recommendation for HPV vaccination had lower odds of being unaware (AOR = 0.04; 95% CI 0.01; 0.16), unengaged (AOR = 0.21; 95% CI 0.10; 0.43), undecided (AOR = 0.55; 95% CI 0.36; 0.84), and decided not to vaccinate (AOR = 0.30; 95% CI 0.15; 0.61). There was no significant difference between the decided to vaccinate and vaccinated groups related to receiving a HCP recommendation. Higher HPV vaccine knowledge was significantly associated with decreased odds of being unaware (AOR = 0.75; 95% CI

Table 2
Parents' PAPM stage by child's gender.

PAPM stage	Parents of girls (n = 1953)	Parents of boys (n = 1826)	Test of proportions parents of girls versus parents of boys	All parents (N = 3779)
	n (%)	*n* (%)	95% CI	*N* (%)
Stage 1-Unaware	136 (7.0)	468 (25.6)	−20.96; −16.37	604 (16.0)
Stage 2-Unengaged	97 (5.0)	298 (16.3)	−13.30; −9.40	395 (10.5)
Stage 3-Undecided	291 (14.9)	389 (21.3)	−8.86; −3.94	680 (18.0)
Stage 4-Decided NOT	191 (9.8)	162 (8.9)	−0.95; 2.76	353 (9.3)
Stage 5-Decided YES	437 (22.4)	349 (19.1)	0.68; 5.85	786 (20.8)
Stage 6-Vaccinated	801 (41.0)	160 (8.8)	29.71; 34.79	961 (25.4)

Table 3
Comparison of parents' vaccine knowledge and attitudes by PAPM stage.

Scale	Total N = 3779	Stage 1-Unaware n = 604	Stage 2-Unengaged n = 395	Stage 3-Undecided n = 680	Stage 4-Decided NOT n = 353	Stage 5-Decided YES n = 786	Stage 6-Vaccinated n = 961	ANOVA F test-statistic	Effect size (ω)
	M (SD)	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*		
HPV vaccine knowledge									
HPV general knowledge	12.79 (6.07)	8.53 (6.51)[a]	11.34 (5.97)[b]	12.95 (5.77)[c]	14.88 (5.45)[d]	14.33 (5.39)[d]	13.93 (5.32)[d]	101.32	0.34
HPV vaccine knowledge	6.01 (2.92)	3.76 (3.07)[a]	4.85 (2.97)[b]	5.89 (2.75)[c]	6.88 (2.55)[d]	6.74 (2.48)[d]	7.06 (2.37)[d]	149.95	0.41
HPV-specific HBM attitudes									
Susceptibility	4.93 (1.38)	4.73 (1.16)[a]	4.61 (1.16)[a,b]	4.50 (1.08)[b]	3.00 (1.37)[c]	5.65 (1.09)[d]	5.64 (1.05)[d]	382.00	0.58
Severity	5.91 (1.08)	5.84 (1.08)[a]	5.82 (1.05)[a]	5.83 (1.06)[a]	5.18 (1.39)[b]	6.15 (0.94)[c]	6.13 (0.96)[c]	53.11	0.25
Benefits	4.90 (1.14)	4.87 (0.95)[a]	4.75 (0.93)[a,b]	4.58 (0.86)[b]	3.10 (1.06)[c]	5.57 (0.86)[d]	5.33 (0.91)[e]	421.15	0.60
Barriers-not affordable	3.61 (1.70)	4.70 (1.33)[a]	4.35 (1.37)[b]	4.16 (1.52)[b]	3.09 (1.56)[c]	3.78 (1.64)[d]	2.30 (1.31)[e]	275.65	0.52
Barriers-not accessible	2.85 (1.15)	3.57 (0.92)[a]	3.35 (0.98)[a,b]	3.18 (1.02)[b]	2.86 (1.16)[c]	2.65 (1.12)[c]	2.15 (0.99)[d]	188.42	0.45
Barriers-harms	3.54 (1.42)	3.74 (1.07)[a]	3.82 (1.10)[a]	4.18 (1.12)[b]	5.50 (1.21)[c]	2.85 (1.17)[d]	2.68 (1.12)[d]	433.92	0.60
Cues to action	4.62 (1.16)	4.14 (0.88)[a]	3.98 (0.88)[a]	4.06 (0.79)[a]	3.43 (1.02)[b]	5.11 (0.94)[c]	5.61 (0.85)[d]	554.38	0.65
Self-efficacy	6.00 (1.01)	5.63 (1.10)[a]	5.65 (1.09)[a]	5.67 (1.03)[a]	6.29 (1.00)[b]	6.27 (0.82)[b]	6.28 (0.83)[b]	79.45	0.31
General vaccine attitudes									
VCBS	3.23 (1.44)	3.46 (1.36)[a]	3.40 (1.38)[a]	3.56 (1.35)[a]	4.70 (1.35)[b]	2.66 (1.31)[c]	2.73 (1.21)[c]	160.04	0.42
VHS-lack of confidence	1.98 (0.72)	2.04 (0.66)[a]	2.07 (0.64)[a]	2.13 (0.65)[a]	2.84 (0.91)[b]	1.69 (0.57)[c]	1.74 (0.54)[c]	196.69	0.45
VHS-risks	3.07 (0.95)	3.15 (0.85)[a]	3.14 (0.86)[a]	3.38 (0.87)[b]	3.90 (0.83)[c]	2.75 (0.94)[d]	2.74 (0.85)[d]	132.25	0.38

Note. All skewness and kurtosis are < 2. VHS scales are measured 1–5; all other scales are measured 1–7. All one-way independent groups ANOVA were significant (all $p < .001$). Effect sizes (ω) are presented for each ANOVA analysis. Post hoc tests were conducted using Tukey HSD. For each scale, groups that were not significantly different ($p < .01$) from each other in post hoc tests are in the same group (notated using a superscript, e.g. [a]).

0.71; 0.79) and unengaged (AOR = 0.86; 95% CI 0.81; 0.91), and significantly associated with increased odds of having decided not to vaccinate (AOR = 1.12; 95% CI 1.04; 1.22).

A higher perception of susceptibility and severity were only significantly associated with decreased odds of being in the stage decided not to vaccinate (AOR = 0.68; 95% CI 0.55; 0.84 and AOR = 0.66; 95% CI 0.54; 0.80). Higher perception of the benefits of vaccination was significantly associated with increased odds of being unaware (AOR = 1.89; 95% CI 1.48; 2.41), unengaged (AOR = 1.62; 95% CI 1.26; 2.08), undecided (AOR = 1.40; 95% CI 1.12; 1.74) and decided to vaccinate (AOR = 2.10; 95% CI 1.72; 2.55), and significantly associated with decreased odds of being decided not to vaccinate (AOR = 0.60; 95% CI 0.45; 0.81).

Compared to those who vaccinated their child, parents in all other stages had significantly increased odds of reporting greater barriers (including affordability, accessibility, and perceived harms). However, perceived accessibility of parents who vaccinated their child did not differ significantly with parents who were undecided, decided not to vaccinate their child, or decided to vaccinate their child. Of note, parents who had a higher score on perceived harms had higher odds of being in Stage 4 (decided not to vaccinate) (AOR = 3.50; 95% CI 2.85; 4.28). Greater perceived influence of others (cues to action) was associated with lower odds of being in any of the earlier stages (compared to vaccinated) (AOR range of 0.20 to 0.51).

4. Discussion

This study examined six distinct stages of HPV vaccine decision-making using the PAPM framework in a national survey of Canadian parents of 9–16 year-old boys and girls. Only 41.0% of girls and 8.8% of boys were in the final PAPM stage (Stage 6-Vaccinated). This is a lower proportion of vaccinated children than reported by other Canadian studies (Shapiro et al., 2017a; Gilbert et al., 2016), which may be due to this study's design, which included data from jurisdictions without male HPV vaccination programs during data collection, relied on parental report of vaccination status, and evaluated a larger age range of children (including children before they were offered the HPV vaccine in funded school-based programs).

In a 2014 study using the PAPM to examine Canadian parents of boys, the majority of parents were unaware of HPV vaccination for their sons (Stage 1, 57.0%), while exceptionally few had decided to vaccinate their son (Stage 5, 5.0%) or had sons who had received the HPV vaccine (Stage 6, 1.1%) (Perez et al., 2017). Data from the present study indicates that two years later and with two additional Canadian

Table 4
Bivariate multinomial logistic regression analysis of parents' PAPM stage (N = 3779).

Variables	Stage 1-Unaware OR (95% CI) n = 604	Stage 2-Unengaged OR (95% CI) n = 395	Stage 3-Undecided OR (95% CI) n = 680	Stage 4-Decided NOT OR (95% CI) n = 353	Stage 5-Decided YES OR (95% CI) n = 786
Child's gender					
Male	*(reference)*	*(reference)*	*(reference)*	*(reference)*	*(reference)*
Female	0.06 (0.04; 0.07)	0.07 (0.05; 0.09)	0.15 (0.12; 0.19)	0.24 (0.18; 0.31)	0.25 (0.20; 0.31)
Child's age (one-year increase)	0.73 (0.69; 0.76)	0.80 (0.76; 0.84)	0.76 (0.73; 0.79)	0.81 (0.76; 0.85)	0.71 (0.68; 0.75)
Language parents answered the survey					
English	*(reference)*	*(reference)*	*(reference)*	*(reference)*	*(reference)*
French	1.26 (1.02; 1.57)	0.65 (0.49; 0.85)	0.56 (0.45; 0.71)	0.87 (0.67; 1.14)	0.48 (0.38; 0.60)
Parent's ethnicity					
Other	*(reference)*	*(reference)*	*(reference)*	*(reference)*	*(reference)*
White	0.64 (0.48; 0.86)	0.61 (0.44; 0.85)	0.75 (0.56; 0.99)	0.90 (0.62; 1.31)	0.71 (0.54; 0.94)
HCP recommendation					
No	*(reference)*	*(reference)*	*(reference)*	*(reference)*	*(reference)*
Yes	0.01 (0.01; 0.05)	0.09 (0.04; 0.17)	0.32 (0.24; 0.45)	0.43 (0.29; 0.62)	0.74 (0.58; 0.95)
HPV vaccine knowledge (one-unit increase)	0.66 (0.64; 0.69)	0.74 (0.71; 0.78)	0.84 (0.81; 0.87)	0.97 (0.92; 1.02)	0.95 (0.91; 0.98)
Susceptibility (one-unit increase)	0.47 (0.43; 0.52)	0.43 (0.39; 0.48)	0.40 (0.36; 0.44)	0.16 (0.14; 0.18)	1.01 (0.92; 1.10)
Severity (one-unit increase)	0.75 (0.68; 0.83)	0.74 (0.66; 0.82)	0.74 (0.67; 0.82)	0.48 (0.43; 0.54)	1.03 (0.93; 1.14)
Benefits (one-unit increase)	0.57 (0.50; 0.63)	0.49 (0.42; 0.56)	0.39 (0.35; 0.44)	0.08 (0.07; 0.1)	1.36 (1.22; 1.51)
Barriers-affordability (one-unit increase)	3.03 (2.78; 3.30)	2.59 (2.37; 2.83)	2.38 (2.20; 2.57)	1.49 (1.37; 1.63)	2.02 (1.88; 2.17)
Barriers-accessibility (one-unit increase)	3.74 (3.34; 4.20)	3.02 (2.67; 3.42)	2.60 (2.34; 2.88)	1.95 (1.73; 2.19)	1.60 (1.46; 1.76)
Barriers-harms (one-unit increase)	2.22 (2.02; 2.44)	2.36 (2.11; 2.63)	3.12 (2.82; 3.45)	8.85 (7.60; 10.31)	1.14 (1.05; 1.24)
Cues to action (one-unit increase)	0.15 (0.13; 0.17)	0.12 (0.10; 0.14)	0.13 (0.11; 0.15)	0.06 (0.05; 0.07)	0.55 (0.50; 0.62)
Self-efficacy (one-unit increase)	0.50 (0.45; 0.56)	0.51 (0.45; 0.57)	0.51 (0.46; 0.57)	1.02 (0.88; 1.19)	0.99 (0.88; 1.11)
Vaccine conspiracy beliefs (one-unit increase)	1.51 (1.40; 1.64)	1.47 (1.34; 1.60)	1.60 (1.48; 1.73)	3.10 (2.78; 3.46)	0.96 (0.89; 1.03)
Hesitancy-lack of confidence (one-unit increase)	2.34 (1.97; 2.79)	2.49 (2.05; 3.03)	2.86 (2.42; 3.38)	9.21 (7.50; 11.31)	0.86 (0.72; 1.02)
Hesitancy-risks (one-unit increase)	1.69 (1.50; 1.90)	1.65 (1.44; 1.89)	2.31 (2.05; 2.61)	5.19 (4.38; 6.16)	1.01 (0.91; 1.12)

Note. The reference category for PAPM stage is 'Stage 6-Vaccinated' (n = 961). OR = odds ratio. 95% CI = 95% confidence interval. HCP = health care provider.

jurisdictions with male HPV vaccine programs (Alberta and Nova Scotia), fewer parents were unaware (25.6%), and more parents had decided to vaccinate (19.1%) or already vaccinated (8.8%) their son (Table 2). By comparison, a survey of parents of boys conducted around the same time in the UK (when there was no funded program for boys) found that 46.8% were unaware (Sherman and Nailer, 2018). This emphasizes the importance of publicly funded vaccine programs and the associated educational campaigns in increasing awareness and uptake (Loke et al., 2017; Bird et al., 2017; Johnson et al., 2017).

Two further studies have used the PAPM to evaluate HPV vaccine decision-making (Tatar et al., 2017; Barnard, 2017). Though these studies were conducted in college students, both found males to be overwhelmingly unaware or unengaged (90% and 85.7%) (Tatar et al., 2017; Barnard, 2017), and Barnard also found females to be predominantly in these stages (62.9%) (Barnard, 2017).

The present study was unique in evaluating PAPM stages for both parents of girls and boys. The literature has primarily focused on parents of girls (Loke et al., 2017; Johnson et al., 2017; Barnard, 2017;

Table 5
Multivariate multinomial logistic regression analysis of parents' PAPM stage (N = 3779).

Variables	Stage 1-Unaware AOR (95% CI) n = 604	Stage 2-Unengaged AOR (95% CI) n = 395	Stage 3-Undecided AOR (95% CI) n = 680	Stage 4-Decided NOT AOR (95% CI) n = 353	Stage 5-Decided YES AOR (95% CI) n = 786
Child's gender					
Male	*(reference)*	*(reference)*	*(reference)*	*(reference)*	*(reference)*
Female	0.15 (0.11; 0.21)	0.15 (0.11; 0.22)	0.33 (0.24; 0.45)	0.36 (0.23; 0.57)	0.49 (0.37; 0.65)
Child's age (one-year increase)	0.63 (0.59; 0.67)	0.69 (0.65; 0.74)	0.68 (0.64; 0.73)	0.80 (0.74; 0.88)	0.64 (0.60; 0.67)
Language parents answered the survey					
English	*(reference)*	*(reference)*	*(reference)*	*(reference)*	*(reference)*
French	1.21 (0.87; 1.69)	0.67 (0.47; 0.97)	0.61 (0.44; 0.84)	0.91 (0.58; 1.43)	0.51 (0.38; 0.67)
Parent's ethnicity					
Other	*(reference)*	*(reference)*	*(reference)*	*(reference)*	*(reference)*
White	1.37 (0.91; 2.06)	1.28 (0.84; 1.96)	1.62 (1.10; 2.39)	1.16 (0.65; 2.05)	1.31 (0.93; 1.84)
HCP recommendation					
No	*(reference)*	*(reference)*	*(reference)*	*(reference)*	*(reference)*
Yes	0.04 (0.01; 0.16)	0.21 (0.10; 0.43)	0.55 (0.36; 0.84)	0.30 (0.15; 0.61)	0.89 (0.66; 1.20)
HPV vaccine knowledge (one-unit increase)	0.75 (0.71; 0.79)	0.86 (0.81; 0.91)	0.98 (0.93; 1.04)	1.12 (1.04; 1.22)	0.96 (0.91; 1.01)
Susceptibility (one-unit increase)	0.97 (0.81; 1.17)	0.98 (0.81; 1.18)	0.89 (0.75; 1.05)	0.68 (0.55; 0.84)	1.06 (0.91; 1.23)
Severity (one-unit increase)	1.06 (0.91; 1.25)	1.06 (0.90; 1.25)	1.08 (0.93; 1.25)	0.66 (0.54; 0.80)	1.02 (0.89; 1.16)
Benefits (one-unit increase)	1.89 (1.48; 2.41)	1.62 (1.26; 2.08)	1.40 (1.12; 1.74)	0.60 (0.45; 0.81)	2.10 (1.72; 2.55)
Barriers-affordability (one-unit increase)	1.99 (1.76; 2.24)	1.62 (1.43; 1.84)	1.70 (1.52; 1.90)	1.22 (1.03; 1.43)	1.68 (1.53; 1.84)
Barriers-accessibility (one-unit increase)	1.50 (1.27; 1.78)	1.26 (1.05; 1.50)	1.10 (0.94; 1.29)	1.07 (0.85; 1.34)	1.14 (0.99; 1.31)
Barriers-harms (one-unit increase)	1.53 (1.31; 1.78)	1.68 (1.43; 1.97)	2.19 (1.90; 2.52)	3.50 (2.85; 4.28)	1.15 (1.01; 1.30)
Cues to action (one-unit increase)	0.27 (0.22; 0.34)	0.20 (0.16; 0.25)	0.24 (0.19; 0.29)	0.21 (0.16; 0.28)	0.51 (0.43; 0.61)
Self-efficacy (one-unit increase)	1.10 (0.91; 1.33)	1.16 (0.96; 1.40)	1.11 (0.93; 1.32)	1.87 (1.49; 2.35)	1.24 (1.04; 1.48)

Note. The reference category for PAPM stage is 'Stage 6-Vaccinated' (n = 961). Cox-Snell R^2 = 0.72. Cragg Uhler R^2 = 0.74. McFadden R^2 = 0.37. (reference) = reference category. AOR = adjusted odds ratio. 95% CI = 95% confidence interval. HCP = health care provider.

Finney Rutten et al., 2017; Hanson et al., 2018; Lindley et al., 2016; Mohammed et al., 2017; Vanwormer et al., 2017; Wang et al., 2018), with none using the PAPM. We found a significant association between child's gender and PAPM stage of decision-making, with parents of boys more likely to be in earlier PAPM stages, a finding similar to results from other studies (Loke et al., 2017; Johnson et al., 2017; Finney Rutten et al., 2017; Hanson et al., 2018; Lindley et al., 2016).

Multinomial analyses highlighted important correlates across all PAPM stages as well as some correlates that are particularly important for specific stages. Overall, this study found that parents of daughters (compared to sons), of older children, and parents with a HCP recommendation had decreased odds of being in any earlier PAPM stage as compared to the last PAPM stage (i.e. vaccinated). The importance of a HCP recommendation in making the decision regarding HPV vaccination is a well-established finding (Holman et al., 2014; Radisic et al., 2017; Perez et al., 2017; Loke et al., 2017; Johnson et al., 2017; Lindley et al., 2016; Gilkey et al., 2012). This study contributes to the literature by highlighting that a HCP recommendation is a significant and important differential factor between parents who are 'hesitant' (unengaged, undecided, and decided not; Stages 2–4) and 'acceptors' (decided to vaccinate and vaccinated; Stages 5–6), but not a significant differential factors between acceptor groups (Stages 5 and 6). This suggests that while a HCP recommendation may increase the likelihood that a parent accepts HPV vaccination; a HCP recommendation alone may not be sufficient to move parents from deciding to vaccinate their child (Stage 5) to having vaccinated their child (Stage 6).

The relationship between knowledge and uptake has previously yielded mixed results (as high and low knowledge have been associated with vaccination) (Radisic et al., 2017; Nickel et al., 2017). Application of the PAPM model shows that low HPV vaccine knowledge is an important correlate of early stages of decision-making (as compared to vaccinated). Interestingly, in the multivariate analysis parents who had decided not to vaccinate their child had significantly higher HPV vaccine knowledge than parents who vaccinated their child. Accordingly, education interventions alone may not be sufficient for HPV vaccination.

In line with previous research, this study found perceived benefits, barriers-harms, and cues to action were key correlates of PAPM stage (Radisic et al., 2017). Previous research using a binary outcome has reported mixed findings regarding the relationship between HPV vaccination with perceived severity and susceptibility of HPV infection and associated disease (Radisic et al., 2017; Krawczyk et al., 2015). By using a nuanced framework of decision-making, this study highlights that when taking all other variables into account, susceptibility and severity were not significant correlates of earlier PAPM stages except for the 'decided not to vaccinate' stage (Stage 4). Future research should use these findings to investigate theoretically informed interventions to specifically target subsets of the population (by child's gender and decision-making stage), with particular attention towards addressing knowledge gaps, perceived barriers, and concerns of parents.

Interestingly, parents of boys (but not parents of girls) living in provinces with HPV vaccination programs for boys had significantly lower odds of being in early PAPM stages. This emphasizes the importance of publicly funded HPV vaccine programs for boys.

4.1. Study strengths and limitations

This study is unique in examining and comparing HPV vaccine decision-making in Canadian parents of boys and girls using two well-established theoretical frameworks (i.e. the HBM and the PAPM), which captures decision-making in a nuanced and precise way. This is the first study to use the PAPM to evaluate HPV vaccine decision-making in parents of girls and boys. Strengths of the study also include a large sample size, data cleaning techniques that eliminated careless responders, and a nationally representative sample (Shapiro et al., 2017d). This study's questionnaire benefited from the use of intelligent programming to personalize survey items, administration in either English or French, avoiding any missing data, the use of psychometrically validated scales, and the randomization of items within scales to reduce the possibility of an order effect (Shapiro et al., 2017d).

This study is not without limitations. The cross-sectional design makes it impossible to determine causality. Although we had a reasonable response rate (67.9%), there remains the potential that there were similarities between non-responders that could influence the representativeness of the sample. Furthermore, although the sample was generally representative of the Canadian population, the sample was slightly wealthier, more educated, and White (as compared to the 2016 Census) (Statistics Canada, 2017). This study was also not able to recruit many participants living in Canada's territories, due to constraints in Leger's panel. Future research is needed to replicate this study's conceptual framework and findings to specifically investigate HPV vaccination in disadvantaged populations, as well as in other countries and in cross-country comparisons.

It is also possible that the measurement of HCP recommendation in this study overlooked parents who were recommended the vaccine by a HCP but had not seen or discussed the HPV vaccine with a HCP (e.g. via a letter that was sent home). Moreover, the scope of variables assessed is limited, and there are other familial, sociological, environmental, and communication factors that were not included. Specifically, future research should consider the impact of having an older child who was eligible for, or received, the HPV vaccine. Future research should also further examine the impact of publicly funded HPV vaccination programs on parents' decision-making.

5. Conclusions

HPV vaccination remains low in Canada. Using a stage-based model of decision-making, this study found that only a quarter of parents were in the final PAPM stage. Parents of daughters, older children, and those with a HCP recommendation had decreased odds of being in any earlier PAPM stage. Individual health beliefs as well as cues to action were key correlates of PAPM stage overall; however, the combinations and importance of correlates varied by PAPM stage and child's gender. These findings indicate that it may be important for future interventions to target and tailor health messaging for different groups depending on their stage of decision-making.

Conflict of interest

GDZ reports grants from Merck and personal fees from Sanofi Pasteur, outside the submitted work. The remaining authors declare no conflict of interest.

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Appendix. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ypmed.2018.09.017.

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