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Association of physicians perceived barriers with human papillomavirus vaccination initiation

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ABSTRACT

Physician recommendation is a strong predictor of vaccine uptake, however their perceived barriers may prevent vaccination. Therefore, we determined the association between physicians' perceived barriers to HPV vaccination and vaccination initiation.

We surveyed pediatricians in a large network of clinics in Houston, Texas to assess their perceived barriers to vaccinating adolescents. We combined survey data with electronic medical records to determine HPV vaccination initiation over a 12-month study period (July 2014–June 2015). Patients were 11–18 year olds who had not begun the vaccination series, had a physician visit during the study period, and whose physician completed the survey. We conducted a multilevel model clustered by physician controlling for patient and physician demographics to calculate the association between physician-reported barriers and HPV vaccination initiation.

Among 36,827 patients seen by 134 pediatricians, 18.6% initiated HPV vaccination. The relative risk of initiating HPV vaccination were lower for patients whose physician reported concerns about HPV vaccine safety (RR: 0.75, 95% CI: 0.58–0.97), efficacy (RR: 0.73, 95% CI: 0.54–0.99), and the financial burden of the vaccine on patients (RR: 0.72, 95% CI: 0.58–0.88). After controlling for patient and physician characteristics, physician concern about the financial burden on patients was significantly associated with lower relative risk of initiating HPV vaccination (RR: 0.76, 95% CI: 0.64–0.90).

In this large study we observed that physician-reported barriers are associated with HPV vaccination initiation. Interventions should be implemented to educate physicians on vaccine safety, efficacy, and that there is no patient cost for CDC-recommended vaccines.

1. Introduction

Persistent infection with a high-risk human papillomavirus (HPV) type is the leading cause of cervical cancer and is associated with a higher cancer risk, including anus, penis, vulva, vagina, and oropharynx (Kash et al., 2015; Reagan-Steiner et al., 2016). It is estimated that 70% of individuals acquire the HPV at some point in their lifetimes (Satterwhite et al., 2013). Despite the effectiveness of the vaccine to confer immunity against HPV types that cause most HPV-related cancers, the rates of vaccination remain suboptimal (Centers for Disease Control and Prevention (CDC), 2010). The Centers for Disease Control and Prevention (CDC) Advisory Committee on Immunization Practices recommends targeting vaccination of 11–12-year-old girls (since 2007) and boys (since 2011), catch-up vaccination of all 13–26 year olds, and allow for vaccination as early as age 9, at the physicians discretion (Centers for Disease Control and Prevention (CDC), 2010; Markowitz et al., 2007; Petrosky et al., 2015). However, despite national recommendations, as of 2015 only 62.8% of females and 49.8% of males ages 13–17 had initiated HPV vaccination, and initiation rates vary dramatically by State (34.8% in Kentucky versus 87.9% in Rhode Island) and race/ethnicity (68.4% among Hispanics versus 59.2% among non-Hispanic whites) in the U.S. (Reagan-Steiner et al., 2016).

Much of the current literature on HPV vaccine uptake focuses on parental or adolescent factors. Mother-identified predictors of vaccination initiation include child's age and awareness of the HPV vaccine, while adolescent-reported predictors of initiation include a history of sexual activity and discussion with a physician about the vaccine (Allen et al., 2010; Bastani et al., 2011; Bednarczyk et al., 2011; Brewer et al., 2011; Guerry et al., 2011; Williams et al., 2011). One of the most influential vaccination motivators cited by parents is physician recommendation

Abbreviations: CDC, Centers for Disease Control and Prevention; EMR, electronic medical records; HPV, human papillomavirus; TCP, Texas Children's Pediatrics.

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(Dempsey et al., 2016; Gottlieb et al., 2009; Guerry et al., 2011; Vadaparampil et al., 2014; Ylitalo et al., 2013). However, physicians themselves have concerns, which often discourage them from recommending HPV vaccination to patients (Kulczycki et al., 2016).

Evidence suggests that physician concerns include safety, handling parents' negative perceptions of the vaccine, comfort level in talking to parents about the possibility their child is sexually active, a lack of preventive care visits in the eligible age group, (Bruno et al., 2014) and the financial burden HPV vaccination may impose on patients or parents (Alexander et al., 2015; Kahn et al., 2005; Keating et al., 2008; Mays and Zimet, 2004; McCave, 2010; Riedesel et al., 2005; Soon et al., 2015; Tissot et al., 2007). However, these studies often describe only physician barriers (Bruno et al., 2014; Javanbakht et al., 2012; Tom et al., 2016) or they associate the barriers with physicians' self-reported vaccination patterns (Ko et al., 2010) and do not assess the association between physician-perceived barriers and actual patient HPV vaccination uptake.

To our knowledge, none of the previously reported studies indicate whether physicians' perceived barriers are associated with the actual vaccination rates of their patients. Therefore, the purpose of this study was to determine physician-reported barriers when vaccinating patients against HPV and the association with HPV vaccination initiation among their patients using an objective measure from electronic medical records (EMR). Understanding how physician-perceived barriers influence HPV vaccination is the first step in developing clinic-based interventions targeted at pediatric physicians to increase vaccination rates.

2. Methods

We conducted an observational study of pediatricians (n = 134) and their patients between 11–18 years of age (n = 36,827). We combined patient-level data from the Texas Children's Pediatrics (TCP) EMR with physician-level data from a pediatrician survey on HPV vaccination. TCP, providing full-service care, is one of the largest networks of pediatric practices in the U.S. comprising 52 clinics in the Houston, Texas, metropolitan area, and >200 board-certified pediatricians serve a diverse patient population. Patients were eligible for the study if their physician completed the HPV vaccination survey, had not initiated HPV vaccination as of July 1, 2014, and had a physician visit between July 1, 2014 and June 30, 2015. This study was conducted as part of a larger, ongoing multilevel randomized intervention study targeting clinic systems, physicians, and patients to improve HPV vaccination rates. This collaborative effort includes the TCP, The University of Texas School of Public Health, and Baylor College of Medicine. The study was approved by the Institutional Review Board at the University of Texas Health Sciences Center at Houston.

2.1. Pediatrician survey

The research team conducted a survey, targeting all pediatricians practicing in the TCP network. Physicians received an email link to an online survey between August–September 2015. The survey took fewer than 30 min to complete, and physicians received a $50 electronic gift card upon completion. The response rate was 59.8%.

The survey focused on physician experiences with the HPV vaccine and addressed organization and patient barriers that they encounter when vaccinating adolescents. For this study, we used data from physician responses to 10 survey items that asked the extent to which they believed the following represented barriers to HPV vaccination: 1) their level of knowledge of the HPV vaccine, 2) concern about parents' negative perceptions of the HPV vaccine, 3) personal discomfort talking about sexually transmitted infections with parents and patients, 4) concern about the financial burden of the HPV vaccine on patients, 5) concern about vaccine safety, 6) concern about vaccine efficacy, 7) that HPV vaccine is not required for school attendance, 8) time it takes to discuss HPV vaccination with patients and parents, 9) difficulty ensuring that patients will complete the 3-dose HPV vaccine series, and 10) infrequent office visits made by adolescent patients. Physicians responded to each question on a 4-point Likert scale by selecting "not a barrier at all," "a minor barrier," "somewhat of a barrier," and "a major barrier" (McCave, 2010). Physicians rarely selected "a major barrier" as a response, and in order for a meaningful interpretation and analysis, we combined "a minor barrier," "somewhat of a barrier," and "a major barrier" into one category to capture "a barrier" to immunizing patients against HPV versus "not a barrier at all."

2.2. Covariates

Physician characteristics included self-report of age, sex, race/ethnicity, years since completion of residency training, patient volume (number of patients seen in a typical day), and the number of years working at TCP. We used the EMRs to identify patient characteristics, which included age, sex, parent-reported race/ethnicity, and type of health insurance (public or private/commercial).

2.3. Outcome variable

We determined vaccination initiation using EMRs. The study outcome measure was a binary variable (yes/no) indicating whether each patient received the first dose of the HPV vaccine during a physician visit anytime within the 12-month study period.

2.4. Analysis

For descriptive purposes, physician characteristics are presented by comparing two groups of physicians with vaccination initiation rates above and below the median percentage of their eligible patients who initiated vaccination during the study period (<25% versus ≥25%). We present the distribution of patient characteristics by HPV vaccination initiation. Chi-square with Fisher exact were used to test the association between each patient and provider characteristic and either the median percentage of patients who initiated the vaccine during the study period or HPV vaccination initiation. To determine whether physicians' perceived barriers were associated with HPV vaccination initiation, we first conducted unadjusted, multilevel, generalized linear models with a log link function with binomial distribution and randomly varying intercepts using patient-level HPV vaccination initiation clustered by treating physician. Next, the variables that were found to be suitable for further analysis ($p \le 0.10$) were entered in a multivariable multilevel log-binomial regression model. All independent variables with at least 1 level with $p \le 0.05$ were retained in the final multivariable multilevel logistic regression model (Smolders et al., 2010). As a sensitivity analysis, we tested for the association between each significant physician barrier and HPV vaccination in separate models, adjusting for physician and patient demographic characteristics. These multilevel models allow for variation between patients across all groups and within each physician cluster. To characterize physician-level effects, we used a latent random variable to calculate the physician-specific probabilities of patient vaccination initiation. We also conducted sensitivity analyses to ensure that the model met the assumptions of the random-effects model. A significance level of $\alpha = 0.05$ was selected. All analyses were conducted using SAS 9.4 software (Cary, NC).

3. Results

A total of 134 (59.8%) physicians completed the study survey (Table 1). The average number of study-eligible patients per physician was 275 (SD: 177.9; min 26, max 917). The majority of the physicians were younger than 49 years, saw fewer than 30 patients per day, were female, finished residency >10 years before, and had worked at the clinic for fewer than 10 years. We stratified the physicians based on

Table 1
Characteristics of physicians (n = 134) by the percent of their patients who initiated HPV vaccination.

	Total physician population no. (%)	Physicians with <25% of patients initiating HPV vaccine no. (%)	Physicians with ≥25% of patients initiating HPV vaccine no. (%)
Total physician cohort	134 (100.0)	67 (50.0)	67 (50.0)
Physician demographics			
Age			
<40	49 (36.6)	19 (38.8)	30 (61.2)
40–49	40 (29.6)	20 (50.0)	20 (50.0)
50–59	23 (17.2)	13 (56.5)	10 (43.5)
>60	22 (16.4)	15 (68.2)	7 (31.8)
Race/ethnicity			
Non-Hispanic White	67 (50.0)	34 (50.8)	33 (49.3)
Black	12 (9.0)	4 (33.3)	8 (66.7)
Hispanic	13 (9.7)	7 (53.9)	6 (46.2)
Other	23 (17.2)	12 (52.2)	11 (47.8)
Missing	19 (14.2)	10 (52.6)	9 (47.4)
Daily patient volume			
<30	81 (60.5)	34 (42.0)	47 (58.0)
30 or more	46 (34.3)	28 (60.9)	18 (39.1)
Missing	7 (5.2)	5 (71.4)	2 (28.6)
Sex			
Female	40 (70.2)	23 (46.8)	17 (53.2)
Male	94 (29.9)	44 (57.5)	50 (42.5)
Time since residency, years			
<5	15 (11.2)	7 (46.7)	8 (53.3)
5–9	30 (22.4)	10 (33.3)	20 (66.7)
10–14	31 (23.1)	15 (48.4)	16 (51.6)
>15	58 (43.3)	35 (60.3)	23 (39.7)
Work time at clinic, years			
<5	39 (29.1)	17 (43.6)	22 (56.4)
5–9	28 (20.9)	10 (35.7)	18 (64.3)
10–15	19 (14.2)	12 (63.2)	7 (36.8)
>15	41 (30.6)	23 (56.1)	18 (43.9)
Missing	7 (5.2)	5 (71.4)	2 (28.6)

HPV: human papillomavirus.

whether they fell below or above the median of HPV vaccination initiation for their panel of patients. On average, they vaccinated 22.2% (SD 11.0) of their eligible patients during the study period, where one physician vaccinated 4.8% (min) and one vaccinated 53.3% (max). Half had <25% of their eligible patients initiate HPV vaccination, and half had ≥25%.

Table 2 details the physician-perceived barriers reported when vaccinating children against HPV. Among all physicians the top four barriers were concern about: 1) personal discomfort talking about sexually transmitted infections with parents and patients vaccine safety, 2) HPV vaccine is not required for school attendance, 3) difficulty ensuring the patients will complete the 3-dose HPV vaccine series, and 4) infrequent office visits made by adolescent patients (Table 2).

Of the 36,827 eligible patients (11–18 years of age), 6850 initiated vaccination within the 12-month study period (Table 3). A greater proportion of patients between the ages of 11–12 initiated HPV vaccination than those between 13–18 years of age. A similar proportion of males and females, about 18%, initiated the series. Among the racial/ethnic groups, a greater proportion of Hispanics and Blacks initiated HPV vaccination than non-Hispanic Whites. More children with public insurance initiated the vaccine series than did children with no insurance (Table 3).

In the unadjusted analysis, the relative risk of initiating HPV vaccination was associated with younger patient age, being male, Hispanic versus non-Hispanic white, and having public insurance (Table 4). For example, patients 13–18 years had lower relative risk of initiation than did patients 11–12, older physicians had lower relative risk of having a patient initiate HPV vaccination, and female physicians had higher relative risk of having a patient initiate HPV vaccination than their male counterparts. The barriers physician's face that were significantly associated with lower relative risk of HPV vaccination initiation compared to not a barrier were: 1) concern about the financial burden of HPV vaccine on patients (RR: 0.72, 95% CI: 0.58–0.88), 2) concern about vaccine safety (RR: 0.75, 95% CI: 0.58–0.97), and 3) concern about vaccine efficacy (RR: 0.73, 95% CI: 0.54–0.99) (Table 4). After adjusting for patient and physician characteristics, in the final model, physicians who were concerned about the financial burden of the HPV vaccine on patients was associated with lower relative risk of HPV initiation than physicians who did not note this as a barrier (RR: 0.76, 95% CI; 0.64–0.90).

In the sensitivity analysis we ran three, rather than one, multivariable, multilevel models for each barrier separately and concern about vaccine safety (RR: 0.76, 95% CI: 0.62–0.93), vaccine efficacy (RR: 0.73, 95% CI: 0.58–0.94), and financial burden of the HPV vaccine on patients (RR: 0.76, 95% CI: 0.64–0.90) were each associated with lower relative risk of HPV vaccination initiation, after controlling for physician and patient demographics (data not shown).

After controlling for physician characteristics and barriers, patient demographic variables were associated with the relative risk of HPV vaccination initiation. For instance, we observed that minorities (Hispanics and Blacks) had increased relative risk of initiation than non-Hispanic Whites, males compared with females, and adolescents with public insurance compared to private insurance. Adolescents between the ages 13–18 had significantly lower relative risk of HPV initiation than those 11–12 years (Table 4).

4. Discussion

In this study, we are the first to link physician-reported barriers and characteristics with the uptake of HPV vaccination initiation, identified through EMRs of their panel of patients. Among this diverse patient population, we found that patients had significantly lower relative risk of initiating HPV vaccination if the physician had concerns about the financial burden, regardless of insurance status. This is striking and important since the 2010 Patient Protection and Affordable Care Act mandated that all immunizations be provided to patients at no cost, the law enacted 5 years before our survey was done. Additionally, for uninsured or underinsured patients, the vaccine is covered free-of-charge under the federally funded program Vaccines for Children Program.

We saw that initiation of HPV vaccination was similar for girls and boys. These gender-similar vaccination rates may differ from an earlier study, which found a higher rate for girls because it was conducted around the time HPV vaccination was recommended for boys (Gilkey et al., 2012) and there was a lag in vaccine uptake or because they assessed whether patients had initiated HPV vaccination at any time in the past rather than new initiations in a 12-month period (Reagan-Steiner et al., 2016). In a national immunization survey of U.S. adolescent girls under the age of 13, 14.1% initiated HPV vaccination in a 1-year period (Rahman et al., 2015).

The HPV vaccination initiation rate (18.6%) by age in this study may also differ from other studies because we observed initiation within a 12-month period among adolescents who visited their physicians for any reason, including well-child visits and acute care. We assessed vaccination initiation in the 11–12 age range as well as those in the 13–18 catch-up range to include all pediatric adolescents eligible for CDC-recommended HPV vaccination. The relative risk of initiation for those in the catch-up age was significantly lower because they may have previously refused vaccination when they were younger or missed the opportunity during their 11–12-year well-child visit. Including acute care visits may have inflated our sample size and underestimated the initiation rate than if had we only examined those who initiated at a well-child visit.

Similar to other studies, we found that the relative risk of initiating HPV vaccination was higher for Hispanic than non-Hispanic White adolescents (Jeudin et al., 2014) and for those with public insurance compared with commercial or private insurance (Rattanawatkul, 2014). Hispanics and patients with public insurance may have better rates of

Table 2
Physician barriers by the percent of patients who initiated HPV vaccination.

	Total physician population no. (%)	Physicians with <25% of patients initiating HPV vaccine no. (%)	Physicians with ≥25% of patients initiating HPV vaccine no. (%)
Total physician cohort	134 (100.0)	67 (50.0)	67 (50.0)
Physician barriers[a]			
Level of knowledge about HPV			
Not a barrier	109 (81.3)	54 (49.5)	55 (50.5)
Barrier	25 (18.7)	13 (52.0)	12 (48.0)
Concern about parents' negative perceptions about HPV vaccine[†]			
Not a barrier	100 (74.6)	44 (44.0)	56 (56.0)
Barrier	34 (25.4)	23 (67.7)	11 (32.4)
Personal discomfort talking about sexually transmitted infections with parents and patients			
Not a barrier	36 (26.9)	13 (36.1)	23 (63.9)
Barrier	98 (73.1)	54 (55.1)	44 (44.9)
Concern about financial burden of HPV vaccine on patients[†]			
Not a barrier	100 (74.6)	44 (44.0)	56 (56.0)
Barrier	34 (25.4)	23 (67.7)	11 (32.4)
Concern about vaccine safety[†]			
Not a barrier	113 (84.3)	52 (46.0)	61 (54.0)
Barrier	21 (15.7)	15 (71.4)	6 (28.6)
Concern about vaccine efficacy			
Not a barrier	120 (89.6)	58 (48.3)	62 (51.7)
Barrier	14 (10.5)	9 (64.3)	5 (35.7)
HPV vaccine is not required for school attendance			
Not a barrier	39 (29.1)	18 (46.2)	21 (53.9)
Barrier	95 (70.9)	49 (51.6)	46 (48.4)
Time it takes to discuss HPV vaccine with patients and parents			
Not a barrier	48 (35.8)	21 (43.8)	27 (56.3)
Barrier	86 (64.2)	46 (53.5)	40 (46.5)
Difficulty ensuring the patients will complete the 3-dose HPV vaccine series			
Not a barrier	36 (26.9)	17 (47.2)	19 (52.8)
Barrier	98 (73.1)	50 (51.0)	48 (49.0)
Infrequent office visits made by adolescent patients			
Not a barrier	19 (14.2)	9 (47.4)	10 (52.6)
Barrier	115 (82.8)	58 (50.4)	57 (49.6)

HPV: human papillomavirus.
[a] Items rated "minor," "somewhat," or "major" were considered to be barriers.
[†] Chi-squared test of association $p < 0.05$.

HPV vaccination initiation because physicians may perceive the cost is more likely to be covered and, therefore, routinely recommend the vaccine. Further, Hispanics are reported to favorably view vaccination because of personal experiences with vaccine-preventable diseases (Perkins et al., 2010).

Table 3
Patient demographic characteristics and HPV vaccination initiation among 11–18 year olds, July 1, 2014–June 30, 2015 (n = 36,827).

	Total patient population	Initiated vaccination[a]	Did not initiate vaccination
	No. (%)	No. (%)	No. (%)
Total sample population	36,827 (100.0)	6839 (18.6)	29,988 (81.4)
Patient age[‡]			
11–12	18,117 (49.2)	4262 (23.5)	13,855 (76.5)
13–18	18,710 (50.8)	2577 (13.8)	16,133 (86.2)
Sex			
Female	17,453 (47.4)	3194 (18.3)	14,259 (81.7)
Male	19,374 (52.6)	3645 (18.8)	15,729 (81.2)
Race/ethnicity[‡]			
Non-Hispanic White	17,380 (47.2)	2477 (14.3)	14,903 (85.8)
Black	4573 (12.4)	1109 (24.3)	3464 (75.8)
Hispanic	8399 (22.8)	2120 (25.2)	6279 (74.8)
Other	6475 (17.6)	1133 (17.5)	5342 (82.5)
Insurance type[‡]			
Public	8138 (22.1)	2405 (29.6)	5733 (70.5)
Private	28,589 (77.9)	4434 (15.5)	24,255 (84.5)

HPV: human papillomavirus.
[a] HPV vaccination initiation includes patients who received the first vaccine dose.
[‡] Chi-squared test of the association between each sample characteristic and HPV vaccination initiation for $p < 0.01$.

Physician barriers were associated with patient initiation of HPV vaccination including concerns about vaccine safety and efficacy and, after controlling for physician and patient characteristics, physician concern about the financial burden of the vaccine for patients. Most previous studies reporting that physicians' significant concern about the financial burden of HPV vaccination (Kahn et al., 2005; Keating et al., 2008; Mays and Zimet, 2004; McCave, 2010; Riedesel et al., 2005; Tissot et al., 2007) were conducted predominately before the implementation of no-cost immunizations for patients under the Patient Protection and Affordable Care Act, yet others conducted after its implementation have also noted that this physician perception is still a significant concern (Alexander et al., 2015; Soon et al., 2015). In a sensitivity analysis, we conducted a separate multivariable analysis for each of the three barriers adjusting for patient and physician characteristics and found that concerns about the vaccine safety, vaccine efficacy, and financial burden of the HPV vaccine on patients were statistically significantly associated with lower odds of HPV vaccination initiation. Physician concern about the HPV vaccine safety and efficacy was also found in another study (Bruno et al., 2014) but is predominately addressed by prior clinical trials that demonstrated its efficacy and safety to protect against the strains of HPV that cause disease (Kash et al., 2015; Reagan-Steiner et al., 2016) and by the CDC Advisory Committee on Immunization Practices expert panel who review the literature and recommend the use of the HPV vaccine for adolescents and young adults (Centers for Disease Control and Prevention (CDC), 2010; Markowitz et al., 2007; Petrosky et al., 2015).

One explanation for these findings could be that physicians concerned about a financial burden to patients or about vaccine safety or efficacy may not recommend the HPV vaccine (Ko et al., 2010; Kulczycki

Table 4
Unadjusted and multivariable multilevel regression analysis for the relative risk of patient initiation of HPV vaccination.

	Unadjusted		Multivariable*		Final model**	
	RR	95% CI	RR	95% CI	RR	95% CI
Level 1: patient characteristics						
Patient age						
11–12	1		1		1	
13–18	0.63	0.60–0.65	0.63	0.60–0.66	0.63	0.60–0.66
Sex						
Female	1		1		1	
Male	1.06	1.02–1.11	1.06	1.02–1.10	1.06	1.02–1.10
Race/ethnicity						
Non-Hispanic White	1		1		1	
Black	1.26	1.17–1.34	1.19	1.10–1.27	1.19	1.11–1.27
Hispanic	1.37	1.30–1.45	1.28	1.21–1.36	1.29	1.21–1.36
Other	1.15	1.08–1.23	1.13	1.06–1.20	1.13	1.06–1.20
Insurance type						
Private	1		1		1	
Public	1.42	1.35–1.50	1.36	1.28–1.43	1.36	1.28–1.43
Level 2: physician characteristics						
Physician age						
<40	1		1		1	
40–49	0.80	0.64–1.00	0.89	0.72–1.10	0.83	0.69–0.99
50–59	0.72	0.56–0.94	0.82	0.62–1.09	0.84	0.68–1.04
>60	0.63	0.49–0.83	0.71	0.53–0.96	0.72	0.58–0.90
Race/ethnicity						
Non-Hispanic White	1					
Black	1.24	0.89–1.73				
Hispanic	1.20	0.87–1.65				
Other	1.08	0.83–1.40				
Missing	0.96	0.73–1.27				
Daily patient volume						
<30	1					
30 or more	1.54	0.90–2.64				
Missing	1.17	0.68–2.03				
Sex						
Male	1		1			
Female	1.28	1.05–1.56	1.10	0.92–1.21		
Time since residency, years						
<5	1					
5–9	1.29	0.94–1.78				
10–14	1.05	0.77–1.45				
>15	0.80	0.59–1.07				
Work time at clinic, years						
<5	1		1			
5–10	1.10	0.85–1.42	1.14	0.93–1.41		
10–15	0.71	0.53–0.94	0.83	0.64–1.09		
>15	0.80	0.64–1.01	1.12	0.85–1.46		
Missing	0.64	0.42–0.97	0.79	0.56–1.13		
Physician-perceived barriers						
a. Level of knowledge about HPV						
Not a barrier	1					
Barrier	0.94	0.74–1.19				
b. Concern about parents' negative perceptions about HPV vaccine						
Not a barrier	1		1			
Barrier	0.84	0.68–1.0	0.94	0.78–1.12		
c. Personal discomfort talking about sexually transmitted infections with parents and patients						
Not a barrier	1					
Barrier	0.87	0.71–1.07				
d. Concern about financial burden of HPV vaccine on patients						
Not a barrier	1		1		1	
Barrier	0.72	0.58–0.88	0.82	0.68–0.98	0.76	0.64–0.90
e. Concern about vaccine safety						
Not a barrier	1		1			
Barrier	0.75	0.58–0.97	0.89	0.67–1.17		
f. Concern about vaccine efficacy						
Not a barrier	1		1			
Barrier	0.73	0.54–0.99	0.88	0.63–1.22		
g. HPV vaccine is not required for school attendance						
Not a barrier	1					
Barrier	0.98	0.79–1.20				
h. Time it takes to discuss HPV vaccine with patients and parents						
Not a barrier	1					
Barrier	0.90	0.74–1.09				

(continued on next page)

Table 4 (*continued*)

	Unadjusted		Multivariable*		Final model**	
	RR	95% CI	RR	95% CI	RR	95% CI
i. Difficulty ensuring the patients will complete the 3-dose HPV vaccine series						
Not a barrier	1					
Barrier	0.89	0.72–1.09				
j. Infrequent office visits made by patients						
Not a barrier	1					
Barrier	1.01	0.77–1.31				

HPV: human papillomavirus.
* Multivariable model contains variables from the unadjusted analysis that were $p \leq 0.10$.
** Final model contains variables from the multivariable model that were $p \leq 0.05$.

et al., 2016). We know that a physician's recommendation is a strong predictor of vaccination initiation, (Dempsey et al., 2016; Gottlieb et al., 2009; Guerry et al., 2011; Rosenthal et al., 2011; Vadaparampil et al., 2014; Ylitalo et al., 2013) and that barriers, including physician perception of patient barriers, are associated with the likelihood that physicians vaccinate children (Ko et al., 2010).

To our knowledge, this is the only study to link physician-reported barriers with the EMRs of their patients to assess vaccination initiation. We had a relatively high response rate for pediatric physicians, which may be partially attributed to the online format. In a sensitivity analysis we compared the HPV vaccination initiation rates among physicians who completed the survey to those who did not complete the survey. We found that those who completed the survey had patients with significantly lower HPV vaccination initiation rates than physicians who did not complete the survey. Therefore, our sample examined barriers among physicians with lower vaccination initiation rates, which is an important target group for interventions. Third, we had a large sample of children, which enabled us to apply a multilevel model clustered by physician to account for the variation at the patient and the physician level. Future studies should examine the causal effects of physician barriers and HPV vaccination initiation and account for other potential confounders, such as parent and clinic organization barriers. Still, given the importance of physician recommendations, continued examination of physician barriers is needed to inform interventions designed to mitigate them and to increase vaccination rates.

Our study has its limitations. First, for this observational study, while we determined the number of eligible patients who initiated HPV vaccination within a 12-month period, we conducted the survey with physicians at the end of the 12-month period. This, however, may still be a good indicator for physician barriers during their previous year's practice since physician barriers to HPV vaccination are not likely to change over time and tend to be slightly minimized (Vadaparampil et al., 2014). Our eligibility criteria also limited the patient sample to a particular subset who had not begun HPV vaccination and whose physicians responded to the survey. Because we excluded adolescents who initiated HPV vaccination according to recommended guidelines prior to the study period, our findings may reflect a sample of patients in the 13–18 catch-up age range who were more hesitant than the larger patient population. In addition, unmeasured parent-related confounders are not accounted for in our analysis. For example, we did not consider parents' decision-making role and willingness to vaccinate their child (Allen et al., 2010; Bastani et al., 2011; Bednarczyk et al., 2011; Brewer et al., 2011; Guerry et al., 2011; Williams et al., 2011). In this study we were not able to illuminate why physicians perceive a financial burden of the vaccine on patients but it is possible that other direct costs such as time off from work and transportation, not directly associated with the cost of the vaccine for parents, may be a burden. However, the question specifically asked physicians about the financial burden of the HPV vaccine. Also, multilevel models do not allow for feedback loops or reciprocal interactions between physicians and patients, however, the goal of our paper was not to study the dynamic relationship between physicians and patients but to study the association between physicians' perceived barriers and HPV vaccination initiation. Finally, results may only be generalized to physicians who practice in similar urban settings and provide care to diverse patient populations.

5. Conclusion

The results from this study suggest that interventions to minimize pediatrician-perceived barriers to vaccinating patients against HPV, particularly their perceptions of the financial burden to patients and of vaccine safety and efficacy, may increase uptake among adolescents. Continued research is needed to understand the persistence of physician perception of financial barriers to patients, given the health policy mandates in the Patient Protection and Affordable Care Act that eliminate vaccination costs for all patients, insured and uninsured. Therefore, no adolescent or parent should have a financial burden associated with receiving HPV vaccination, and this concern is likely unfounded. Seeing this as a concern among pediatricians indicates that educating them on changing coverage is an important strategy to increase uptake of new guideline recommendations. Continued studies monitoring physician perceptions of barriers are also needed to inform pediatrician-targeted interventions and to understand other aspects of this dynamic physician-patient relationship.

Transparency document

The Transparency document associated with this article can be found, in online version.

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Conflict of interest

The authors declare no conflict of interest.

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