Preventive Medicine 78 (2015) 65–71

Contents lists available at ScienceDirect

Preventive Medicine

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

HPV vaccine for teen boys: Dyadic analysis of parents' and sons' beliefs and willingness

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ARTICLE INFO

Available online 17 July 2015

Keywords:
Human papillomavirus (HPV) vaccine
Males
Parents
Decision making
Dyadic analysis

ABSTRACT

Objective. Parents and adolescents often decide together whether the child should receive human papillomavirus (HPV) vaccine. However, few studies have investigated the dyadic nature of beliefs that affect this process.

Method. Data came from the 2010 HPV Immunization in Sons (HIS) Study, a national sample of 412 parents and their adolescent sons. We conducted dyadic multivariate logistic regression to examine the relationships between parents' and sons' HPV vaccine beliefs and their willingness to have the son receive the vaccine.

Results. Less than half of parents and sons were willing to have the sons receive HPV vaccine (43% and 29%, respectively). Willing parents and sons anticipated greater regret if the son did not receive HPV vaccine but later contracted an HPV infection (parent odds ratio [OR] = 1.72, 95% confidence interval [CI] = 1.24–2.40; son OR = 1.51, 95% CI = 1.04–2.19) (both $p < .05$). Lower concerns about side effects, such as pain and fainting, were also associated with willingness.

Conclusion. Parents and sons were more willing to have the son receive HPV vaccine if they had higher anticipated regret about potential HPV infection and lower concerns about side effects. Communication campaigns may be able to target these beliefs to increase parents' and sons' willingness to seek HPV vaccination.

The three-dose quadrivalent human papillomavirus (HPV) vaccine targets strains of HPV that are associated with almost all cases of genital warts (Centers for Disease Control and Prevention (CDC), 2010) and a substantial portion of anogenital cancers (Gillison et al., 2008). The CDC began recommending routine HPV vaccination for adolescent girls in 2007 (Markowitz et al., 2007) and for adolescent boys in 2011 (Centers for Disease Control and Prevention (CDC), 2011). However, uptake remains low, with only 57% of girls and 35% of boys receiving at least one dose of the series as of 2013 (Elam-Evans et al., 2014).

Parents increasingly share decisions about adolescents' healthcare with their children as they get older, including the choice to receive HPV vaccine (Hughes et al., 2011; Fernandez et al., 2010; Morales-Campos et al., 2013; Rand et al., 2011; McRee et al., 2010; Gamble et al., 2010; Dorell et al., 2013). Generally, parents and adolescents have similar HPV vaccine beliefs (Gamble et al., 2010; Brewer and Fazekas, 2007; Vietri et al., 2011), including their risk appraisals, which predict their vaccination intentions and behaviors. However, some beliefs affect parents' and adolescents' motivations differently: The promise of preventing cancer encourages parents (Nan et al., 2014; Staras et al., 2014), while fear of needles or pain discourages adolescents (Hughes et al., 2011; Rand et al., 2011; Gamble et al., 2010; Bernard et al., 2011) from seeking vaccination.

In addition to their individual attitudes and beliefs, parents and sons often engage in interpersonal negotiation when forming decisions about HPV vaccination (e.g., navigating power balance) (Cicirelli, 2006; Beresford and Sloper, 2008). In parent–child relationships with relatively young children and a clear power imbalance in favor of parents, children may be forced to capitulate to parents' decisions. However, in relationships with older children or adolescents, where power may be more balanced, more negotiation may be necessary, and "the goal of maintaining the relationship appear[s] to become as important as making an effective decision" (Beresford and Sloper, 2008). Thus, decision making about HPV vaccination may vary for children of different ages (McRee et al., 2011).

Most previous studies on HPV vaccine beliefs have focused on either the parent or the adolescent, without considering how the two members' beliefs operate jointly within a dyad or how this process may vary by the adolescent's age. In addition, the bulk of HPV vaccine studies have examined vaccination behaviors among girls (given the CDC's earlier recommendation for routine vaccination among girls than boys). We aimed to fill these gaps by conducting dyadic analyses of the joint contributions of parents' and sons' HPV vaccine beliefs on their willingness to have the son vaccinated.

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http://dx.doi.org/10.1016/j.ypmed.2015.07.002
0091-7435/

We hypothesized that parents and sons who anticipated greater regret of the son contracting HPV without vaccination would express greater vaccination willingness (Hypothesis 1). Anticipated regret results from a comparison of one potential outcome (forgoing vaccination and later contracting HPV) to another (receiving HPV vaccine and never becoming infected); to the extent that parents and sons find the former outcome more aversive than the latter, they should be motivated to seek HPV vaccination (Brewer et al., 2011; Ziarnowski et al., 2009). We also hypothesized that parents' and sons' willingness would be uniquely motivated by protecting the son from long-term health effects of HPV infection and immediate side effects of vaccination, respectively (Hypothesis 2). When making proxy healthcare decisions, parents are compelled to act in the "best interest" of the child (Gilmour et al., 2011; Diekema, 2005), which should encourage them to evaluate the long-term benefits of vaccination (i.e., protection from disease). However, vaccination side effects are intrinsically more proximal to sons, and avoidance of discomfort is a powerful motivator of health behaviors (Ajzen and Timko, 1986), including vaccination (Hughes et al., 2011; Rand et al., 2011; Gamble et al., 2010; Bernard et al., 2011). Finally, we examined whether the relationship between beliefs and vaccination willingness varied by the age of adolescent sons, hypothesizing that parents' beliefs would be less closely related to HPV vaccination willingness among older sons than younger sons (Hypothesis 3). We examined these hypotheses in a national sample of adolescent boys and their parents.

Materials and methods

Participants

Data came from the parent and son surveys of the HPV Immunization in Sons (HIS) Study (Reiter et al., 2011; Reiter et al., 2013). Knowledge Networks (now called GfK) maintains a large, probability-based panel of research participants from U.S. households (Dennis, 2009). In exchange for completing multiple online surveys each month, panel members receive either a laptop computer with free internet access or points that they can redeem for small cash payments.

In 2010, Knowledge Networks invited panel members who were parents of boys ages 11 to 17 to participate in the HIS Study. Of 752 parents who received invitations to participate, 547 (73%) consented to and completed the parent survey. We excluded from analysis parent–son dyads in which the parents did not provide consent for their sons to participate ($n = 119$) or the sons did not provide assent ($n = 7$). Finally, we excluded 8 dyads in which the sons had already received at least one dose of HPV vaccine and 1 dyad in which the son did not provide a response for our dependent variable. This resulted in a final analytic sample of 412 parents matched with their 412 sons.

Procedures

Parents gave informed consent before they began the online survey. Parents with more than one son ages 11 through 17 years answered questions about the son with the most recent birthday. At the conclusion of the parents' survey, the identified son became eligible to complete a separate survey online. Parents provided informed consent for their sons, and sons gave assent before beginning the survey. The University of North Carolina Institutional Review Board approved the study procedures.

Measures

The complete surveys for the HIS Study are available online (http://www.unc.edu/~ntbrewer/hpv.htm). Survey items were based on those from our past HPV vaccine research (Brewer and Fazekas, 2007; Reiter et al., 2010; Reiter et al., 2009a; Keating et al., 2008). In the current study, we descriptively analyzed awareness of HPV and HPV vaccination, and we conducted inferential analysis of the dyadic influences of HPV vaccine beliefs on vaccination willingness.

Awareness

Survey items assessed whether participants were aware of HPV and of HPV vaccine (Table 1). For participants who were aware of HPV vaccine, an item also assessed whether they were aware that adolescent males could receive HPV vaccine. Next, the survey presented these statements to all participants: "HPV is a common sexually transmitted infection that sometimes leads to genital warts or cancer" and "The HPV vaccine is sometimes called the cervical cancer vaccine, Gardasil, or Cervarix. It was first available only for females but is now also available for guys. By guys, we mean boys and young men 9–26 years old."

Beliefs

Surveys assessed 7 beliefs among parents and sons regarding HPV and HPV vaccination (Table 1). These items assessed perceived importance of vaccination, perceived likelihood of HPV infection, anticipated regret, and expected pain. For Hypothesis 1, we measured anticipated regret with an item assessing regret about forgoing vaccination if the son did not receive HPV vaccine and later developed an HPV infection. For Hypothesis 2, we measured concerns about HPV-related diseases with an item assessing perceived importance of protecting the son from genital warts and some cancers, and we measured concerns about vaccination side effects with items assessing expected pain and anticipated regret of fainting from vaccination. For belief items, higher values reflected greater degrees of endorsement of that item.

HPV vaccination willingness

Items asked sons how willing they were to receive HPV vaccine and parents how willing they were to get HPV vaccine for the son if it were free (Table 1). We dichotomized the 5-point response scale: definitely or probably willing (coded as 1) or definitely or probably not willing or not sure (coded as 0). Previous studies of HPV vaccine attitudes among males have used similar dichotomous measures of willingness (Gilbert et al., 2011; Rank et al., 2012).

Demographics

Parent-specific variables were gender (male or female), age (<45 years or ≥45 years), and education level (less than college or at least some college). Child-specific variables were age (11–12 years, 13–15 years, or 16–17 years), race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, or other), health insurance coverage (yes or no), and uptake of tetanus, diphtheria, and pertussis booster and meningococcal conjugate (yes or no for each vaccination variable).

Data analysis

To compare parents' and sons' answers, we used paired *t*-tests (for continuous variables) or McNemar's tests (for dichotomous variables). We calculated Pearson product-moment *r* statistics to measure the non-independence between parents' and sons' responses. Pearson *r* statistics are preferable to intraclass correlations for measuring non-independence among dyads whose members' roles are distinguishable (Kenny, nd).

To examine whether vaccine beliefs were associated with parents' HPV vaccination willingness, we used logistic regression. First, we created "paired" models including two independent variables, one for each dyad member's response to a given HPV vaccine belief measure, therefore controlling for the other dyad member's responses on the same measure. Then, we constructed a multivariate logistic regression model for parents' HPV vaccination willingness, including statistically significant correlates ($p < .05$) from the paired models described above. We included both parents' and sons' belief responses in the multivariate model, even if only one member's response had a statistically significant relationship in the paired models, in order to preserve the dyadic nature of the analysis. Thus, multivariate models included both parents' and sons' responses to each HPV vaccine belief measure that demonstrated an association with vaccine willingness in the paired models. We repeated these analyses using sons' willingness as the outcome. Previous researchers have used multivariate regressions to analyze dyadic data in studies of health promotion (Padula, 1997), physical activity (Rutkowski and Connelly, 2012), and healthcare transitions (Sawicki, Keleman, & Weitzman, 2014) (Sawicki et al., 2014).

We used the multivariate models to evaluate Hypotheses 1 and 2. We also used these models to examine whether the combined contributions of parents' beliefs differed from sons' beliefs in explaining variation in each dependent variable using a Wald test of the joint associations. To evaluate Hypothesis 3, we added interaction terms to the multivariate model of sons' HPV vaccination willingness for the categorical measure of sons' age and each of the parents' HPV vaccine beliefs. Then, we conducted Wald tests of the joint associations of the interaction terms with sons' HPV vaccination willingness.

Paired and multivariate models controlled for parents' gender, age, and education, and sons' race, age, insurance status, and receipt of other vaccines. We did not include awareness in regression models because awareness could

Table 1
Questionnaire items in HPV Immunization in Sons (HIS) Study, 2010.

Construct	Parent survey item	Son survey item	Response options
Awareness			
Of HPV	Have you heard of HPV or human papillomavirus before today?	Have you heard of HPV before today?	1 = Yes 0 = No
Of HPV vaccine	Have you ever heard of the HPV vaccine before today?	Have you ever heard of the HPV vaccine before today?	1 = Yes 0 = No
That males can receive HPV vaccine[a]	Before today, had you heard that the HPV vaccine can be given to guys?	Before today, had you heard that the HPV vaccine can be given to guys?	1 = Yes 0 = No
Beliefs			
Perceived importance of son being protected	How important is it to you that [name] getting the HPV vaccine could protect him against genital warts and maybe some cancers?	How important is it to you that your getting the HPV vaccine could protect you against genital warts and maybe some cancers?	5 = Extremely important 4 = Very important 3 = Fairly important 2 = Slightly important 1 = Not at all important
Perceived importance of son's partner being protected	How important is it to you that [name] getting the HPV vaccine could protect his future girlfriend or wife against genital warts and maybe some cancers?	How important is it to you that your getting the HPV vaccine could protect your future girlfriend or wife against genital warts and maybe some cancers?	5 = Extremely important 4 = Very important 3 = Fairly important 2 = Slightly important 1 = Not at all important
Perceived importance of community being protected	How important is it to you that [name] getting the HPV vaccine could reduce genital warts and some cancers in the community?	How important is it to you that your getting the HPV vaccine could reduce genital warts and some cancers in the community?	5 = Extremely important 4 = Very important 3 = Fairly important 2 = Slightly important 1 = Not at all important
Perceived likelihood of HPV	Without the vaccine, what do you think is the chance that [name] will ever get a disease caused by HPV?	Without the vaccine, what do you think is the chance that you will ever get a disease caused by HPV?	1 = No chance 2 = Low chance 3 = Moderate chance 4 = High chance
Anticipated regret of HPV infection	Imagine that [name] never got the HPV vaccine. He later got an HPV infection that could lead to health problems. How much would you regret that he did NOT get the HPV vaccine?	Imagine that you never got the HPV vaccine. You later got an HPV infection that could lead to health problems. How much would you regret that you did NOT get the HPV vaccine?	1 = Not at all 2 = A little 3 = A moderate amount 4 = A lot
Anticipated regret of fainting from vaccination	Imagine that [name] got the HPV vaccine and it made him faint (pass out). How much would you regret that he GOT the HPV vaccine?	Imagine that you got the HPV vaccine and it made you faint (pass out). How much would you regret that you GOT the HPV vaccine?	1 = Not at all 2 = A little 3 = A moderate amount 4 = A lot
Expected pain from HPV vaccination	If [name] got the HPV vaccine, how much pain would you expect him to have?	If you got the HPV vaccine, how much pain would you expect to have?	1 = No pain 2 = Mild pain 3 = Moderate pain 4 = Severe pain
HPV vaccination willingness			
Willingness	How willing would you be to get the HPV vaccine for [name] if it was free?	How willing would you be to get the HPV vaccine?	5 = Definitely willing 4 = Probably willing 3 = Not sure 2 = Probably not willing 1 = Definitely not willing

[a] Item only appeared for participants who were aware of HPV vaccine.

as easily be an outcome as a predictor of vaccination willingness. We evaluated multicollinearity in the multivariate models by estimating the tolerance values for each independent variable. Per guidelines for multiple regression analysis, we did not find that tolerance for any independent variable was below .20 (Menard, 2002), indicating that multicollinearity was not problematic for these models. We analyzed data with SAS version 9.4 (Cary, NC) using two-tailed statistical tests with a critical alpha of .05.

Results

Parents in the analytic sample were nearly evenly split between female (53%) and male (47%) (Table 2). About half of parents had at least some college education (55%). Sons were evenly distributed across age categories. Most sons were non-Hispanic white (62%) and had health insurance (92%).

Awareness and beliefs

More parents than sons were aware of HPV (79% vs. 25%, respectively) and HPV vaccine (78% vs. 26%, respectively) (both $p < .001$) (Table 3). Among dyads in which both members were aware of HPV vaccine, parents and sons had equal, low levels of awareness that boys could receive the vaccine (44% vs. 38%, respectively).

More parents (43%) than sons (29%) indicated that they were willing to have the son receive HPV vaccine ($p < .001$). Compared to sons, parents reported greater importance of protecting the son and the community from HPV-related illness and higher likelihood of the son contracting HPV without vaccination (all $p < .01$), but they expected less pain from vaccination ($p < .001$). Responses on the other belief items were similar (all $p > .05$). Responses within the dyads were moderately correlated, ranging from $r = .12$ to .52 (all $p < .05$) (Table 3).

Parents' HPV vaccination willingness

In paired models, parents' or sons' responses to each of the HPV vaccine beliefs were associated with parents' HPV vaccination willingness (Table 4). Results from the multivariate model of parents' willingness supported Hypothesis 1. Parents were more willing to vaccinate if they had higher anticipated regret of not vaccinating and the son later contracting HPV (odds ratio [OR] = 1.72, 95% confidence interval [CI] = 1.24, 2.40). However, the results did not support Hypothesis 2. Parents' willingness was not associated with their beliefs about the importance of vaccination for protecting the son.

Table 2
Demographic characteristics of participants; HPV Immunization in Sons (HIS) Study, 2010.

	n	%
Parent characteristics		
Gender		
Female	220	53.4
Male	192	46.6
Age		
<45 years	248	60.2
45 or older	164	39.8
Education		
Less than college	186	45.2
Some college or more	226	54.9
Son characteristics		
Age		
11–12 years	125	30.3
13–15 years	156	37.9
16–17 years	131	31.8
Race/ethnicity		
Non-Hispanic white	254	61.7
Non-Hispanic black	50	12.1
Hispanic	64	15.5
Other	44	10.7
Health insurance coverage		
Yes	377	91.5
No	35	8.5
Received tetanus, diphtheria, and pertussis booster vaccine		
Yes	334	81.1
No	78	18.9
Received meningococcal conjugate vaccine		
Yes	134	32.5
No	278	67.5

In addition, parents were more likely to be willing to have the son receive HPV vaccine if they reported higher levels of perceived importance of vaccination for protecting the son's future partner and if their sons had higher levels of perceived likelihood of contracting HPV (Table 4). Parents were less likely to be willing to vaccinate if they had higher anticipated regret of the son fainting after vaccination. Parents' own beliefs explained more variation in their willingness to vaccinate than sons' beliefs (Wald chi-square = 14.67, $p < .001$).

Sons' HPV vaccination willingness

In paired models, parents' or sons' responses to each of the HPV vaccine beliefs were associated with sons' HPV vaccination willingness (Table 4). Results from the multivariate model of sons' willingness supported Hypothesis 1. Sons were more willing to vaccinate if they had higher anticipated regret of not getting HPV vaccine and later contracting HPV (OR = 1.51, 95% CI = 1.04, 2.19). The results partially supported Hypothesis 2. Sons were less willing to get the vaccine if they had greater concerns about vaccination side effects in terms of pain (OR = 0.55, 95% CI = 0.37, 0.82) but not fainting (OR = 0.77, 95% CI = 0.50, 1.04). The relationship between parents' beliefs and sons' vaccination willingness did not vary by sons' age (joint interaction $p = .55$), which did not provide support for Hypothesis 3.

Sons were also more likely to be willing to receive HPV vaccine if they reported higher levels of perceived importance of vaccination for protecting their future partner and perceived likelihood of contracting HPV (Table 4). They were less likely to be willing to vaccinate if their parents had higher levels of anticipated regret of fainting from vaccination. Sons' and parents' beliefs did not differ in how much they explained the variation in sons' willingness (Wald chi-square = 0.62, $p = .43$).

Conclusion

Addressing low HPV vaccination coverage among adolescent males is a priority for the United States (President's Cancer Panel, 2014). In a national, probability-based study, less than half of parents and their adolescent sons were willing to vaccinate. Our findings suggest that HPV vaccination is the result of dyadic interactions between parents' and sons' beliefs. Increasing vaccination willingness through interventions targeting dyadic HPV vaccine beliefs could result in increased levels of uptake among adolescent boys.

In line with Hypothesis 1, both parents' and sons' vaccination willingness was associated with greater anticipated regret of the son contracting HPV if he did not get the vaccine. This finding builds on a large literature showing that anticipated regret is a powerful motivator of vaccination (Brewer et al., 2011; Ziarnowski et al., 2009; Hofman et al., 2014). A recent meta-analysis demonstrated that anticipated regret can be particularly effective in motivating health behaviors when highlighting the proximal and severe consequences of inaction (Brewer, nd). Although consequences of HPV infection (e.g., cancer) may not be proximal, they can be quite severe. In addition to anticipated regret, both parents' and sons' willingness was associated with greater perceived importance of protecting the son's future partner from HPV-related illness. Given that this construct was correlated with willingness for both dyad members, campaigns that address anticipated regret and the importance of protecting a son's future partner may be particularly promising for promoting vaccination among adolescent boys.

Our results offered partial support for Hypothesis 2—that concerns about long-term health effects of HPV infection and vaccination side

Table 3
Distributions, differences, and non-independence of parents' and sons' beliefs about HPV and HPV vaccine; HPV Immunization in Sons (HIS) Survey, 2010.

	Mean or proportion		Difference in means	Non-independence of parent and son responses	
	Parents	Sons	*p*	*r*	*p*
Awareness					
Of HPV	79.4%	25.2%	<.001	.12	.02
Of HPV vaccine	77.7%	26.2%	<.001	.16	.01
That males can receive HPV vaccine[a]	43.8%	37.5%	.22	.37	<.001
Beliefs					
Perceived importance of son being protected [range *1–5*]	3.73	3.57	.01	.51	<.001
Perceived importance of son's partner being protected [range *1–5*]	3.67	3.66	.84	.52	<.001
Perceived importance of community being protected [range *1–5*]	3.57	3.34	<.001	.47	<.001
Perceived likelihood of HPV [range *1–4*]	2.17	2.02	<.001	.23	<.001
Anticipated regret of HPV infection [range *1–4*]	3.17	3.14	.47	.40	<.001
Anticipated regret of fainting from HPV vaccination [range *1–4*]	2.72	2.78	.29	.32	<.001
Expected pain from HPV vaccination [range *1–4*]	1.89	2.35	<.001	.33	<.001
HPV vaccination willingness					
Willingness [*willing* versus *not willing*]	43.4%	28.9%	<.001	.36	<.001

[a] Asked only of participants who were aware of HPV vaccine ($n = 320$ parents; $n = 108$ sons). Proportions reported here reflect awareness only among dyads in which both the parent and the son were aware of HPV vaccine ($k = 96$ dyads).

Table 4
Dyadic analysis of the correlates of willingness to have the son receive HPV vaccine; HPV Immunization in Sons (HIS) Study, 2010.

	Parents' vaccination willingness				Sons' vaccination willingness			
	Paired models		Multivariate model		Paired models		Multivariate model	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Perceived importance of son being protected								
Parent	2.44	(1.90, 3.12)*	1.16	(0.77, 1.75)	1.27	(0.99, 1.63)	0.91	(0.58, 1.45)
Son	1.01	(0.82, 1.24)	0.79	(0.55, 1.14)	2.37	(1.79, 3.14)*	1.17	(0.79, 1.72)
Perceived importance of son's partner being protected								
Parent	3.10	(2.34, 4.10)*	2.85	(1.73, 4.70)*	1.36	(1.06, 1.75)*	1.16	(0.71, 1.87)
Son	0.93	(0.74, 1.16)	0.90	(0.61, 1.32)	2.73	(2.00, 3.72)*	1.95	(1.23, 3.07)*
Perceived importance of community being protected								
Parent	2.18	(1.74, 2.74)*	0.93	(0.63, 1.38)	1.32	(1.04, 1.66)*	1.10	(0.74, 1.65)
Son	1.02	(0.84, 1.23)	0.99	(0.73, 1.36)	1.98	(1.56, 2.52)*	1.09	(0.76, 1.56)
Perceived likelihood of HPV infection								
Parent	1.95	(1.38, 2.76)*	1.33	(0.89, 2.00)	1.19	(0.83, 1.71)	1.01	(0.65, 1.57)
Son	1.51	(1.09, 2.08)*	1.65	(1.11, 2.47)*	2.15	(1.51, 3.05)*	1.86	(1.20, 2.89)*
Anticipated regret of HPV infection								
Parent	2.12	(1.62, 2.77)*	1.72	(1.24, 2.40)*	1.54	(1.15, 2.07)*	1.37	(0.94, 2.00)
Son	1.10	(0.87, 1.40)	0.94	(0.70, 1.28)	1.88	(1.40, 2.52)*	1.51	(1.04, 2.19)*
Anticipated regret of fainting from vaccination								
Parent	0.78	(0.64, 0.96)*	0.70	(0.54, 0.91)*	0.65	(0.52, 0.83)*	0.66	(0.50, 0.87)*
Son	0.72	(0.59, 0.88)*	0.84	(0.64, 1.09)	0.63	(0.50, 0.79)*	0.77	(0.57, 1.04)
Expected pain from vaccination								
Parent	1.09	(0.75, 1.60)	1.38	(0.85, 2.24)	1.37	(0.90, 2.10)	1.74	(1.04, 2.91)*
Son	0.71	(0.55, 0.92)*	0.84	(0.59, 1.19)	0.46	(0.34, 0.63)*	0.55	(0.37, 0.82)*

Note. All models controlled for sons' race, age, insurance status, and receipt of other vaccines, and parents' gender, age, and education. Each paired model adjusted for one pair of parent and son beliefs about a single topic. Each multivariate model adjusted for any beliefs that were statistically significant in the paired models for either parent or son. OR = odds ratio. CI = confidence interval.

* $p < .05$.

effects would uniquely motivate willingness for parents and sons, respectively. Parents' HPV vaccination willingness was not associated with their beliefs about the importance of protecting sons from diseases caused by HPV infection in multivariate analysis. It is possible that parents did not fully understand the connection between HPV and diseases that could affect their sons (e.g., genital warts, anal cancer) because early vaccine promotion efforts emphasized the relationship between the vaccine and cervical cancer (Rothman and Rothman, 2009; Jones and Cook, 2008; Liddon et al., 2010). Yet other constructs measuring closely related HPV vaccine beliefs (i.e., anticipated regret of HPV infection, importance of protecting the son's future partner, and perceived likelihood of HPV infection) were associated with willingness, providing some support for this hypothesis. However, as hypothesized, expectations about pain after vaccination were associated with sons' willingness, although we also found evidence for the negative association with parents' anticipated regret of fainting after vaccination. Parents and sons may overestimate the potential for vaccination side effects, which other studies have reported as minor and similar to side effects associated with other adolescent vaccines (Reiter et al., 2009b; U. S. Food Drug Administration (FDA), 2014). Assuaging these fears could result in increased levels of HPV vaccination.

Although we hypothesized that parents' beliefs may be less important for vaccination willingness among older sons than among younger sons, we found that the relationship between parents' beliefs and sons' vaccination willingness did not vary by sons' age. These findings indicate that parent–son dyads implement similar HPV vaccination decision making processes when sons are between the ages of 11 and 17. It is possible that differences in the influence of parents' beliefs could emerge for behavioral outcomes (i.e., uptake of HPV vaccine) that did not arise when survey participants reported their vaccination willingness. Future studies are needed to expand on the influence of child's age on parent–child decision making.

Finally, we compared the contributions of each dyad member's beliefs to parents' and sons' vaccination willingness. Parents' beliefs explained more variation in parents' willingness than sons' beliefs, but there was no difference in how much parents' versus sons' beliefs explained variation in sons' willingness. This finding implies that parents make decisions about HPV vaccination with minimal influence from their sons' beliefs, while sons' willingness reflects both their own and their parents' beliefs. As such, interventions that focus on changing parents' beliefs may ultimately increase vaccination willingness for both parents and sons. However, it is important to recognize the independent relationship between sons' willingness and their own vaccine beliefs, especially for older adolescents who may be more involved in the decision-making process.

A few recent studies have demonstrated that adolescents themselves have a role to play in parents' vaccination intentions (McRee et al., 2011; Roberts et al., 2010; Zimet et al., 2005) and their own vaccination behaviors (Alexander et al., BMC Pediatr., 2012; Berenson et al., 2014). An underlying assumption of studies of adolescent vaccination that only include parents is either that adolescents do not influence uptake or that parents and adolescents hold such similar attitudes and beliefs that including both dyad members is redundant. As we have demonstrated in the present study, parents and adolescent sons have similar but not identical HPV vaccine beliefs, which in turn can influence their own and each other's vaccination willingness. Although the paired models indicated that each of the HPV vaccine beliefs under study was associated with vaccination willingness, putting all of these paired beliefs into a multivariate model highlighted the unique influence of a small set of beliefs for both parents and sons: perceived importance of protecting a son's future sexual partner, perceived likelihood of HPV infection, anticipated regret of HPV infection if the son did not receive the vaccine, and anticipated regret of fainting after HPV vaccination.

Study strengths include use of dyadic analysis, which is a more valid evaluation of how parents and adolescents make HPV vaccination

decisions together than studies involving only one of these groups. In addition, our results were robust to several sociodemographic and healthcare controls. In terms of limitations, data collection took place in 2010, a year before the CDC issued their recommendation for routine administration for boys, so the context in which families make HPV vaccination decisions may be different now than at the time of the study. Our study was cross-sectional, limiting our ability to draw causal inferences about behavior change; future studies should use longitudinal data or stage models of behavior change to understand how HPV vaccination willingness develops. Finally, we measured the dependent variable differently for parents versus sons (asking the latter how willing they were to vaccinate, but asking the former how willing they were to vaccinate if it were free). For parents, a no cost vaccine is the best-case scenario, and increasing willingness in that situation is a first step to encouraging parents who may have to pay for the vaccine.

In conclusion, we found that parents' and their adolescent sons' willingness to have the sons receive HPV vaccine was associated with their anticipated regret if the son were to contract HPV and the importance they placed on protecting the son's future partner from HPV-related illness. Future interventions can target these beliefs in order to encourage parents and sons to vaccinate, ultimately leading to increased HPV vaccine coverage and reduced rates of HPV-related illness.

Conflict of interest

There has no conflict of interest.

Acknowledgments

JLM was supported by an individual predoctoral fellowship from the National Cancer Institute (F31 CA189411). A research grant to NTB and PLR from Merck Sharp & Dohme Corp. (50928) funded the study. Merck Sharp & Dohme Corp. played no role in the study design, planning, implementation, analysis, or reporting of the findings.

JLM presented portions of this research at the Society of Behavioral Medicine's 2015 Annual Meeting (recipient of the Meritorious Student Abstract Award, awarded by the Society of Behavioral Medicine, and the Outstanding Abstract Award, awarded by the Student Special Interest Group).

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