Human Papillomavirus Vaccination Rates in Young Cancer Survivors

James L. Klosky, Melissa M. Hudson, Yanjun Chen, James A. Connelly, Karen Wasilewski-Masker, Can-Lan Sun, Liton Francisco, Laura Gustafson, Kathryn M. Russell, Gina Sabbatini, Jessica S. Flynn, Jocelyn M. York, Anna R. Giuliano, Leslie L. Robison, F. Lennie Wong, Smita Bhatia, and Wendy Landier

Author affiliations and support information (if applicable) appear at the end of this article.

Published at jco.org on August 24, 2017.

Clinical trial information: NCT01492582.

Corresponding author: Wendy Landier, PhD, CRNP, Institute for Cancer Outcomes and Survivorship, Department of Pediatrics, School of Medicine, University of Alabama at Birmingham, 1600 7th Ave S, Lowder 500, Birmingham, AL 35233; e-mail: wlandier@peds.uab.edu.

© 2017 by American Society of Clinical Oncology

0732-183X/17/3531w-3582w/\$20.00

ABSTRACT

Purpose

Cancer survivors are at high risk for human papillomavirus (HPV)-related morbidities; we estimated the prevalence of HPV vaccine initiation in cancer survivors versus the US population and examined predictors of noninitiation.

Methods

Participants included 982 cancer survivors (9 to 26 years of age; 1 to 5 years postcompletion of therapy); we assessed HPV vaccine initiation, sociodemographic and clinical characteristics, and vaccine-specific health beliefs; age-, sex-, and year-matched US population comparisons were from the National Immunization Survey-Teen and the National Health Interview Survey (2012-2015).

Results

The mean age at the time of the study was 16.3 ± 4.7 years; the mean time off therapy was 2.7 ± 1.2 years; participants were 55% male and 66% non-Hispanic white; 59% had leukemia/lymphoma. Vaccine initiation rates were significantly lower in cancer survivors versus the general population (23.8%; 95% CI, 20.6% to 27.0% v 40.5%; 95% CI, 40.2% to 40.7%; $P < .001$); survivors were more likely to be HPV vaccine-naïve than general population peers (odds ratio [OR], 1.72; 95% CI, 1.41 to 2.09; $P < .001$). Initiation in adolescent survivors (ages 13 to 17 years) was 22.0% (95% CI, 17.3% to 26.7%), significantly lower than population peers (42.5%; 95% CI, 42.2% to 42.8%; $P < .001$). Initiation in young adult survivors and peers (ages 18 to 26 years) was comparably low (25.3%; 95% CI, 20.9% to 29.7% v 24.2%; 95% CI, 23.6% to 24.9%). Predictors of noninitiation included lack of provider recommendation (OR, 10.8; 95% CI, 6.5 to 18.0; $P < .001$), survivors' perceived lack of insurance coverage for HPV vaccine (OR, 6.6; 95% CI, 3.9 to 11.0; $P < .001$), male sex (OR, 2.9; 95% CI, 1.7 to 4.8; $P < .001$), endorsement of vaccine-related barriers (OR, 2.7; 95% CI, 1.6 to 4.6; $P < .001$), and younger age (9 to 12 years; OR, 3.7; 95% CI, 1.8-7.6; $P < .001$; comparison, 13 to 17 years).

Conclusion

HPV vaccine initiation rates in cancer survivors are low. Lack of provider recommendation and barriers to vaccine receipt should be targeted in vaccine promotion efforts.

J Clin Oncol 35:3582-3590. © 2017 by American Society of Clinical Oncology

INTRODUCTION

Modern advances in treatment of pediatric cancer have resulted in a rapidly growing population of survivors.¹ A substantial number of these survivors are adolescents and young adults (AYAs)—a group at highest risk for sexually transmitted infection (STI).^{2,3} Human papillomavirus (HPV) is the most common STI in the United States³; HPV prevalence among sexually active AYAs ranges from 44.8% in females⁴ to 51.2% in males,⁵ with an estimated 6.9 million AYAs becoming newly infected annually.³

Persistent infection with oncogenic HPV (eg, types 16, 18, 31, 33, 45, 52, and 58) is strongly associated with development of HPV-related neoplasms affecting the anogenital tract and oropharyngeal mucosa.⁶⁻¹¹ Treatment of an unrelated cancer may result in prolonged immunosuppression,¹²⁻¹⁴ which in conjunction with genotoxic therapy, increases the risk of HPV acquisition, HPV persistence, and invasive HPV-related malignancies,^{6,15-17} placing cancer survivors at significantly higher risk for HPV-related morbidity than the general population.¹⁸⁻²⁴

Routine vaccination against HPV has been recommended by the Centers for Disease Control

ASSOCIATED CONTENT

Appendix
DOI: <https://doi.org/10.1200/JCO.2017.74.1843>

DOI: <https://doi.org/10.1200/JCO.2017.74.1843>

and Prevention's Advisory Committee on Immunization Practices (ACIP) since 2006 for girls²⁵ and since 2011 for boys.²⁶ ACIP recommends HPV vaccine initiation as early as 9 years of age.²⁷ Recommendations extend to 26 years of age for females and 21 years of age for males (but to age 26 for male special populations, including individuals with cancer).²⁸

Since the initial ACIP recommendations, HPV vaccine uptake in the United States has remained low.^{29,30} Factors associated with low uptake in the general population include lack of HPV-specific knowledge,^{31,32} health beliefs (ie, negative attitude toward vaccines, low perceived susceptibility to and severity of HPV-related disease, lack of perceived vaccine benefits, presence of perceived barriers to vaccination, low self-efficacy, and concern that vaccination encourages sexual activity),³³⁻³⁵ communication difficulties regarding sexual health,³⁶ vaccine safety concerns,³⁷ social and environmental influences,³³ and lack of health care provider recommendation for the vaccine.³⁴ There is a paucity of data regarding HPV vaccine uptake among young cancer survivors,³⁸ particularly among males and those recently completing cancer therapy.

This study addressed these gaps by estimating the prevalence of HPV vaccine initiation among young cancer survivors 1 to 5 years after completion of therapy. The study compared vaccine uptake in survivors with the general US population and identified factors associated with HPV vaccine noninitiation.

METHODS

Study Design

We conducted a cross-sectional survey (NCT01492582) to determine the prevalence of HPV vaccine initiation and predictors of noninitiation in a cohort of young cancer survivors ages 9 to 26 years, identified from five National Cancer Institute–designated Comprehensive Cancer Centers. HPV vaccine initiation rates among survivors were compared with age-, sex- and year-matched US population peers using data from the National Immunization Survey-Teen (NIS-Teen; ages 13 to 17 years),³⁹⁻⁴² and National Health Interview Survey (NHIS; ages 18 to 26 years).⁴³⁻⁴⁶

Participants

Eligible patients included cancer survivors who were in remission and had completed therapy 12 to 60 months before survey participation, ages 9 to 26 years, English- or Spanish-speaking, and scheduled for a clinic visit at a participating site (St. Jude Children's Research Hospital, City of Hope, University of Michigan, Emory University, or University of Alabama at Birmingham). To reduce participation bias, eligible patients were identified from clinic rosters and approached on arrival for routine appointments. Informed consent/assent was obtained in the patient or parent's preferred language according to site-specific institutional review board requirements.

Study Instruments

Survey. Eligible survivors (≥ 18 years old) or parents (of survivors 9 to 17 years old) completed the HPV Vaccination Survey that elicited sociodemographic information, current HPV vaccination status (including age at initiation and number of doses received, if any). The survey also elicited information pertaining to receipt of provider recommendation regarding HPV vaccination,⁴⁷⁻⁴⁹ knowledge regarding HPV infection and related health risks,³² HPV-related health beliefs (including perceived susceptibility to and severity of HPV-related illness; general vaccine attitudes and beliefs³⁴; and perceived barriers [eg, concerns about cost, logistics, safety, or vaccines in general] and benefits [eg, STI and cancer

prevention], cues to action, self-efficacy, and decision making related to HPV vaccination^{33,35,50-54}), health-related practices,⁵⁵ socio-environmental influences,^{33,54,56} HPV-specific communication,³⁶ and parent-child sexual communication.^{57,58} The survey was available in English and Spanish, in four versions (patient [male/female] and parent [of male/female patient]), and was completed via paper and pencil. Typical survey completion time was 15 to 30 minutes.

Medical record abstraction. Data abstracted from patients' medical records included birth date, cancer diagnosis, diagnosis date, treatment modalities (chemotherapy, radiation, hematopoietic cell transplant [HCT]), and treatment completion date.

Population Comparison Data

Data from the NIS-Teen (ages 13 to 17 years)^{29,59-61} and NHIS (ages 18 to 26 years)^{46,62-64} 2012 to 2015 surveys were used to compare survivors' HPV vaccine initiation rates with those in the general population using age group (ages 13 to 17 years; ages 18 to 26 years), sex, and survey-year (2012, 2013, 2014, or 2015) matched comparisons. In these national surveys representative of the US population, receipt of HPV vaccine is self- or parent-reported via telephone interview,^{59,62} providing a comparable comparison with the self-/parent-reported data collected in our survey.⁶⁵

Statistical Analysis

Population comparison. The primary end point was self- or parent-reported HPV vaccine initiation (ie, receipt of one or more HPV vaccine doses). HPV vaccine initiation rates for the 13- to 26-year-old cancer survivor cohort and age-group-matched and sex-matched US population data (NIS-Teen [ages 13 to 17 years] and NHIS [ages 18 to 26 years]) were compared in unadjusted descriptive models using χ^2 tests for the entire cohort (male/female ages 13 to 26 years) and stratified by age group (teens 13 to 17 years; young adults 18 to 26 years) and sex. Multivariable logistic regression was used to compare vaccine initiation in survivors versus population data, adjusting for age, sex, race/ethnicity, census region, education level, household income, and data collection year. Separate age-stratified (teens 13 to 17 years, young adults 18 to 26 years) and sex-stratified (males 13 to 26 years, females 13 to 26 years) models were also developed, adjusting for race/ethnicity, census region, household income, education level, data collection year, and sex (for age-stratified models) or age (for sex-stratified models). The same techniques were used to compare HPV vaccine dose completion in 13- to 26-year-old survivors versus population.

Within cancer survivor analysis. Predictors of HPV vaccine noninitiation were determined using logistic regression. To account for multiple comparisons, two-sided tests with $P < .01$ were considered statistically significant. Associations of vaccine noninitiation with sociodemographic, clinical, and survey response data were first examined univariably using logistic regression. Variables with $P < .1$ were then included in a multivariable model, followed by stepwise backward variable elimination to obtain a final parsimonious model composed of explanatory variables with $P < .01$. Race, primary cancer diagnosis, treatment (chemotherapy [yes/no], radiation [yes/no], HCT [yes/no]), and time from therapy completion were included in the model regardless of P values. Additional models were developed for subgroups stratified by age/sex. PROC LOGISTIC of SAS (version 9.4; SAS Institute, Cary, NC) was used for analysis.

RESULTS

Of the 1,227 eligible patients (or parents) approached, 1,046 (85.2%) consented to participate and 982 (80.0%) returned evaluable surveys (Fig 1). Participants were more likely to be older (mean age, 16.3 v 15.4 years; $P = .005$) and non-Hispanic white (65.5 v 58.8%; $P = .006$) compared with nonparticipants, respectively (Appendix Table A1, online only). Clinical and sociodemographic

characteristics are listed in Table 1. Cancer survivors were a median of 16.3 (range, 9.0 to 26.9) years old and completed therapy a median of 2.7 (range, 1.0 to 5.0) years before study participation; 54.6% were male, 65.5% were non-Hispanic white, 36.2% had a diagnosis of acute leukemia, 93.0% received chemotherapy, and 19.3% had undergone HCT.

Prevalence of HPV Vaccine Initiation

Among 13- to 26-year-old cancer survivors, 23.8% (95% CI, 20.6% to 27.0%) initiated HPV vaccination, compared with 40.5% (95% CI, 40.2% to 40.7%) in the general population ($P < .001$). When stratified by age, HPV vaccine initiation rates were significantly lower among 13- to 17-year-old survivors than age-matched population comparisons (22.0%; 95% CI, 17.3% to 26.7% ν 42.5%; 95% CI, 42.2% to 42.8%; $P < .001$). In contrast, initiation rates among 18- to 26-year-old survivors were comparable to age-matched general population peers (25.3% ν 24.2%; $P = .6$). Stratifying by sex within each age group revealed that HPV vaccine initiation rates in 13- to 17-year-old survivors were significantly lower than population comparisons (females, 32.6% ν 51.9%; $P < .001$; males, 14.0% ν 33.8%; $P < .001$). Within the 18- to 26-year-old age group, initiation rates among female survivors were higher than in the general population (45.7% ν 38.2%; $P = .04$), whereas rates in male survivors were similar to population comparisons (7.5% ν 8.3%; $P = .7$; Fig 2A). Prevalence of vaccine initiation among 9- to 12-year-old survivors was 5.9% (95% CI, 3.3% to 8.6%) overall; the prevalence was 8.0% among females and 4.2% among males. No population comparisons are available for this age group.

Using multivariable logistic regression and adjusting for age, sex, race/ethnicity, US census region, education level, household income, and year of data collection, cancer survivors were more likely to be vaccine-naïve compared with general population peers (odds ratio [OR], 1.7; 95% CI, 1.4 to 2.1; $P < .001$). In separate age- and sex-stratified models, the odds of HPV vaccine

Fig 1. Flow diagram of cancer survivor cohort derivation. (*) Evaluable surveys were defined as those surveys that contained a response to the item that queried the survivor's human papillomavirus vaccine initiation status (ie, human papillomavirus vaccine initiation ν noninitiation, the primary study outcome).

Table 1. Sociodemographic and Clinical Characteristics of Study Participants

Characteristic	No. (%)
Cancer survivor cohort	982 (100)
Age at study participation, years	
Mean $\pm$ SD	16.3 $\pm$ 4.7
Median (range)	16.3 (9.03-26.95)
Time from diagnosis, years	
Mean $\pm$ SD	4.2 $\pm$ 2.1
Median (range)	4.1 (1.2-23.1)
Age at diagnosis, years	
Mean $\pm$ SD	12.1 $\pm$ 5.3
Median (range)	12.2 (0-24.7)
Time off therapy, years	
Mean $\pm$ SD	2.7 $\pm$ 1.2
Median (range)	2.7 (1.0-5.0)
Age group, years	
9-12	303 (30.9)
13-17	303 (30.9)
18-26	376 (38.3)
Sex	
Male	536 (54.6)
Female	446 (45.4)
Race/ethnicity	
Non-Hispanic white	643 (65.5)
Hispanic	120 (12.2)
African American	153 (15.6)
Other	66 (6.7)
Annual household income, \$US	
< 20K	224 (22.8)
20K-50K	145 (14.8)
> 50K	500 (50.9)
Education*	
Low	92 (9.4)
Appropriate	503 (51.2)
Exceeds	372 (37.9)
Missing	15 (1.5)
US region	
Northeast	9 (0.9)
Midwest	183 (18.6)
South	628 (64.0)
West	154 (15.7)
International	8 (0.8)
Diagnosis	
Leukemia	355 (36.2)
Lymphoma	224 (22.8)
Solid tumor	403 (41.0)
Chemotherapy	
No	69 (7.0)
Yes	913 (93.0)
Radiation	
No	544 (55.4)
Yes	438 (44.6)
Hematopoietic cell transplant	
No	793 (80.8)
Yes	189 (19.3)
HPV vaccine initiation	
Not†	803 (81.8)
Yes‡	179 (18.2)

NOTE. Statistics were calculated for this table by excluding patients with missing values for the characteristics.

Abbreviation: GED, General Educational Development (high-school equivalency credential); HPV, human papillomavirus; SD, standard deviation.

*Educational level (reported for parents of patients younger than 18 years of age and for patients ages 18 to 26 years). For parents and patients $\geq$ 20 years of age: low, < high school graduate; appropriate, high school graduate or GED $\pm$ some college or other technical degree; exceeds, $\geq$ college degree. For patients ages 18 to 19 years: low, < high school; appropriate, some high school, high school graduate, or GED; exceeds, $\geq$ some college.

†Received zero doses of HPV vaccine.

‡Received one or more doses of HPV vaccine.

Fig 2. (A) Human papillomavirus (HPV) vaccine initiation, overall and by age group and sex, in US general population versus cancer survivors, ages 13-26 years, 2012-2015. (B) Receipt of HPV vaccine by number of doses completed, in US general population versus cancer survivors, ages 13-26 years, 2012-2015.

noninitiation among 18- to 26-year-old survivors were similar to the general population overall (OR, 1.2; 95% CI, 0.9 to 1.6; $P = .3$), and when stratified by sex (females: OR, 1.0; 95% CI, 0.7 to 1.5; $P = .8$; males: OR, 1.5; 95% CI, 0.8 to 2.8; $P = .2$). In contrast, the odds of being vaccine-naïve were significantly higher in 13- to 17-year-old survivors compared with the general population (OR, 2.5; 95% CI, 1.9 to 3.4; $P < .001$), as well as when stratified by sex (females: OR, 2.3; 95% CI, 1.6 to 3.4; $P < .001$; males: OR, 2.9; 95% CI, 1.9 to 4.6; $P < .001$; Table 2).

HPV Vaccine Doses Received and Series Completion Rates

The proportion (95% CI) of 13- to 26-year-olds receiving at least one, two, or three HPV vaccine doses in cancer survivors compared with the general population were as follows: one or more doses, 23.8% (20.6% to 27.0%) versus 40.5% (40.2% to 40.7%); two or more doses, 18.1% (15.1% to 21.0) versus 29.1% (28.8% to 29.3%); three or more doses, 13.5% (10.9% to 16.0%) versus 20.8% (20.6% to 21.0%), respectively ($P < .001$ for all comparisons; Fig 2B). The odds of survivors not receiving two or more doses or three or more doses, regardless of receipt of the first dose, were higher than the general population, respectively (two or more doses: OR, 1.2; 95% CI, 1.0 to 1.5; $P = .04$; three or more doses: OR, 7.5; 95% CI, 6.1 to 9.4; $P < .001$). However, among those survivors who received at least one dose, completion rates (95% CI) for the three-dose series were similar for survivors and the general population: 56.5% (48.9% to 64.2%) versus 54.0% (53.6% to 54.4%), respectively ($P = .5$).

Risk Factors for HPV Vaccine Noninitiation Among Cancer Survivors

All age groups. In the multivariable logistic regression model restricted to cancer survivors and adjusted for cancer diagnosis, treatment type (chemotherapy, radiation, HCT), time from therapy completion, and race/ethnicity, significant predictors of HPV vaccine noninitiation among 9- to 26-year-olds included lack of provider recommendation (OR, 10.8; 95% CI, 6.5 to 18.0; $P < .001$), perceived lack of insurance coverage for the vaccine (OR, 6.6; 95% CI, 3.9 to 11.0; $P < .001$), male sex (OR, 2.9; 95% CI, 1.7 to 4.8; $P < .001$), endorsement of barriers to HPV vaccination (OR, 2.7; 95% CI, 1.6 to 4.6; $P < .001$), and age (9 to 12 years of age: OR, 3.7; 95% CI, 1.8 to 7.6; $P < .001$; 18 to 26 years of age: OR, 0.5; 95% CI, 0.3 to 0.9; $P = .02$; reference group: 13 to 17 years of age; Table 3).

Stratified by age group. Decreased risk of vaccine noninitiation was associated with increasing age in 9- to 12-year-old survivors (OR, 0.3 per year; 95% CI, 0.1 to 0.8; $P = .009$). An increased risk of noninitiation was associated with endorsement of barriers to HPV vaccination in 13- to 17-year-old survivors (OR, 3.7; 95% CI, 1.5 to 9.6; $P = .006$); and with male sex in 18- to 26-year-olds: OR, 5.8; 95% CI, 2.1 to 15.7; $P < .001$). Perceived lack of insurance coverage for the HPV vaccine was associated with vaccine noninitiation among 13- to 17-year-olds: OR, 7.2; 95% CI, 3.2 to 16.5; $P < .001$; and 18- to 26-year-olds: OR, 10.3; 95% CI, 4.0 to 26.5; $P < .001$. Lack of provider recommendation was a significant predictor of HPV vaccine noninitiation across all age groups (9-12 years of age: OR, 13.0; 95% CI, 1.9 to 89.6; $P = .009$; 13 to 17 years of age: OR, 7.5; 95% CI, 3.1 to 18.1; $P < .001$; 18 to 26 years: OR, 23.3; 95% CI, 9.9 to 55.1; $P < .001$; Appendix Tables A2, A3, and A4).

Table 2. HPV Vaccine Noninitiation in Cancer Survivor Cohort Versus the General Population, Multivariable Model

Age Group	OR	95% CI	P
Overall (ages 13-26 years, male and female)			
General population	1.00		
Cancer survivors	1.72	1.41 to 2.09	< .001
Males (ages 13-26 years)			
General population	1.00		
Cancer survivors	2.71	1.89 to 3.87	< .001
Females (ages 13-26 years)			
General population	1.00		
Cancer survivors	1.34	1.04 to 1.71	.02
Teenagers (ages 13-17 years, male and female)			
General population	1.00		
Cancer survivors	2.52	1.88 to 3.37	< .001
Male teenagers			
General population	1.00		
Cancer survivors	2.92	1.87 to 4.57	< .001
Female teenagers			
General population	1.00		
Cancer survivors	2.31	1.56 to 3.41	< .001
Young adults (ages 18-26 years, male and female)			
General population	1.00		
Cancer survivors	1.18	0.88 to 1.58	.28
Male young adults			
General population	1.00		
Cancer survivors	1.54	0.84 to 2.84	.16
Female young adults			
General population	1.00		
Cancer survivors	1.04	0.73 to 1.46	.84

NOTE. Each row in this table represents a separate multivariable analysis, adjusted for patient age, sex, race/ethnicity, US census region, household income, educational level of survey respondent, and year of data collection. Abbreviations: HPV, human papillomavirus; OR, odds ratio.

Predictors of Vaccine Noninitiation Among Survivors Receiving a Provider Recommendation

Seventy-two percent of study participants reported a lack of provider recommendation regarding HPV vaccine; only 5% of these survivors reported initiating the vaccine (Fig 3). Among the 28% of survivors who received a provider recommendation, 51% reported vaccine initiation. Predictors of vaccine noninitiation among those who had received a provider recommendation included perceived lack of insurance coverage for HPV vaccine (OR, 7.5; 95% CI, 3.7 to 15.3; $P < .001$); endorsement of barriers to HPV vaccination (OR, 3.4; 95% CI, 1.6 to 6.9; $P = .001$); and age 9 to 12 years (OR, 5.0; 95% CI, 1.9 to 13.1; $P < .001$; reference group: 13 to 17 years). Older survivors (18 to 26 years) with provider recommendations were more likely to initiate compared with 13- to 17-year-olds (OR [vaccine noninitiation] 0.24; 95% CI, 0.1 to 0.5; $P < .001$; Appendix Table A5).

DISCUSSION

To our knowledge, this is the first study to compare HPV vaccine initiation rates in young cancer survivors with those in the general population and to identify predictors of vaccine noninitiation in this vulnerable population. In this large study from five comprehensive

cancer centers across the United States, we found that among survivors age 13 to 26, only 24% of the survivors initiated HPV vaccination, with just 13.5% completing the three-dose series. Survivors were significantly more likely to be vaccine-naïve compared with their general population peers. These findings raise significant concerns, because they suggest that over 85% of young cancer survivors may lack protection against vaccine-preventable HPV, placing them at risk for infection and subsequent HPV-related morbidity, including malignancies. Cancer survivors are at increased risk for subsequent HPV-associated malignancies compared with the general population^{24,38} and thus would benefit from HPV vaccination.

The strongest predictor of HPV vaccine noninitiation for both male and female survivors across all age groups was lack of provider recommendation. Only 28% of survivors reported receiving such a recommendation, and those who lacked provider recommendation were at 10-fold increased risk for vaccine noninitiation compared with those receiving a recommendation. These findings align with previous research in the general population, demonstrating that lack of provider recommendation for HPV vaccination is a robust predictor for vaccine noninitiation.⁶⁶⁻⁶⁹ Of additional concern is that cancer survivors often receive medical care from both primary and subspecialty providers, and clear delineation among these providers regarding responsibility for vaccines may be lacking. In a recent study of subspecialists caring for adolescents with chronic medical conditions (including cancer), lack of communication between subspecialists and primary medical providers was identified as a significant barrier to HPV vaccine initiation.⁷⁰

Perceived lack of insurance coverage for HPV vaccine was a significant predictor of vaccine noninitiation among survivors, particularly among those who received a provider recommendation (7.5-fold increased risk of noninitiation). Although the Affordable Care Act mandates that most insurance plans cover preventive services, including vaccines, without a copayment or deductible,⁷¹ employer-sponsored plans in place before the Affordable Care Act implementation are exempt from this provision. During the first (2012) and last (2015) years of our survey, 48% and 25% of workers, respectively, were covered by such exempt employer-sponsored plans.^{72,73} In addition, the federally funded Vaccines for Children Program provides free vaccine coverage to medically uninsured and Medicaid-eligible children in the United States, but does not provide coverage to some underinsured youth or to those over 18 years of age.⁷⁴ Lack of insurance coverage is a risk factor for vaccine noninitiation in the general population.⁷⁵⁻⁷⁷ Given the multiple regulations and exemptions affecting insurance coverage for vaccines in the United States, it is possible that survivors perceive lack of insurance coverage for HPV vaccine as a significant barrier, whether or not this is actually the case. With recent changes in HPV vaccine formulation (ie, sole availability of nonvalent vaccine)⁷⁸ and administration schedules (from three-dose to two-dose series for healthy 9- to 14-year-olds, although not applicable to patients with cancer),⁷⁹ and with current uncertainties regarding national health care policies,⁸⁰ continued monitoring of the effect of insurance coverage on HPV vaccination is important.

Additional predictors of vaccine noninitiation included male sex, endorsement of barriers to vaccine receipt, and younger

Table 3. Factors Associated With HPV Vaccine Noninitiation in Young Cancer Survivors (ages 9 to 26 years), Multivariable Model

Variable	OR	95% CI	P
Lack of provider recommendation for HPV vaccine			
No	1.00		
Yes	10.79	6.48 to 17.96	< .001
Survivors' perceived lack of insurance coverage for HPV vaccine			
No	1.00		
Yes	6.56	3.91 to 10.99	< .001
Endorsement of barriers (by patients/parents) to receipt of HPV vaccine			
No	1.00		
Yes	2.69	1.58 to 4.58	< .001
Sex			
Female	1.00		
Male	2.87	1.72 to 4.81	< .001
Age group, years			
13-17	1.00		
9-12	3.65	1.75 to 7.63	< .001
18-26	0.52	0.30 to 0.91	.02
Low self-efficacy			
No	1.00		
Yes	1.27	0.88 to 1.83	.20
Race			
White	1.00		
Non-white	1.25	0.75 to 2.08	.40
Primary cancer diagnosis			
Solid tumor	1.00		
Leukemia	1.31	0.68 to 2.50	.42
Lymphoma	0.70	0.37 to 1.31	.26
Time off therapy (continuous)			
Per year increase off therapy	1.10	0.90 to 1.34	.35
Chemotherapy (yes v no)	1.48	0.56 to 3.88	.43
Radiation (yes v no)	0.72	0.41 to 1.26	.24
Hematopoietic cell transplant (yes v no)	1.52	0.75 to 3.07	.25

NOTE. Because of multiple comparisons in this statistical model, $P < .01$ is considered statistically significant.

Abbreviations: HPV, human papillomavirus; OR, odds ratio.

age. Despite low rates of vaccine uptake for males in the general population,^{35,61,81} vaccinating males is critical in preventing anogenital cancers.⁸²⁻⁸⁴ Nevertheless, our findings suggest that rates of vaccine uptake in male cancer survivors are suboptimal. Endorsement of barriers to vaccine receipt has also been

Fig 3. Provider recommendation and human papillomavirus (HPV) vaccine initiation among cancer survivors, ages 9-26 years.

associated with low vaccine uptake in the general population, but seems to be mitigated by vaccine endorsement and recommendation by medical providers.^{35,85} Maximum HPV vaccine benefit occurs when administration precedes sexual debut, so it is concerning that younger age was associated with vaccine noninitiation. In the general population, factors shown to influence age at vaccine initiation include provider preferences for vaccinating older adolescents and parental beliefs that their child is too young for vaccination.^{77,86-88}

Although, to our knowledge, this is the first large study to report the prevalence and correlates of HPV vaccine noninitiation in young male and female cancer survivors, this work needs to be considered in the context of its limitations. This cohort was limited to survivors who were 1 to 5 years after treatment completion, and we used self- or parent-report of vaccine history. Although determining HPV vaccination history via medical record review may be more accurate in certain cases, overall, the validity of self-reported HPV vaccination has been demonstrated among both healthy young adults and those surviving childhood cancer.^{65,89} We excluded survivors who did not return for a clinic visit, which could have resulted in selection bias; however, survivors with less contact with the health care system may have been even less likely to receive the vaccine. Multiple testing and type I error are always challenges in observational studies; we used $P < .01$ as a conservative cut point, but results with P values near this cut point should be viewed with caution.

Because our study focused on survivors followed in the United States, when taken in the larger global context, our findings are even more concerning. Other developed countries, including the United Kingdom, Australia, Norway, Sweden, and Denmark, have achieved $> 80\%$ vaccine initiation rates and 70% completion rates in targeted general population birth cohorts.^{90,91} Most of these countries have universal health care coverage and school-based HPV immunization programs. Lack of universal health care coverage in the United States and local/state control of school immunization requirements and programs⁹² may contribute to low (ie, approximately 40% initiation rate for 13- to 26-year-olds) HPV vaccine uptake in the United States. Nevertheless, to our knowledge, there are no reports of HPV vaccine uptake among cancer survivors in any country outside of the United States; therefore, vaccine uptake among the vulnerable cancer survivor population in countries with high rates of HPV vaccination in the general population remains unknown and offers an opportunity for future research.

In conclusion, we found that only a small proportion of young cancer survivors initiated HPV vaccination despite increased vulnerability to HPV-related morbidity in this population. We also found that predictors of vaccine noninitiation in survivors were largely the same as those reported in the general population. In addition, despite the clear association between provider recommendation and vaccine initiation, we found that most survivors had not received a recommendation from their provider prompting vaccine initiation. Additional research is needed to delineate specific barriers that may be unique to the survivor population and that may inform future interventions to promote HPV vaccine uptake among young cancer survivors.

AUTHORS' DISCLOSURES OF POTENTIAL CONFLICTS OF INTEREST

Disclosures provided by the authors are available with this article at jco.org.

AUTHOR CONTRIBUTIONS

Conception and design: James L. Klosky, Melissa M Hudson, Anna R Giuliano, Leslie L Robison, Smita Bhatia, Wendy Landier

Administrative support: James L. Klosky, Melissa M Hudson, Liton Francisco, Leslie L. Robison, Smita Bhatia, Wendy Landier

Provision of study materials or patients: James L. Klosky, James A Connelly, Karen Wasilewski-Masker, Wendy Landier

Collection and assembly of data: James L. Klosky, James A. Connelly, Karen Wasilewski-Masker, Can-Lan Sun, Liton Francisco, Laura Gustafson, Kathryn M. Russell, Gina Sabbatini, Jessica S. Flynn, Jocelyn M. York, Wendy Landier

Data analysis and interpretation: James L. Klosky, Melissa M. Hudson, Yanjun Chen, Kathryn M. Russell, F. Lennie Wong, Smita Bhatia, Wendy Landier

Manuscript writing: All authors

Final approval of manuscript: All authors

Accountable for all aspects of the work: All authors

REFERENCES

- Mariotto AB, Rowland JH, Yabroff KR, et al: Long-term survivors of childhood cancers in the United States. *Cancer Epidemiol Biomarkers Prev* 18: 1033-1040, 2009
- Howlander N, Noone AM, Krapcho M, et al: SEER Cancer Statistics Review, 1975-2008 Bethesda, MD National Cancer Institute, based on November 2010 SEER data submission, http://seer.cancer.gov/csr/1975_2008/, April 15, 2011
- Satterwhite CL, Tortolero-Luna G, Meites E, et al: Sexually transmitted infections among US women and men: Prevalence and incidence estimates, 2008. *Sex Transm Dis* 40:187-193, 2013
- Dunne EF, Unger ER, Sternberg M, et al: Prevalence of HPV infection among females in the United States. *JAMA* 297:813-819, 2007
- Nielsen CM, Flores R, Harris RB, et al: Human papillomavirus prevalence and type distribution in male anogenital sites and semen. *Cancer Epidemiol Biomarkers Prev* 16:1107-1114, 2007
- Leigh IM, Buchanan JA, Harwood CA, et al: Role of human papillomaviruses in cutaneous and oral manifestations of immunosuppression. *J Acquir Immune Defic Syndr* 21:S49-S57, 1999
- Ho GY, Burk RD, Klein S, et al: Persistent genital human papillomavirus infection as a risk factor for persistent cervical dysplasia. *J Natl Cancer Inst* 87:1365-1371, 1995
- Giuliano AR, Tortolero-Luna G, Ferrer E, et al: Epidemiology of human papillomavirus infection in men, cancers other than cervical and benign conditions. *Vaccine* 26:K17-K28, 2008
- Khan MJ, Castle PE, Lorincz AT, et al: The elevated 10-year risk of cervical precancer and cancer in women with human papillomavirus (HPV) type 16 or 18 and the possible utility of type-specific HPV testing in clinical practice. *J Natl Cancer Inst* 97: 1072-1079, 2005
- Schlecht NF, Kulaga S, Robitaille J, et al: Persistent human papillomavirus infection as a predictor of cervical intraepithelial neoplasia. *JAMA* 286: 3106-3114, 2001
- de Sanjose S, Quint WG, Alemany L, et al: Human papillomavirus genotype attribution in invasive cervical cancer: A retrospective cross-sectional worldwide study. *Lancet Oncol* 11:1048-1056, 2010
- Kosmidis S, Baka M, Bouhoutsou D, et al: Longitudinal assessment of immunological status and rate of immune recovery following treatment in children with ALL. *Pediatr Blood Cancer* 50:528-532, 2008
- Fioredda F, Cavillo M, Banov L, et al: Immunization after the elective end of antineoplastic chemotherapy in children. *Pediatr Blood Cancer* 52:165-168, 2009
- Jaffe D, Papadopoulos EB, Young JW, et al: Immunogenicity of recombinant hepatitis B vaccine (rHBV) in recipients of unrelated or related allogeneic hematopoietic cell (HC) transplants. *Blood* 108: 2470-2475, 2006
- Petry KU, Scheffel D, Bode U, et al: Cellular immunodeficiency enhances the progression of human papillomavirus-associated cervical lesions. *Int J Cancer* 57:836-840, 1994
- Rose B, Wilkins D, Li W, et al: Human papillomavirus in the oral cavity of patients with and without renal transplantation. *Transplantation* 82: 570-573, 2006
- Malouf MA, Hopkins PM, Singleton L, et al: Sexual health issues after lung transplantation: Importance of cervical screening. *J Heart Lung Transplant* 23:894-897, 2004
- Katz RL, Veanattukalathil S, Weiss KM: Human papillomavirus infection and neoplasia of the cervix and anogenital region in women with Hodgkin's disease. *Acta Cytol* 31:845-854, 1987
- Bhatia S, Louie AD, Bhatia R, et al: Solid cancers after bone marrow transplantation. *J Clin Oncol* 19:464-471, 2001
- Socié G, Curtis RE, Deeg HJ, et al: New malignant diseases after allogeneic marrow transplantation for childhood acute leukemia. *J Clin Oncol* 18: 348-357, 2000
- Sasadeusz J, Kelly H, Szer J, et al: Abnormal cervical cytology in bone marrow transplant recipients. *Bone Marrow Transplant* 28:393-397, 2001
- Daneshpouy M, Socié G, Clavel C, et al: Human papillomavirus infection and anogenital condyloma in bone marrow transplant recipients. *Transplantation* 71:167-169, 2001
- Ojha RP, Jackson BE, Tota JE, et al: Younger age distribution of cervical cancer incidence among survivors of pediatric and young adult cancers. *Gynecol Oncol* 134:309-313, 2014
- Ojha RP, Tota JE, Offutt-Powell TN, et al: Human papillomavirus-associated subsequent malignancies among long-term survivors of pediatric and young adult cancers. *PLoS One* 8:e70349, 2013
- Markowitz LE, Dunne EF, Saraiya M, et al: Quadrivalent human papillomavirus vaccine: Recommendations of the Advisory Committee on Immunization Practices (ACIP). *MMWR Recomm Rep* 56:1-24, 2007
- Centers for Disease Control and Prevention: Recommendations on the use of quadrivalent human papillomavirus vaccine in males—Advisory Committee on Immunization Practices (ACIP), 2011. *MMWR Morb Mortal Wkly Rep* 60:1705-1708, 2011
- Markowitz LE, Dunne EF, Saraiya M, et al: Human papillomavirus vaccination: Recommendations of the Advisory Committee on Immunization Practices (ACIP). *MMWR Recomm Rep* 63:1-30, 2014
- Kim DK, Riley LE, Harriman KH, et al: Recommended immunization schedule for adults aged 19 years or older, United States, 2017. *Ann Intern Med* 166:209-219, 2017
- Reagan-Steiner S, Yankey D, Jeyarajah J, et al: National, regional, state, and selected local area vaccination coverage among adolescents aged 13-17 years - United States, 2015. *MMWR Morb Mortal Wkly Rep* 65:850-858, 2016
- Bailey HH, Chuang LT, duPont NC, et al: American Society of Clinical Oncology Statement: Human papillomavirus vaccination for cancer prevention. *J Clin Oncol* 34:1803-1812, 2016
- Ragin CC, Edwards RP, Jones J, et al: Knowledge about human papillomavirus and the HPV vaccine—a survey of the general population. *Infect Agent Cancer* 4:S10, 2009 (suppl 1)
- Lindley MC, Jeyarajah J, Yankey D, et al: Comparing human papillomavirus vaccine knowledge and intentions among parents of boys and girls. *Hum Vaccin Immunother* 12:1519-1527, 2016
- Gamble HL, Klosky JL, Parra GR, et al: Factors influencing familial decision-making regarding human papillomavirus vaccination. *J Pediatr Psychol* 35: 704-715, 2010
- Gargano LM, Herbert NL, Painter JE, et al: Impact of a physician recommendation and parental immunization attitudes on receipt or intention to receive adolescent vaccines. *Hum Vaccin Immunother* 9:2627-2633, 2013
- Holman DM, Benard V, Roland KB, et al: Barriers to human papillomavirus vaccination among US adolescents: A systematic review of the literature. *JAMA Pediatr* 168:76-82, 2014
- McRee AL, Reiter PL, Gottlieb SL, et al: Mother-daughter communication about HPV vaccine. *J Adolesc Health* 48:314-317, 2011
- Gerend MA, Weibley E, Bland H: Parental response to human papillomavirus vaccine availability: Uptake and intentions. *J Adolesc Health* 45:528-531, 2009
- Temkin SM, Seibel NL: Are we missing an opportunity for cancer prevention? Human papillomavirus vaccination for survivors of pediatric and young adult cancers. *Cancer* 121:3395-3402, 2015
- Centers for Disease Control and Prevention: 2012 National Immunization Survey, Teen, United States, http://www.cdc.gov/nchs/nis/data_files_teen.htm

40. Centers for Disease Control and Prevention: 2013 National Immunization Survey, Teen, United States, http://www.cdc.gov/nchs/nis/data_files_teen.htm
41. Centers for Disease Control and Prevention: 2014 National Immunization Survey, Teen, United States, http://www.cdc.gov/nchs/nis/data_files_teen.htm
42. Centers for Disease Control and Prevention: 2015 National Immunization Survey, Teen, United States, http://www.cdc.gov/nchs/nis/data_files_teen.htm
43. Centers for Disease Control and Prevention: 2012 National Health Interview Survey, <http://www.cdc.gov/nchs/nhis/data-questionnaires-documentation.htm>
44. Centers for Disease Control and Prevention: 2013 National Health Interview Survey, <http://www.cdc.gov/nchs/nhis/data-questionnaires-documentation.htm>
45. Centers for Disease Control and Prevention: 2014 National Health Interview Survey, <http://www.cdc.gov/nchs/nhis/data-questionnaires-documentation.htm>
46. Centers for Disease Control and Prevention: 2015 National Health Interview Survey, <http://www.cdc.gov/nchs/nhis/data-questionnaires-documentation.htm>
47. Vadaparampil ST, Malo TL, Sutton SK, et al: Missing the target for routine human papillomavirus vaccination: Consistent and strong physician recommendations are lacking for 11- to 12-year-old males. *Cancer Epidemiol Biomarkers Prev* 25:1435-1446, 2016
48. Donahue KL, Stupiansky NW, Alexander AB, et al: Acceptability of the human papillomavirus vaccine and reasons for non-vaccination among parents of adolescent sons. *Vaccine* 32:3883-3885, 2014
49. Dempsey AF, Abraham LM, Dalton V, et al: Understanding the reasons why mothers do or do not have their adolescent daughters vaccinated against human papillomavirus. *Ann Epidemiol* 19:531-538, 2009
50. Cox DS, Cox AD, Sturm L, et al: Behavioral interventions to increase HPV vaccination acceptability among mothers of young girls. *Health Psychol* 29:29-39, 2010
51. Dempsey AF, Zimet GD, Davis RL, et al: Factors that are associated with parental acceptance of human papillomavirus vaccines: A randomized intervention study of written information about HPV. *Pediatrics* 117:1486-1493, 2006
52. Gerend MA, Lee SC, Shepherd JE: Predictors of human papillomavirus vaccination acceptability among underserved women. *Sex Transm Dis* 34:468-471, 2007
53. Kahn JA, Rosenthal SL, Jin Y, et al: Rates of human papillomavirus vaccination, attitudes about vaccination, and human papillomavirus prevalence in young women. *Obstet Gynecol* 111:1103-1110, 2008
54. Brabin L, Roberts SA, Farzaneh F, et al: Future acceptance of adolescent human papillomavirus vaccination: A survey of parental attitudes. *Vaccine* 24:3087-3094, 2006
55. Rosenthal SL, Rupp R, Zimet GD, et al: Uptake of HPV vaccine: Demographics, sexual history and values, parenting style, and vaccine attitudes. *J Adolesc Health* 43:239-245, 2008
56. Constantine NA, Jerman P: Acceptance of human papillomavirus vaccination among Californian parents of daughters: A representative statewide analysis. *J Adolesc Health* 40:108-115, 2007
57. Cox MF, Fasolino TK, Tavakoli AS: Factor analysis and psychometric properties of the Mother-Adolescent Sexual Communication (MASC) instrument for sexual risk behavior. *J Nurs Meas* 16:171-183, 2008
58. Miller KS, Kotchick BA, Dorsey S, et al: Family communication about sex: What are parents saying and are their adolescents listening? *Fam Plann Perspect* 30:218-22, 235, 1998
59. Centers for Disease Control and Prevention: National and state vaccination coverage among adolescents aged 13-17 years—United States, 2012. *MMWR Morb Mortal Wkly Rep* 62:685-693, 2013
60. Elam-Evans LD, Yankey D, Jeyarajah J, et al: National, regional, state, and selected local area vaccination coverage among adolescents aged 13-17 years—United States, 2013. *MMWR Morb Mortal Wkly Rep* 63:625-633, 2014
61. Reagan-Steiner S, Yankey D, Jeyarajah J, et al: National, regional, state, and selected local area vaccination coverage among adolescents aged 13-17 years—United States, 2014. *MMWR Morb Mortal Wkly Rep* 64:784-792, 2015
62. Williams WW, Lu PJ, O'Halloran A, et al: Noninfluenza vaccination coverage among adults - United States, 2012. *MMWR Morb Mortal Wkly Rep* 63:95-102, 2014
63. Williams WW, Lu PJ, O'Halloran A, et al: Vaccination coverage among adults, excluding influenza vaccination - United States, 2013. *MMWR Morb Mortal Wkly Rep* 64:95-102, 2015
64. Williams WW, Lu PJ, O'Halloran A, et al: Surveillance of vaccination coverage among adult populations - United States, 2014. *MMWR Surveill Summ* 65:1-36, 2016
65. Ojha RP, Tota JE, Offutt-Powell TN, et al: The accuracy of human papillomavirus vaccination status based on adult proxy recall or household immunization records for adolescent females in the United States: Results from the National Immunization Survey-Teen. *Ann Epidemiol* 23:281-285, 2013
66. Malo TL, Ali KN, Sutton SK, et al: The content and context of physicians' communication with males about human papillomavirus vaccination. *Hum Vaccin Immunother* 12:1511-1518, 2016
67. Scherr CL, Augusto B, Ali K, et al: Provider-reported acceptance and use of the Centers for Disease Control and Prevention messages and materials to support HPV vaccine recommendation for adolescent males. *Vaccine* 34:4229-4234, 2016
68. Klosky JL, Favaro B, Peck KR, et al: Prevalence and predictors of human papillomavirus (HPV) vaccination among young women surviving childhood cancer. *J Cancer Surviv* 10:449-456, 2016
69. Vadaparampil ST, Malo TL, Kahn JA, et al: Physicians' human papillomavirus vaccine recommendations, 2009 and 2011. *Am J Prev Med* 46:80-84, 2014
70. Hofstetter AM, Lappetito L, Stockwell MS, et al: Human papillomavirus vaccination of adolescents with chronic medical conditions: A national survey of pediatric subspecialists. *J Pediatr Adolesc Gynecol* 30:88-95, 2017
71. U. S. Department of Health and Human Services: About the law: Affordable Care Act. <https://www.hhs.gov/healthcare/about-the-law/index.html>
72. Claxton G, Rae M, Panchal N, et al: Health benefits in 2012: Moderate premium increases for employer-sponsored plans; young adults gained coverage under ACA. *Health Aff (Millwood)* 31:2324-2333, 2012
73. Claxton G, Rae M, Panchal N, et al: Health benefits in 2015: Stable trends in the employer market. *Health Aff (Millwood)* 34:1779-1788, 2015
74. Walsh B, Doherty E, O'Neill C: Since the start of the vaccines for children program, uptake has increased, and most disparities have decreased. *Health Aff (Millwood)* 35:356-364, 2016
75. Fisher H, Trotter CL, Audrey S, et al: Inequalities in the uptake of human papillomavirus vaccination: A systematic review and meta-analysis. *Int J Epidemiol* 42:896-908, 2013
76. Seib K, Underwood NL, Gargano LM, et al: Preexisting chronic health conditions and health insurance status associated with vaccine receipt among adolescents. *J Adolesc Health* 58:148-153, 2016
77. Laz TH, Rahman M, Berenson AB: Human papillomavirus vaccine uptake among 18- to 26-year-old women in the United States: National Health Interview Survey, 2010. *Cancer* 119:1386-1392, 2013
78. Centers for Disease Control and Prevention: Human papillomavirus vaccine information statement. <https://www.cdc.gov/vaccines/hcp/vis/vis-statements/hpv.html>
79. Meites E, Kempe A, Markowitz LE: Use of a 2-dose schedule for human papillomavirus vaccination - Updated Recommendations of the Advisory Committee on Immunization Practices. *MMWR Morb Mortal Wkly Rep* 65:1405-1408, 2016
80. Obama BH: Repealing the ACA without a replacement - the risks to American health care. *N Engl J Med* 376:297-299, 2017
81. Daniel-Lilloa J, Gilbert PA, Parker EA: Human papillomavirus vaccination in the United States: Uneven uptake by gender, race/ethnicity, and sexual orientation. *Am J Public Health* 106:746-747, 2016
82. Viens LJ, Henley SJ, Watson M, et al: Human papillomavirus-associated cancers - United States, 2008-2012. *MMWR Morb Mortal Wkly Rep* 65:661-666, 2016
83. Taylor S, Bunge E, Bakker M, et al: The incidence, clearance and persistence of non-cervical human papillomavirus infections: A systematic review of the literature. *BMC Infect Dis* 16:293, 2016
84. Castellsagué X, Giuliano AR, Goldstone S, et al: Immunogenicity and safety of the 9-valent HPV vaccine in men. *Vaccine* 33:6892-6901, 2015
85. Gilkey MB, Calo WA, Moss JL, et al: Provider communication and HPV vaccination: The impact of recommendation quality. *Vaccine* 34:1187-1192, 2016
86. Goff SL, Mazor KM, Gagne SJ, et al: Vaccine counseling: A content analysis of patient-physician discussions regarding human papilloma virus vaccine. *Vaccine* 29:7343-7349, 2011
87. Dorell CG, Yankey D, Santibanez TA, et al: Human papillomavirus vaccination series initiation and completion, 2008-2009. *Pediatrics* 128:830-839, 2011 [Erratum: *Pediatrics* 130:166-168, 2012]
88. Hughes CC, Jones AL, Feemster KA, et al: HPV vaccine decision making in pediatric primary care: A semi-structured interview study. *BMC Pediatr* 11:74, 2011
89. Petrosky EY, Hariri S, Markowitz LE, et al: Is vaccine type seropositivity a marker for human papillomavirus vaccination? National Health and Nutrition Examination Survey, 2003-2010. *Int J Infect Dis* 33:137-141, 2015
90. Bruni L, Barrionuevo-Rosas L, Albero G, et al: Human papillomavirus and related diseases in the world. Summary report June 30, 2017. <http://www.hpvcentre.net/statistics/reports/XVX.pdf>. Barcelona, Spain, Institut Català d'Oncologia, 2017
91. Bruni L, Diaz M, Barrionuevo-Rosas L, et al: Global estimates of human papillomavirus vaccination coverage by region and income level: A pooled analysis. *Lancet Glob Health* 4:e453-e463, 2016
92. Keim-Malpass J, Mitchell EM, DeGuzman PB, et al: Legislative activity related to the human papillomavirus (HPV) vaccine in the United States (2006-2015): A need for evidence-based policy. *Risk Manag Healthc Policy* 10:29-32, 2017

Affiliations

James L. Klosky, **Melissa M. Hudson**, **Kathryn M. Russell**, **Gina Sabbatini**, **Jessica S. Flynn**, and **Leslie L. Robison**, St. Jude Children's Research Hospital, Memphis, TN; **Yanjun Chen**, **Liton Francisco**, **Jocelyn M. York**, **Smita Bhatia**, and **Wendy Landier**, University of Alabama–Birmingham, Birmingham, AL; **James A. Connelly**, University of Michigan, Ann Arbor, MI and Vanderbilt University, Nashville, TN; **Karen Wasilewski-Masker**, Emory University and Children's Healthcare of Atlanta, Atlanta, GA; **Can-Lan Sun**, **Laura Gustafson**, and **F. Lennie Wong**, City of Hope, Duarte, CA; and **Anna R. Giuliano**, Moffitt Cancer Center, Tampa, FL.

Support

Supported by the National Cancer Institute Grant No. R01CA166559 (W.L. and J.L.K.) and supported in part by the Investigator-Initiated Studies Program of Merck Sharp & Dohme (MISP #40083; W.L.) and the American Lebanese Syrian Associated Charities' support of the Consortium for Pediatric Intervention Research. A.R.G. is a member of Merck's Scientific Advisory Board and Merck's Global Advisory Board, and her institution has received funds from Merck to conduct research studies unrelated to this research. The opinions expressed in this article are those of the authors and do not necessarily represent those of the organizations providing funding for this study.

Prior Presentation

Presented in part at the American Society of Clinical Oncology Annual Meeting, Chicago, IL, June 3-7, 2016.

2018 Genitourinary Cancers Symposium

Plan to attend the Genitourinary Cancers Symposium taking place February 8-10, 2018 in San Francisco, CA. The symposium addresses the multidisciplinary needs of physicians and other members of the cancer care and research community who diagnose, treat, and study genitourinary malignancies. The symposium will explore the latest science and its clinical application, as well as feature keynote lectures from world-renowned experts on the most clinically relevant research across the spectrum of GU cancers. Abstracts with novel and emerging data will be featured in oral abstract sessions, new rapid-fire panel sessions, and poster sessions with networking events.

For additional details, visit gucasym.org

**Genitourinary
Cancers Symposium**
TRANSLATING EVIDENCE TO MULTIDISCIPLINARY CARE

February 8-10, 2018
Moscone West Building
San Francisco, California

AUTHORS' DISCLOSURES OF POTENTIAL CONFLICTS OF INTEREST

Human Papillomavirus Vaccination Rates in Young Cancer Survivors

The following represents disclosure information provided by authors of this manuscript. All relationships are considered compensated. Relationships are self-held unless noted. I = Immediate Family Member, Inst = My Institution. Relationships may not relate to the subject matter of this manuscript. For more information about ASCO's conflict of interest policy, please refer to www.asco.org/rwc or ascopubs.org/jco/site/ifc.

James L. Klosky

No relationship to disclose

Melissa M. Hudson

Consulting or Advisory Role: Coleman Supportive Oncology Initiative for Children With Cancer, Oncology Research Information Exchange Network
Pfizer Genotropin Advisory Board 2016, Princess Máxima Center

YanJun Chen

No relationship to disclose

James A. Connelly

No relationship to disclose

Karen Wasilewski-Masker

No relationship to disclose

Can-Lan Sun

No relationship to disclose

Liton Francisco

No relationship to disclose

Laura Gustafson

No relationship to disclose

Kathryn M. Russell

No relationship to disclose

Gina Sabbatini

No relationship to disclose

Jessica S. Flynn

No relationship to disclose

Jocelyn M. York

Stock or Other Ownership: Intelligent Medical Objects (I)

Anna R. Giuliano

Honoraria: Merck

Consulting or Advisory Role: Merck (Inst)

Research Funding: Merck (Inst)

Travel, Accommodations, Expenses: Merck

Leslie L. Robison

No relationship to disclose

F. Lennie Wong

No relationship to disclose

Smita Bhatia

No relationship to disclose

Wendy Landier

Research Funding: Merck Sharp & Dohme (Inst)

Appendix**Table A1.** Characteristics of Eligible Study Participants Versus Nonparticipants

Characteristic	Participants (N = 982)	Nonparticipants (n = 245)*	P
Age at study consent or refusal (years)			
Mean $\pm$ SD	16.32 $\pm$ 4.72	15.39 $\pm$ 4.53	.005
Median (range)	16.31 (9.03-26.95)	14.92 (9.03-26.34)	
Time off therapy at consent or refusal (years)			
Mean $\pm$ SD	2.72 $\pm$ 1.22	2.69 $\pm$ 1.20	.569
Median (range)	2.72 (1.00-5.00)	2.53 (1.01-5.0)	
Sex, No. (%)			
Male	536 (54.6)	139 (56.7)	.545
Female	446 (45.4)	106 (43.3)	
Race/ethnicity, No. (%)			
Non-Hispanic white	643 (65.5)	144 (58.8)	.006
Hispanic	120 (12.2)	49 (20.0)	
African American	153 (15.6)	42 (17.1)	
Other	66 (6.7)	10 (4.1)	
Diagnosis, No. (%)			
Leukemia	355 (36.2)	100 (40.8)	.293
Lymphoma	224 (22.8)	57 (23.3)	
Solid tumor	403 (41.0)	88 (35.9)	

Abbreviation: SD, standard deviation.

*Nonparticipants comprised those eligible patients/parents who were approached regarding study participation but either refused participation (n = 181) or consented but did not return a survey (n = 46) or returned an inevaluable survey (n = 18). Inevaluable surveys were defined as those surveys that did not contain a response to the item that queried the survivor's human papillomavirus vaccine initiation status (ie, human papillomavirus vaccine initiation v noninitiation, the primary study outcome).

Table A2. Factors Associated With HPV Vaccine Noninitiation in 9- to 12-Year-Old Cancer Survivors

Variable	OR	95% CI*	P
Lack of provider recommendation for HPV vaccine			
No	1.00		
Yes	12.98	1.88 to 89.64	.009
Patient age (continuous)			
Per year increase in age	0.33	0.14 to 0.76	.009

NOTE. Analysis adjusted for patient diagnosis, sex, race, time off therapy, and treatment received (chemotherapy [yes/no], radiation [yes/no], and hematopoietic cell transplant [yes/no]). Additional variables included in multivariable parsimonious model (nonsignificant): Perceived lack of insurance coverage for HPV vaccine, low self-efficacy, parent-child sexual communication (mother-adolescent sexual communication-context), and general attitude toward vaccines (vaccine attitude).

Abbreviations: HPV, human papillomavirus; OR, odds ratio.

HPV Vaccination Rates in Cancer Survivors

Table A3. Factors Associated With HPV Vaccine Noninitiation in 13- to 17-Year-Old Cancer Survivors

Variable	OR	95% CI*	P
Lack of provider recommendation for HPV vaccine			
No	1.00		
Yes	7.53	3.13 to 18.11	< .001
Survivors' perceived lack of insurance coverage for HPV vaccine			
No	1.00		
Yes	7.15	3.16 to 16.51	< .001
Endorsement of barriers (by patients/parents) to receipt of HPV vaccine			
No	1.00		
Yes	3.74	1.46 to 9.59	.006
Sex			
Female	1.00		
Male	2.11	0.92 to 4.84	.079
Endorsement of benefits (by patients/parents) for receipt of HPV vaccine			
No	1.00		
Yes	0.58	0.26 to 1.27	.170

NOTE. Analysis adjusted for patient age, diagnosis, race, time off therapy, and treatment received [chemotherapy (yes/no), radiation (yes/no), and hematopoietic cell transplant (yes/no)]
Abbreviations: HPV, human papillomavirus; OR, odds ratio.

Table A4. Factors Associated With HPV Vaccine Noninitiation in 18- to 26-Year-Old Cancer Survivors

Variable	OR	95% CI*	P
Lack of provider recommendation for HPV vaccine			
No	1.00		
Yes	23.34	9.89 to 55.10	< .001
Survivors' perceived lack of insurance coverage for HPV vaccine			
No	1.00		
Yes	10.28	3.99 to 26.52	< .001
Sex			
Female	1.00		
Male	5.75	2.11 to 15.70	< .001
HPV vaccine communication with parent/caregiver			
Per unit increase in score	0.60	0.38 to 0.94	.026

NOTE. Analysis adjusted for patient age, diagnosis, race, time off therapy, and treatment received [chemotherapy (yes/no), radiation (yes/no), and hematopoietic cell transplant (yes/no)]
Abbreviations: HPV, human papillomavirus; OR, odds ratio.

Table A5. Factors Associated With HPV Vaccine Noninitiation in Young Cancer Survivors (ages 9 to 26 years) Who Received a Provider Recommendation

Variable	OR	95% CI*	P
Survivors' perceived lack of insurance coverage for HPV vaccine			
No	1.00		
Yes	7.46	3.65 to 15.28	< .001
Endorsement of barriers (by patients/parents) to receipt of HPV vaccine			
No	1.00		
Yes	3.36	1.63 to 6.94	.001
Age group, years			
13-17	1.00		
9-12	5.04	1.94 to 13.07	< .001
18-26	0.24	0.11 to 0.51	< .001

NOTE. Analysis adjusted for patient diagnosis, race, sex, time off therapy, and treatment received (chemotherapy [yes/no], radiation [yes/no], and hematopoietic cell transplant [yes/no]).

Abbreviation: HPV, human papillomavirus; OR, odds ratio.