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Factors Associated with Intention of Human Papillomavirus (HPV) Vaccine Initiation Among Females With and Without a History of Childhood Cancer

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Abstract
Vaccination is available to prevent human papillomavirus (HPV) types that cause cervical and other cancers. This study aimed to describe and compare vaccine intention among young females with and without a cancer history, in addition to identifying factors associated with a HPV vaccination intention. Vaccine-naïve females (aged 18–26 years, $n = 120$) and maternal caregivers with vaccine-naïve daughters (aged 9–17 years, $n = 197$) completed surveys querying HPV vaccination intention, HPV knowledge, and communication, along with sociodemographic, medical, and health belief factors. Multivariable logistic regression was utilized to calculate odds ratio (OR) and 95% confidence intervals for HPV vaccination intention. No differences in vaccine intention were identified across cancer and comparison groups. Vaccine intention and predictors of intention among vaccine-naïve females differ by age, and there is variation in the factors which influence vaccine intention by age group. These results suggest interventions should be tailored based on developmental level.

Keywords Oncology · Adolescents · Young adults · Human papillomavirus · Vaccination · Intention

HPV is the most common sexually transmitted infection (Satterwhite et al., 2013) with approximately 85% of sexually active women being exposed in their lifetime (Chesson, Dunne, Hariri, & Markowitz, 2014). Because HPV has a causal role in the expression of cervical and other cancers (Lajer et al., 2012), efforts have been successful in producing safe and effective vaccinations against HPV(Kreimer et al., 2015). Rates of infection are highest among 20–24-year-old females (Horner et al., 2009) with rates rising significantly after sexual debut. Females surviving childhood cancer are at increased risk for HPV-related complications including the development of HPV-associated malignancies (Ojha et al., 2013, 2014), and these cancers are expressed earlier in adulthood compared to peers (Ojha et al., 2014). Due to these increased risks, the Children's Oncology Group (Ransome, Carty, Cogburn, & Williams, 2017) has recommended HPV vaccination for all eligible females surviving childhood cancer (Children's Oncology Group, 2013).

To assist in vaccine promotion among females who remain vaccine naïve, factors associated with the vaccination intention (a robust and modifiable factor predictive of HPV vaccine initiation) must be identified. For example, 53% of vaccine-naïve college-aged women report intention to initiate vaccination, with peer acceptance of the vaccine being the most significant predictor of vaccine intention (Allen et al., 2009). With regard to predictors of parental intention, positive attitudes regarding HPV vaccination are the most robust predictor of maternal intention to vaccinate 9–15-year-old daughters, followed by subjective norms (Askelson et al., 2010). Although studies have examined intention to vaccinate in the healthy population, no published studies have examined HPV vaccine intention among survivors of childhood cancer.

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Multiple factors influence HPV vaccine intention, which subsequently predicts HPV vaccine initiation. In order to optimally promote HPV vaccination among those who are vaccine naïve, it is important to assess vaccine intention, while identifying associated modifiable and other factors that may be responsive to intervention. With vaccine initiation rates being suboptimal in both the general population and among cancer survivors (Kester, Zimet, Fortenberry, Kahn, & Shew, 2013; Klosky et al., 2013), it is important to distinguish those vaccine-naïve individuals and families who plan to initiate vaccination from those without clear intention so that appropriate interventions can be delivered based on intention status. The current study serves as a description and comparison of HPV vaccination intention among a large cohort of vaccine-naïve survivors of childhood cancer and healthy comparison females ranging in age from preadolescent to young adult, which also includes the identification of factors which are most influential in distinguishing those with and without intention to vaccinate.

Method

Participants

Females aged 9–26 years (maternal caregivers, for those < 18 years) with a history of childhood cancer were recruited from the survivorship clinic at St. Jude Children's Research Hospital. The control sample without a history of cancer consisted of acquaintances of the survivor participants, and was supplemented by students in the subject pool at The University of Memphis.

As part of a larger protocol which included females regardless of HPV vaccine status, eligibility criteria for participants included: (1) either (a) the maternal caregiver ("mother") of a 9–17-year-old female or (b) a 18–26-year-old female, (2) proficient in reading and writing English, (3) cognitively able to understand and complete the study questionnaire, and (4) willing and able to provide informed consent per institutional review board (IRB) guidelines. Only the participants who reported they/their daughters were vaccine naïve were considered in this study. A total of 152 mothers of daughters aged 9–17 years with a history of childhood cancer (daughter $M_{age} = 12.70$ years, SD = 2.65), 45 mothers of daughters aged 9–17 years without a cancer history (daughter $M_{age} = 12.49$ years, SD = 2.26), 68 young adult females aged 18-26 with a history of childhood cancer ($M_{age} = 21.60$ years, SD= 2.68), and 52 young adult females aged 18–26 without a history of childhood cancer ($M_{age} = 20.49$ years, SD= 2.26) were enrolled in the study and returned completed questionnaires indicating noninitiation of the HPV vaccine (Fig. 1).

With the exception of race and age, participants with and without a history of cancer did not significantly differ on any of the measured sociodemographic variables (Table 1). Due to the differences of vaccine intent by age, participants were thus divided into three groups (a) preadolescents—aged 9–13 years ($n = 121$; $M_{age} = 10.90$ years, SD = 1.43), (b) adolescents—aged 14–17 ($n = 76$; $M_{age} = 15.40$ years, SD = 1.13), and (c) young adults—aged 18–26 years ($n = 120$; $M_{age} = 21.13$ years, SD = 2.56).

Procedure

Participants with a Cancer History

Over an 18-month interval, females with a history of childhood cancer or their mothers were recruited during regularly scheduled appointments in the survivorship clinic, a long-term follow-up clinic for childhood cancer survivors are those who are greater than 5 years post diagnosis and at least 2 years disease free. A trained member of the research team approached eligible participants, and obtained verbal informed consent consistent with methods outlined in this Institutional Review Board (IRB)-approved protocol. Participants completed pencil-and-paper questionnaires, then were asked to provide contact information for up to five acquaintances in order to obtain a control sample without a history of childhood cancer with the goal of securing a control group that was demographically similar to the cancer survivors.

Participants Without a Cancer History

During this same time period, a research team member contacted the acquaintances of participants via telephone. Those who verbally consented were given the opportunity to complete the questionnaire online or via a mailed paper survey. In order to supplement the acquaintance–control sample among the young adult females, students from the University of Memphis were recruited via the Department of Psychology's undergraduate subject pool system, which provides students opportunities to participate in various research studies. The study team members obtained verbal consent for study participation, which was followed by participants' completion of pencil-and-paper questionnaires. A history of childhood cancer was an exclusion criterion for all control participants.

Questionnaires were identical for all groups, aside from "your daughter" language for maternal caregiver questionnaires opposed to "your" for young adult questionnaires. After completing questionnaires, all participants were provided with an information sheet on HPV and HPV vaccination.

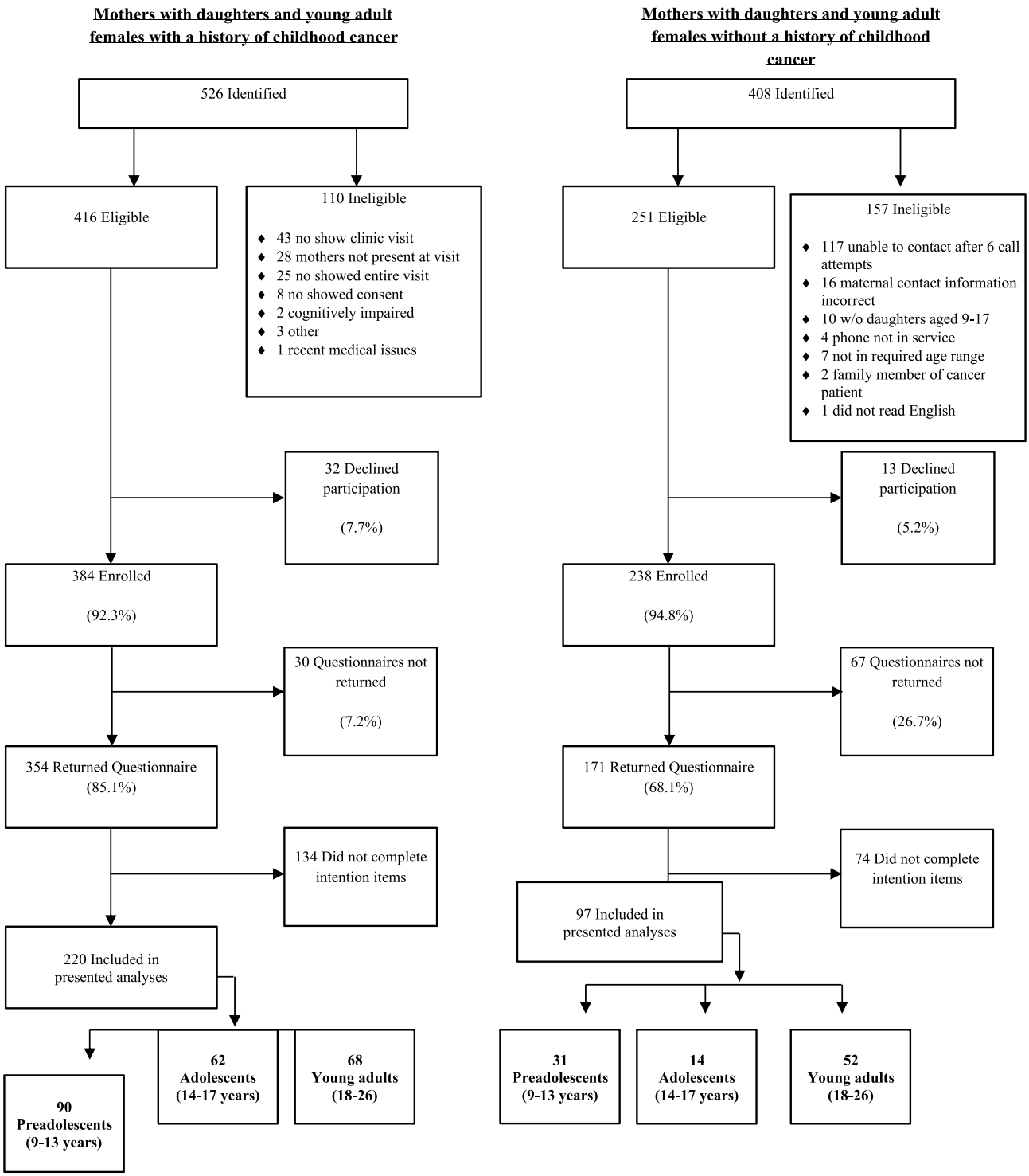

Fig. 1 Flowchart depicting recruitment and questionnaire completion for participants

Measures

Outcome Variable

HPV vaccine intention was measured with the following series of questions: "If you/your daughter has NOT already started the HPV vaccination series, please answer the following questions: How likely is it that you will/you will have your daughter…(a) start the HPV vaccine within the next month? (b) …next 6 months? (c) …next

Table 1 Demographic and treatment characteristics of study participants

	Cancer survivors $n=220$ Freq (%)	Controls $n=97$ Freq (%)	Combined $N=317$ Freq (%)
Respondent race/ethnicity			
White	173 (78.6)	57 (58.8)****	230 (72.6)
Non-White	47 (21.4)	40 (41.2)	87 (27.4)
Respondent education level			
Less than college degree	161 (73.2)	73 (75.3)	234 (73.8)
College degree or more	57 (25.9)	23 (23.7)	80 (25.2)
Respondent household income			
Less than $20,000	35 (15.9)	24 (24.7)	59 (18.6)
$20,000 to $59,999	75 (34.1)	32 (33.0)	107 (33.8)
$60,000 and above	97 (44.1)	33 (34.0)	130 (41.0)
Maternal marital status[a]			
Married	111 (73.0)	36 (80.0)	147 (74.6)
Divorced/separated/widowed	24 (15.8)	6 (13.3)	30 (15.2)
Other	15 (9.9)	3 (6.7)	18 (9.1)
Age of youth in years, *M* (SD) 9–13 years	90 (40.9)	31 (32.0)****	121 (38.2)
14–17 years	62 (28.2)	14 (14.4)	76 (24.0)
18–26 years	68 (30.9)	52 (53.6)	122 (38.5)
Patient's cancer diagnosis			
Leukemia/lymphoma	92 (41.8)	–	–
Brain/CNS tumor	45 (20.5)	–	–
Solid tumor	83 (37.7)	–	–

Percentages may not equal 100 due to missing data

**** < .001

[a]Maternal marital status is only available for the preadolescent and adolescent groups ($n=152$ cancer survivors, $n=45$ controls)

12 months? (d) vaccinated for HPV in the future?" Participants rated their intention on a 7-point Likert-scale from definitely will not (0) to definitely will (6). For analytic purposes, vaccine intention was defined as a binary outcome variable (0 = no intention, 1 = some intention), such that participants who gave a rating of 4–6 on item a (if not a, then rating of 4–6 on item b; if not b, then rating 4–6 on item c; if not c, then rating of 5–6 on item d) were considered having intention to vaccinate. Participants who answered these items and did not meet criteria for intention to vaccinate were categorized as having no intention to vaccinate.

Independent Variables

All participants completed questionnaires querying HPV knowledge and communication, along with sociodemographic, medical, and health belief factors.

Health Beliefs

The HPV Vaccine Health Beliefs Questionnaire (Cox, Cox, Sturm, & Zimet, 2010) was utilized to measure perceptions of vulnerability to HPV, severity of HPV, and barriers to, benefits of, and self-efficacy for initiating/completing the vaccine. Internal reliability for this validated instrument was acceptable for all subscales in our sample: Vulnerability ($\alpha = .93$), Severity ($\alpha = .82$), Barriers ($\alpha = .75$), Benefits ($\alpha = .78$), and Self-Efficacy ($\alpha = .88$). Additional scales measuring vaccine-related Cues to Action and Self-Efficacy were also included as part of the questionnaire with scales adapted from previously validated measures (Dempsey, Zimet, Davis, & Koutsky, 2006; Gerend, Lee, & Shepherd, 2007).

Medical and Sociodemographic Variables

Participants provided sociodemographic information (e.g., age, education, relationship status). Furthermore, medical factors, such as history of OB/GYN care, sexually transmitted infections, and Pap smears were also collected with these items being adapted from previous research instruments (Brabin, Roberts, Farzaneh, & Kitchener, 2006; Constantine & Jerman, 2007; Dempsey et al., 2006). Items measuring maternal perceptions of daughter's sexual activity and relationship status were assessed with six items adapted from previous self-report questionnaires (Rosenthal et al., 2008). Young adults completed similar self-report measures of sexual activity and relationship status. For analyses, items with a yes/no/not sure response format were collapsed into binary output of yes (1) and no/not sure (0).

HPV Knowledge

Knowledge of HPV, cervical cancer, and HPV vaccination were measured by correct responses to ten multiple choice items, which were summed for a total knowledge score, with higher scores representing greater knowledge. The questionnaire content was adapted from Brabin and colleagues (Brabin et al., 2006), as well as abstracted from the Centers for Disease Control and Prevention's HPV information website (Centers for Disease Control and Prevention, 2009).

Sexual Communication

For maternal participants, the 18-item Mother-Adolescent Sexual Communication Instrument assessed maternal–adolescent sexual behavior and development communication (Cox, Fasolino, & Tavakoli, 2008). For young adult participants, The Miller Sexual Communication Scale (Miller, Levin, Whitaker, & Xu, 1998) assessed sexual communication between young adults and their mothers. Internal reliability in our sample was high for maternal participants ($\alpha = .84$) and young adults ($\alpha = .91$), and convergent and discriminant validity have been previously established and described (Cox et al., 2008).

Statistical Analysis

After the proportion of vaccine intention was identified within groups, initial univariable analyses were performed to examine differences in HPV vaccine intention between participants with and without a history of cancer. No significant survivor/control differences in intention were identified, and therefore these groups were combined, though participant health status (with/without cancer history) was retained as a predictor variable in the final multivariable models regardless of significance at the univariable level.

Because vaccine intention significantly differed by age in the combined group, developmental age categories were developed (preadolescent 9–13, adolescent 14–17, and young adult 18–26 years of age). As such, univariable analyses were completed to examine vaccine intention differences, along with the associated sociodemographic, medical, and health belief factors, within these three age groups. All significant univariate findings ($p < .10$ for adolescent and young adults models; $p < .05$ for preadolescent group, due to the number of variables significant at $p < .10$) and participant health status were retained for each age group's final multivariate logistic regression model. Odds ratios (OR) and 95% confidence intervals (CI) were utilized to examine factors significantly associated the with vaccine intention within age groups. Differences for continuous variables were assessed using univariable one-way analysis of variance (ANOVAs) and for categorical variables were assessed using χ^2 and Fisher's Exact tests.

Results

Vaccine Intention

Overall, 49.5% (109/220) of cancer survivors and 57.8% (56/97) of healthy controls expressed intention to receive the HPV vaccine series in the future. Again, no significant differences emerged when comparing the proportion of those with/without vaccine intention across cancer survivors and healthy controls.

Univariable Analyses

As univariable analyses did not reveal significant differences between participants with and without a history of cancer in intention to vaccinate ($\chi^2 = 1.35$, $p = .25$), the two groups were subsequently combined. Univariable analyses found intention to vaccinate varied significantly by age group ($\chi^2 = 11.95$, $p < .01$). Specifically, 63.6% (77/121) of mothers with preadolescent daughters reported intention to get their daughter vaccinated, whereas 40.8% (31/76) of the adolescent mothers reported intention, and 47% (57/120) of the young adult females expressed intention to get vaccinated. Cancer/control differences by intention were observed in the adolescent group only, with mothers of adolescent survivors having significantly lower intention to vaccinate in the future relative to controls ($p < .05$). Univariable analyses identified significant risk factors associated with the intention to vaccinaion, and these specific predictors varied for each of the three developmental age groups (see Tables 2, 3).

Table 2 Univariable differences in vaccine intention by categorical predictors

	9–13 years ($n=121$)		14–17 years ($n=76$)		18–26 years ($n=120$)	
	No intention	Intention	No intention	Intention	No intention	Intention
	$n=44$	$n=77$	$n=45$	$n=31$	$n=57$	$n=63$
	Freq (%)	Freq (%)	Freq (%)	Freq (%)	Freq (%)	Freq (%)
Health status						
Cancer	31 (34.4)	59 (65.6)	40 (64.5)	22 (35.5)**	40 (58.8)	28 (41.2)
Healthy	13 (41.9)	18 (58.1)	5 (35.7)	9 (64.3)	23 (44.2)	29 (55.8)
Race/ethnicity						
White	35 (34.7)	66 (65.3)	35 (62.5)	21 (37.5)	49 (67.1)	24 (32.9)***
Non-White	9 (45.0)	11 (55.0)	10 (50.0)	10 (50.0)	14 (29.8)	33 (70.2)
Household income						
Less than $20,000	2 (14.3)	12 (85.7)***	2 (22.2)	7 (77.8)*	20 (55.6)	16 (44.4)
$20,000–$59,999	22 (56.4)	17 (43.6)	18 (64.3)	10 (35.7)	18 (45.0)	22 (55.0)
$60,000 and above	18 (28.6)	45 (71.4)	24 (63.2)	14 (36.8)	15 (51.7)	14 (23.7)
Daughter allowed to date						
No	41 (37.6)	68 (62.4)	27 (67.5)	13 (32.5)**	–	–
Yes	1 (16.7)	5 (83.3)	13 (41.9)	18 (58.1)	–	–
Past committed relationship						
No	41 (36.9)	70 (63.1)	35 (60.3)	23 (39.7)	14 (43.8)	18 (56.3)*
Yes	2 (33.3)	4 (66.7)	6 (54.5)	5 (45.5)	47 (61.0)	30 (39.0)
Expect future sexual activity						
No	33 (46.5)	38 (53.5)***	33 (70.2)	14 (29.8)**	–	–
Yes/not sure	10 (20.8)	38 (79.2)	9 (39.1)	14 (60.9)	–	–
Doctor recommended HPV vaccine						
No	35 (41.7)	49 (58.3)*	27 (69.2)	12 (30.8)*	51 (66.2)	26 (33.8)***
Yes	8 (24.2)	25 (75.8)	14 (46.7)	16 (53.3)	10 (26.3)	28 (73.7)
Patient visited ObGyn						
No	40 (36.0)	71 (64.0)	37 (63.8)	21 (36.2)*	16 (44.4)	20 (55.5)
Yes	3 (37.5)	5 (62.5)	6 (37.5)	10 (62.5)	46 (56.8)	35 (43.2)

Percentages may not equal 100 due to missing data

***$p<.01$; **$p<.05$; *$p<.10$

Multivariable Analyses

The final models are described separately for each age group below and presented in Table 4.

Preadolescent Intention Model

The multivariable model for HPV vaccine intention among mothers of preadolescent girls included annual household income, health status, expectation of daughter's engagement in sexual activity prior to high school graduation, physician recommendation of HPV vaccination, HPV knowledge, medical and social environmental influences, the timing of sexual communication with daughter, and health beliefs regarding of severity of HPV, barriers to vaccination, and benefits to vaccination. The final multivariable logistic regression model revealed that maternal expectation of daughter's sexual activity prior to high school graduation (OR 14.39; 95% CI [1.97–105.35], $p=.009$), higher perceptions of vaccine-related health benefits (OR 3.14; 95% CI [1.82–5.44], $p<.001$), and greater social influence (OR 1.37; 95% CI [1.08–1.75], $p=.010$) were associated with the increased intention to vaccinate, whereas higher perceived barriers to vaccination were associated with a decreased likelihood of vaccine intention (OR 0.79; 95% CI [0.64–0.98], $p=.031$). Relative to a low (< $20,000) annual income, middle ($20,000 to $59,999) and high (≥ $60,000) annual income were associated with a decreased likelihood of having vaccination intention (OR 0.004; 95% CI [0.00–0.18], $p=.014$, and OR 0.02; 95% CI [0.00–0.66], $p=.022$, respectively).

Table 3 Univariable differences in vaccine intention by continuous predictors

	9–13 years ($n=121$)		14–17 years ($n=76$)		18–26 years ($n=120$)	
	No Intention	Intention	No Intention	Intention	No Intention	Intention
	$n=44$	$n=77$	$n=45$	$n=31$	$n=57$	$n=63$
	M (SD)	*M* (SD)	*M* (SD)	*M* (SD)	*M* (SD)	*M* (SD)
HPV knowledge	6.1 (1.7)	6.8 (1.7)*	6.2 (1.7)	6.4 (1.7)	6.2 (1.9)	5.6 (1.8)*
Health beliefs						
Susceptibility to HPV	11.8 (4.4)	12.4 (5.0)	11.1 (4.1)	12.0 (3.8)	10.7 (4.9)	11.3 (4.3)
Severity of HPV	31.5 (4.7)	33.2 (4.5)*	31.7 (5.6)	32.8 (4.7)	32.0 (5.1)	31.5 (4.5)
Barriers to vaccination	28.9 (4.5)	24.0 (5.5)***	28.7 (4.6)	25.4 (6.4)*	27.4 (6.1)	26.9 (6.2)
Benefits to vaccination	19.2 (3.1)	24.6 (3.4)***	20.6 (4.1)	23.6 (3.5)***	21.8 (3.9)	24.0 (3.0)***
Vaccination self efficacy	24.9 (3.7)	26.3 (3.3)	23.1 (4.8)	25.3 (3.3)	23.2 (3.9)	25.2 (3.6)
Environmental influence						
Medical	21.3 (5.6)	24.6 (4.6)***	22.7 (4.0)	24.4 (4.1)*	24.2 (3.9)	26.5 (2.9)***
Social	18.5 (4.3)	21.5 (4.8)***	18.8 (5.2)	21.7 (4.9)**	31.3 (7.2)	34.2 (5.5)**
Miller sexual communication						
Content	–	–	–	–	30.1 (9.7)	33.6 (9.8)**
Process	–	–	–	–	32.8 (8.2)	34.7 (7.4)
Overall	–	–	–	–	63.0 (15.2)	68.3 (15.7)*
Mother-adolescent sexual communication instrument						
Content	29.2 (6.7)	28.6 (7.1)	31.0 (6.1)	31.9 (7.4)	–	–
Context	10.0 (1.5)	9.8 (2.3)	9.3 (1.9)	9.1 (2.6)	–	–
Timing	12.8 (2.9)	14.1 (3.7)*	14.3 (3.2)	13.7 (3.6)	–	–
Style	11.4 (2.2)	10.8 (2.5)	11.9 (1.8)	11.7 (2.3)	–	–
Overall	64.6 (9.0)	65.2 (9.3)	67.5 (8.6)	67.7 (12.0)	–	–

Percentages may not equal 100 due to missing data

***$p<.01$; **$p<.05$; *$p<.10$

Adolescent Intention Model

The multivariable model for HPV vaccine intention among mothers of adolescent daughters included health status, annual household income, daughter being allowed to date, expectation of daughter's sexual activity prior to high school graduation, daughter has visited gynecologist, physician recommendation of HPV vaccination, medical and social environmental influence, and health beliefs regarding barriers and benefits to HPV vaccination. In the final adolescent multivariate vaccine intention model, income was the only statistically significant factor associated with the vaccine intention. Consistent with preadolescents, middle ($20,000 to $59,999) and high (≥ $60,000) annual incomes were associated with a decreased likelihood of having the intention to vaccinate (OR 0.02; 95% CI [0.00–1.50], $p=.076$, and (OR 0.01; 95% CI [0.00–0.62], $p=.029$, respectively), relative to those reporting a low (< $20,000) annual income.

Young Adult Intention Model

The multivariable model for HPV vaccine intention among young adult females included race/ethnicity, health status, being currently without a partner but having been in a past committed relationship, physician recommendation of HPV vaccination, HPV knowledge, medical and social environmental influence, sexual communication with their mothers, and health beliefs regarding benefits to HPV vaccination. Vaccine-naïve young adult females of non-white race (OR 4.25; 95% CI [1.33–13.62], $p=.015$) and those reporting a physician's recommendation for the HPV vaccine (OR 8.08; 95% CI [2.05–31.75], $p=.003$) were more likely to report vaccine intention, relative to those who were white or did not report a physician recommendation. However, females with the increased HPV-specific knowledge (OR 0.64; 95% CI [0.44–0.91], $p=.014$) were more likely to have intention to vaccinate in the future.

Table 4 Multivariate logistic regression for factors associating with HPV vaccination intention

Variable	OR	95% CI[a]	*p*
9–13 year olds			
Household income			
< $20k	1.00	–	–
$20–$60k	0.004	[0.00, 0.18]	.014
>$60k	0.02	[0.00, 0.66]	.022
Expect future sexual activity			
No	1.00	–	–
Yes/not sure	14.39	[1.97, 105.35]	.009
Health belief: barriers to vaccination	0.79	[0.64, 0.98]	.031
Health belief: benefits of vaccination	3.14	[1.82, 5.44]	<.001
Environmental influence: social	1.37	[1.08, 1.75]	.010
14–17 year olds			
Household income			
< $20k	1.00	–	–
$20–$60k	0.02	[0.00, 1.50]	.076
> $60k	0.01	[0.00, 0.62]	.029
18–26 year olds			
Race/ethnicity			
White	1.00	–	–
Non-White	4.25	[1.33, 13.62]	.015
Doctor recommended HPV vaccine			
No	1.00	–	–
Yes	8.08	[2.05, 31.75]	.003
HPV knowledge	0.64	[0.44, 0.91]	.014

Only significant variables are included

[a]CI = 95% confidence interval for odds ratio (OR)

Discussion

Specific to HPV, intention to vaccinate has been predictive of later vaccine initiation (Bowyer, Forster, Marlow, & Waller, 2013; Brewer et al., 2011; Rodriguez et al., 2018) and can be improved upon with intervention (Juraskova, Bari, O'Brien, & McCaffery, 2011). The present study assessed HPV vaccination intention among young adult females and mothers of young daughters across survivor and healthy control groups and found families who have survived childhood cancer intend to vaccinate for HPV at rates similar to those with no cancer history. Few sociodemographic differences were found across survivor and control groups, presumably as a function of our acquaintance–control design. Furthermore, social influence was identified as being significantly associated with the vaccine intention among mothers of preadolescents in the multivariable model (and on the univariate level for both the adolescent and young adult groups) and has been demonstrated to more globally affect both HPV vaccine intention and initiation. As social influence is so pervasive, our lack of observed intention differences across survivorship and comparison groups may have been influenced by the acquaintance–control study design. This approach was decided upon in order to control for sociodemographic variables across groups, but as both survivors and acquaintance controls came from the same social networks, the study design may have inadvertently contributed to the lack of differences observed across these groups. When developing future vaccine intention study designs, researchers should be particularly thoughtful in considering the benefits of controlling for sociodemographic variables in an acquaintance–control design versus alternative sampling approaches which may reduce shared social influences, and ultimately, HPV vaccine intention and initiation outcomes. Even though significant differences did not generally emerge in vaccine intention across vaccine-naïve cancer survivors and healthy controls, our findings suggest intention rates are suboptimal overall, and slightly lower, for survivors (particularly mothers of adolescent survivors) of childhood cancer. These low rates are particularly concerning due to the health vulnerabilities of cancer survivors, including their increased risk of developing HPV-associated health complications including second cancers (Ojha et al., 2013, 2014). Furthermore, no overall differences between families with and without a history of cancer in intention to vaccinate were identified, but when cancer/control groups were combined, age was significantly associated with the vaccine intention, thus providing a rationale for examining factors of intention distinctly by developmental groups (i.e., preadolescent, adolescent, and young adult). These results suggest interventions should be tailored to meet the specific needs of youth within these developmental groups.

Among preadolescents, caregiver perceptions of vaccine benefits and barriers (de Visser & McDonnell, 2008; Dempsey et al., 2006), expectations of daughter's sexual activity prior to high school graduation, and socioenvironmental influences (Allen et al., 2010) all associated with the increased vaccine intention. These results suggest that psychoeducational interventions which include information regarding normative sexual development in adolescents, along with the benefits and barriers of obtaining the vaccine HPV vaccination may have the most potential for increasing HPV vaccine intention, and ultimately initiation in this vaccine-targeted age group.

Mothers who expected their preadolescent or adolescent daughters to become sexually active prior to graduating to high school were also more likely to have vaccine intention. Inconsistent with the previous literature (Brewer & Fazekas, 2007; Constantine & Jerman, 2007), our findings suggest mothers are aware that HPV is a potential consequence of engaging in sexual activity. Also, interventions may be more effective for maternal caregivers of preadolescents, which incorporate and acknowledge the influence of their family

and friends. However, perceived barriers were associated with the decreased vaccine intention, which is consistent with the previous literature (Oldach & Katz, 2012). Clinicians should be encouraged to query family-specific barriers to HPV vaccination, as misperceptions or misinformation about the vaccine are common. It is crucial to keep in mind that barriers to obtaining the vaccine may vary by developmental level. For example, preadolescent females may be more focused on the perceived pain of the shot as a barrier as opposed to older adolescents and young adult females. These findings suggest that providers need to tailor their interventions specific to the barriers noted by the families for whom they provide care.

Among preadolescent and adolescent maternal caregivers, having a middle or high household income was associated with having a lower likelihood of having vaccine intention relative to those reporting a low household income. Programs that offer the vaccine for free or reduced cost for low-income families, such as the Vaccines for Children program (Centers for Disease Control and Prevention, 2014), along with the absence of copays for the vaccine through the Affordable Care Act (U.S. Department of Health and Human Services, 2010) remove financial barriers from low-income families and may explain these relatively higher rates of intention among this lower income group. Although this finding may be characteristic of families who have volitionally refused vaccination, future studies should explore other possible barriers endorsed by these families since finances are less likely to be a barrier.

Finally, being non-white or reporting physician recommendation for vaccination associated with the increased vaccine intention among 18–26 year olds. However, HPV knowledge was associated with the decreased vaccine intention. These results suggest that among young adult women, physician recommendation is extremely important, which has been substantiated by previous research in a variety of populations (Klosky et al., 2017; Nan, Dahlstrom, Richards, & Rangarajan, 2015; Zimet, Mays, & Fortenberry, 2000). Physician recommendation has uniformly been the most robust predictor associated with vaccine initiation (Etter, Zimet, & Rickert, 2012; Olshen, Woods, Austin, Luskin, & Bauchner, 2005; Rosenthal et al., 2011), and these results extend these findings to vaccine intention. Physicians and other providers should be aware of their influence and be encouraged to strongly recommend vaccination to their young adult patients.

Less clear is the finding among young adults that being non-white is associated with the increased vaccine intention. One possibility may be that the non-white young adults not only have a higher risk for STIs than white young adults, but may also be aware of this risk and are proactive in taking means to protect themselves from HPV (Pflieger, Cook, Niccolai, & Connell, 2013). Furthermore, physicians may be more likely to recommend the vaccine to those who are non-white because they are aware of the increased STI risk of their non-white patients. This finding may be compounded by non-white participants in this sample being more likely to have less education ($p = .002$) than the white participants in the sample. Furthermore, those who have not been vaccinated and have more knowledge about the vaccine may be inherently more skeptical about initiating the vaccine. Physicians should have an open dialog with these young adult patients in order to dispel any myths and answer any questions associated with the vaccine, though the effectiveness of these interventions may be variable (Nan et al., 2015).

When interpreting our findings, the study's limitations should also be considered. As in all cross-sectional study designs, only associations, not causalities, can be determined. This sample was exclusively comprised of females, and as such, these results may not generalize to males. The cancer sample was also comprised of long-term survivors only. Furthermore, maternal caregivers for those 9–17 are the only reporters of intention, and future studies could benefit from including both maternal and paternal perspectives. An additional study limitation was all cancer participants were recruited from a single site, though they did not necessarily reside locally.

Future studies should strive for larger sample sizes with more equivalent numbers of participants in survivorship and control samples, while testing the utility of providing parents and young adults with accurate HPV information, as this knowledge may influence intention for vaccinating against HPV in the future (Wegwarth, Kurzenhäuser-Carstens, & Gigerenzer, 2014). Adjusting for time since vaccine licensure, it is also necessary to test the efficacy of a knowledge intervention. Future interventions aimed at increasing HPV vaccination rates among childhood cancer survivors may seek to provide the HPV vaccine series at pediatric oncology centers for patients who are able to return to clinic for the extended vaccination series. Medical providers at such institutions should also coordinate care with medical providers at local health care facilities for patient families and young adults who are unable to return for the series of injections.

In conclusion, findings of the current study further our understanding regarding the rate of HPV vaccination intention among vaccine-naïve females, in addition to the factors associated with the HPV vaccine intention among child, adolescent, and young adults both with and without a history of childhood cancer. Future interventions designed to increase HPV vaccination among females may draw upon these findings when targeting intention. When creating these interventions, consideration of the developmental context must also be taken to account, as factors influencing HPV vaccine intention differ by age.

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Compliance with Ethical Standards

Conflict of interest Authors Robin N. Hardin, Kathryn M. Russell, Jessica S. Flynn, Heather L. Gammel, Jasmine R. Eddinger, Lauren A.-M. Schenck, and James L. Klosky declare that they have no conflicts of interest.

Human and Animal Rights All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments, or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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