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HPV vaccine recommendation practices of current and future physicians in North Carolina: an exploratory study

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Abstract

We assessed human papillomavirus (HPV) prevention practices and HPV literacy of pediatricians, family physicians and medical students in North Carolina. An online survey was distributed to physicians in 2018, and paper surveys were collected among medical students in 2019. Surveys measured HPV literacy, HPV prevention practices and HPV prevention self-efficacy. In terms of comfort, 27% of medical students and 24% of physicians anticipated having an uncomfortable conversion when recommending the vaccine to patients. Most physicians (76%, $n = 230$) followed the HPV vaccine age recommendation guidelines; however, those with higher HPV vaccine knowledge were more compliant with the guidelines ($P < 0.01$). Female physicians were more likely to start routinely recommending the HPV vaccine to women (84%, $n = 134$ versus 72%, $n = 92$) and men (81%, $n = 127$ versus 71%, $n = 84$) between the ages of 9 and 12 years ($P < 0.05$). Only 27%, $n = 73$ of physicians and 18%, $n = 19$ of medical students followed/knew the 'provider-driven' HPV-recommended style. Female physicians were more likely to use this communication style (32%, $n = 48$ versus 20%, $n = 23$, $P = 0.03$). HPV prevention curriculum should be incorporated into medical programs. The gender-related practice patterns found indicate a need for training of male providers specifically. Quality improvement efforts are needed for all physicians to strengthen vaccine communication, recommendation practices and guideline adherence.

Introduction

Human papillomavirus (HPV) is the most common sexually transmitted infection (STI) in the United States [1]. Some strains of HPV cause genital warts, and others can lead to anogenital (i.e. cervical, anal, vaginal, penile and vulvar) and oropharyngeal cancers in both men and women [2, 3]. Substantial proportions of HPV-related morbidities and deaths may be prevented through vaccination. Since 2016, Gardasil®9 (Merck Sharp & Dohme Corp., New Jersey) is the only HPV vaccine licensed and distributed in the United States [4]. Gardasil® 9 can prevent approximately 90% of cervical, vulvar, vaginal and anal cancers caused by HPV types 16, 18, 3133, 45, 52 and 58 [5].

The US Advisory Committee on Immunization Practices (ACIP) recommends routine vaccination at 11 or 12 years of age, with catch-up vaccination

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for everyone between ages 13 and 26 [4]. Although less benefit from HPV vaccination has been shown in adults 27–45 years old, people in this age range should use shared clinical decision-making with their healthcare provider to understand if they may benefit from HPV vaccination [4]. Although it is well known that the HPV vaccine has the potential to reduce HPV-related disease, as of 2019, 54.2% of US adolescents were up-to-date with HPV vaccination (up-to-date includes those with $\geq$3 doses and those with two doses when the first HPV vaccine dose was initiated at age <15 years) and 71.5% had received at least one dose in the United States [6]. Both of these figures are below the Healthy People 2030 goal to increase the proportion of adolescents who get recommended doses of the HPV vaccine to 80% [7]. For the purposes of this paper, the term adolescents include those between the ages of 13 and 17 years.

Healthcare provider recommendation is the single best predictor of adolescent vaccination against HPV [8–11]. Studies have shown that provider recommendation for HPV vaccination is significantly associated with both receipt and completion of the HPV vaccine and is a critical strategy in increasing vaccination coverage [12–14]. However, studies have found that providers are not in compliance with ACIP and American Academy of Family Physicians recommendations which call for consistent and strong recommendations of the HPV vaccine and recommend bundling it with other pre-teen vaccines such as Tetanus, Diphtheria, and Pertussis and meningococcal vaccine to not single out the HPV vaccine [15]. This bundling approach normalizes the HPV vaccine and increases its acceptance [15]. Lack of recommendation by providers could be related to their own lack of understanding of HPV epidemiology, current vaccine recommendations or limited guidance on how to communicate HPV recommendations to adolescents and their parents [16]. Therefore, it is critical to determine factors that can affect providers' HPV vaccination practices. Factors that may be associated with recommendation practices of the HPV vaccine among providers are their HPV health literacy and their attitude toward vaccination, as attitudes have been shown to predict recommendation behavior even more strongly than professional guidelines [17–19].

A study by Afonso et al. conducted an assessment of HPV vaccination rates and their HPV knowledge and attitudes toward vaccination among US medical students in a Midwestern medical school [20]. Although the majority of students was well informed about HPV transmission, cervical cancer and vaccine safety, there were knowledge gaps in regard to the protective effect of the HPV vaccine in cancers other than cervical and the immunity provided by the vaccine [20]. Another study by Berenson et al. found that medical students at the University of Texas Medical Branch at Galveston had inadequate baseline knowledge of HPV epidemiology and the HPV vaccine [21]. This same study also found that unvaccinated medical students (those who self-reported to not have received the HPV vaccine) may delay recommendation of the HPV vaccine until patients are 15–16 years old, suggesting that they are less likely to recommend the HPV vaccine based on ACIP recommendations compared with vaccinated medical students [22]. Medical students are a key audience for HPV-related communication and training because of their impending role as healthcare providers. Medical students should be taught approaches to providing effective primary prevention in terms of HPV vaccine recommendation and counseling parents, adolescents and young adults aged 18–26 years about HPV and the HPV vaccine as a cancer-preventing vaccine. Given this information, this study sought to assess HPV health literacy and HPV prevention practices of pediatricians, family physicians and medical students in North Carolina (NC). This study is exploratory and represents the first phase of a larger intervention study. The larger study included the development and evaluation of enhanced training curricula for medical students to increase HPV health literacy and intention to provide a strong HPV vaccine recommendation. A paper describing the results of this study is currently under review.

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Materials and methods

Participants

We conducted a quantitative assessment to measure HPV health literacy skills, current and/or intended HPV prevention practices (communication/education and vaccine recommendation) and self-efficacy in providing primary HPV prevention among licensed and practicing physicians in pediatrics and family medicine in NC and among medical students attending at a school of medicine in NC. At the time of study initiation, there were ∼38 000 licensed and active physicians in NC, of which ∼6000 specialized in pediatrics and family medicine, and there were ∼350 medical students at the school of medicine where this study was conducted.

We assessed health literacy and prevention practices of practicing physicians and health literacy and intended practices of medical students (future medical providers). Inclusion criteria for the practicing physician survey included physicians who are members of the NC Pediatrics Society or the NC Academy of Family Physicians with an active email address and all pediatric and family medicine physicians who are registered with the NC Medical Board with an active email address. Inclusion criteria for the medical student survey included medical students attending the school of medicine in NC. All study documents and protocols were approved by the University and Medical Center Institutional Review Board prior to study implementation.

Procedure

A link to an online survey via Qualtrics was distributed to the NC Pediatric Society Listserv in August 2018 (∼1300 members) and the NC Academy of Family Medicine's e-newsletter (twice in July 2018) (∼4000 members including active members, residents and medical students) and emailed to all pediatric and family medicine physicians who are registered with the NC Medical Board with an active email address in November 2018 (∼21 000). Online consent using an information sheet was obtained from study participants prior to completing the survey. As an incentive, physicians who completed the survey entered a drawing for an Apple Watch by providing their email addresses at the end of the survey. We provided one Apple Watch per recruitment site ($n = 3$) using a random number table to select a number from the list of survey respondents. Email addresses were kept in a separate file from survey responses. Only physicians who self-selected to enter their email addresses were eligible for the drawing, and they did not have to enter their email addresses to participate in the survey. For medical students, study recruitment occurred in common places at the school of medicine on selected days/times when the study team knew medical students had scheduled mandatory events. Paper survey data were collected face-to-face, and a $5 Starbucks gift card was provided as an incentive in January 2019. Verbal consent using a written information sheet was obtained prior to survey completion.

The physician and medical student surveys containing 25 items were developed using some validated surveys employed with similar populations [23, 24] and piloted among a panel of experts, including physicians, social scientists and medical students (see the sample survey in the Appendix). Both the physician and medical student survey inquired about six main constructs: (i) HPV knowledge, (ii) HPV vaccine knowledge, (iii) attitudes about HPV, (iv) perceived social pressures around issues of HPV prevention, (v) perceived behavioral control (self-efficacy) over the behavior of HPV prevention and (vi) intention or actual engagement in HPV prevention practices, including style and comfort in the recommendation. In addition to questions that measured these six variables, the instrument included questions on basic demographics and background such as medical specialty, years in practice, type of practice, sex, age, race/ethnicity, if there is an HPV vaccination policy where they practice, and interest in an HPV-related training for the physician survey. The medical student survey also queried on demographics including age, race/ethnicity, sex, current year in medical school,

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intended specialty, vaccination status and interest in receiving HPV-related training. Medical students were also asked if they believed the HPV-related education they had received in their medical education program thus far was adequate for clinical practice (yes, no and not sure response categories).

Statistical analysis

We conducted all analyses using SPSS software version 25 [25]. Descriptive data (frequencies, percentages and means) and exploratory bivariate analyses (chi-squared test) were conducted. Bivariate analysis was explored between provider demographic characteristics and HPV vaccine recommendation practice survey items (compliance with HPV vaccine age recommendations, communication style and comfort).

Results

NC pediatric and family medicine physician survey

Of all physicians who responded, 644 had usable surveys, and 307 of those (48%) reported providing vaccinations to adolescents. Here, we present the findings of the 307 pediatric and family medicine physicians who reported providing adolescent vaccinations in NC. The exact response rate of NC physicians surveyed is unknown because it is unknown how many functional email addresses were in the sample. The response rate is likely low (<1%); however, this research is exploratory in nature. Most of the samples were white (80%), over half were female (56%) and half reported working in private practice (50%), followed by a hospital-based clinic (34%) and others (16%) (Table I). Age was equally distributed with roughly a third of the sample falling into each of the three categories (18–44 years old; 45–54 years old and 55 years or older). Almost a third of the sample had been practicing medicine under 10 years (29%), a quarter had been practicing 10–19 years (25%) and under half (46%) had been practicing medicine over 20 years. Less than half (42%) reported an HPV vaccination policy within their practice.

Table I. *Demographic characteristics of NC physicians (n = 307)*[a]

	n (%)
Sex	
Female	160 (56)
Male	128 (44)
Race/ethnicity	
White	227 (80)
Other	57 (20)
Age	
18–44 years old	101 (35)
45–54 years old	90 (31)
≥55 years old	98 (34)
Years in practice	
<10 years	84 (29)
10–19 years	71 (25)
20+ years	134 (46)
Practice has HPV vaccination policy	120 (42)
Type of practice/clinic	
Private practice	143 (50)
Hospital-based clinic, including university	99 (34)
Other, including federally qualified health center, military and public health department	46 (16)

[a]Numbers may not add up to 307 due to missing data.

In terms of HPV and HPV vaccine knowledge, most physicians knew that HPV can be spread through oral sex (85%), that most people will be infected with at least one type of HPV in their lives (71%) and that HPV vaccination was recommended from 11 years of age through 26 years of age for gay, bisexual and men who have sex with men (MSM) (65%) (Table II). Fewer (52%) knew the correct recommendation time between the first and second HPV vaccine dose, and less than half (43%) knew that most HPV infections were clear within 2 years or that the rate of HPV-related oropharyngeal cancer is higher among men (51%).

Most physicians (>76%) were in compliance with the ACIP HPV vaccine age recommendation guidelines (i.e. start routinely recommending HPV vaccine between the ages of 9 and 12 years). Specifically, 76% of physicians were in compliance for men, and 79% were in compliance for women. Differences were found based on provider

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Table II. *HPV and HPV vaccine knowledge among NC physicians (n = 307)*

Item	*n* (% correct)
Most HPV infections clear within 2 years	132 (43)
The rate of HPV-related oropharyngeal cancer is higher among women[a]	133 (43)
Most people will be infected with at least one type of mucosal HPV at some point in their lives	218 (71)
HPV can spread through oral sex	262 (85)
The recommendation time between the first and second dose of the HPV vaccine is 6–12 months	160 (52)
Vaccination is recommended through age 26 for gay, bisexual and MSM[b]	201 (65)

Note: we coded skipped answers as incorrect.
[a]Correct answer is false.
[b]This was the recommendation at the time the study was conducted. Presently, the vaccine is recommended for everyone 11–26 years age.

gender (Table III). Female physicians as compared with male physicians were significantly more likely to start routinely recommending the HPV vaccine to both women (84% versus 72%) and men (81% versus 71%) between the ages of 9 and 12 years ($P < 0.05$) (Table III).

Only 27% of physicians sampled followed the 'provider-driven' Centers for Disease Control and Prevention (CDC)-recommended style of informing the patient their child is due for the HPV vaccine, providing them information and making the decision to order the HPV vaccine unless the parent has an objection (Table III). Female physicians were significantly more likely to use the 'provider-driven' HPV vaccine-recommended communication style as compared with male physicians (32% versus 20%, $P = 0.03$). Similarly, female physicians were more likely to use the CDC recommendation to bundle all pre-teen vaccinations during the patients' visit as compared with male physicians (85% versus 73%, $P = 0.02$) and were more likely to feel comfortable talking to adolescents about STIs (98% versus 89%, $P < 0.01$). Physicians with higher HPV vaccine knowledge were more likely to comply with the ACIP HPV vaccine age recommendation guidelines for both women and men ($P < 0.01$). Although not statistically significant, providers with less years in practice were more likely to comply with HPV vaccine age recommendation guidelines. Race/ethnicity was not significantly related to HPV vaccine recommendation practices in this sample.

In terms of comfort, almost all physicians (98%) reported being comfortable recommending the HPV vaccine; however, 24% anticipated having an uncomfortable conversation when recommending the vaccine to patients. Physicians who had less years in practice anticipated having an uncomfortable conversation when they thought about recommending the HPV vaccine to adolescents as compared with physicians with more years in practice ($P = 0.04$). For example, 26% of providers with less than 10 years of experience practicing medicine and 33% of providers with 10–19 years in practice anticipated having an uncomfortable conversation when they think about recommending the HPV vaccine to adolescents as compared to those who have practiced medicine for over 20 years (17%) (Table III). HPV knowledge was not significantly related to comfort in recommending the HPV vaccine to patients or in talking with adolescents about STIs. Last, just over half (51%) of respondents were interested in receiving a brief training in the newest HPV vaccine guidelines and information.

Medical student survey

The medical student survey reached 105 students which represented ~30% of the medical student body at the institution where data were collected. Of survey respondents, the mean age was 24, and 51% were female (Table IV). Over half of the samples were white (58%), which reported they received the HPV vaccine themselves (56%), and the majority (72%) was first-year medical students. Close to one-third (30%) of medical students reported an intended specialty in family medicine/pediatrics.

In terms of HPV and HPV vaccine knowledge, the majority of students knew that a person can transmit HPV even though a genital wart may not

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Table III. *Relationship between HPV vaccine recommendation practices and selected provider demographics (n = 307)*[a]

	n (%)	*P*-value[b]
Do physicians start routinely recommending the HPV vaccine for 'women' and 'men' at the same age?		
Yes	241 (83)	
No	48 (17)	
Compliance with HPV vaccine age recommendation for women by provider sex		**0.02**
Female	134 (84)	
Male	92 (72)	
Compliance with HPV vaccine age recommendation for men by provider sex		**0.04**
Female	127 (81)	
Male	84 (71)	
Compliance with HPV vaccine age recommendation for women by years in practice		0.47
<10 years	68 (81)	
10–19 years	58 (82)	
20+ years	101 (75)	
Compliance with HPV vaccine age recommendation for men by years in practice		0.35
<10 years	66 (81)	
10–19 years	54 (78)	
20+ years	92 (73)	
Compliance with HPV vaccine age recommendation for women by race/ethnicity		0.84
White	178 (78)	
Other	44 (77)	
Compliance with HPV vaccine age recommendation for men by race/ethnicity		0.53
White	166 (77)	
Other	41 (73)	
Compliance with the 'provider-driven' HPV vaccine-recommended communication style by provider sex		**0.03**
Female	48 (32)	
Male	23 (20)	
Compliance with HPV vaccine recommendation of bundling all pre-teen vaccinations during current patient visit by provider sex		**0.02**
Female	126 (85)	
Male	82 (73)	
Comfort talking with adolescents about STIs by provider sex		**<0.01**
Female	146 (98)	
Male	101 (89)	
Anticipate having an uncomfortable conversation when recommending the HPV vaccine to adolescents by years in practice		**0.04**
<10 years	20 (26)	
10–19 years	22 (33)	
20+ years	21 (17)	

[a]Numbers may not add up to 307 due to missing data.
[b]Chi-squared test. Note: Statistically significant differences are bolded.

be present (91%), that the HPV vaccine is recommended for routine vaccination at age 11 or 12 years, for both women and men (84%), and that HPV can spread through oral sex (84%) (Table V). Fewer knew that most people will be infected with at least one type of mucosal HPV at some point in their lives (70%) and that HPV can cause anal and penile cancers (66%). Even less knew

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Table IV. *Demographic characteristics of medical students (n = 105)*

Age, mean (SD)	24.3 (1.3)
	n (%)
Sex	
Female	54 (51)
Male	50 (48)
Race/ethnicity	
Black	20 (19)
White	61 (58)
Other[a]	24 (23)
Current year in school	
1st	74 (72)
2nd–4th	29 (28)
Intended specialty	
Family medicine/pediatrics	31 (30)
Other[b]	72 (70)
Received HPV vaccine themselves	
Yes	59 (56)
No/ not sure	46 (44)
If Yes, how many shots completed[c]	
1	1 (3)
2	5 (17)
3	23 (79)

[a]Other includes Hispanic, Native America, Asian and Other.
[b]Other includes several other specialties such as internal medicine.
[c]Only a three-dose HPV vaccination series was available to this population when they were adolescents.

Table V. *HPV and HPV vaccine knowledge among medical students (n = 105)*

	n (% correct)
Most HPV infections clear within 2 years	36 (35)
The rate of HPV-related oropharyngeal cancer is higher among women[a]	23 (22)
Most people will be infected with at least one type of mucosal HPV at some point in their lives	73 (70)
A person can transmit HPV even though a genital wart may not be present	96 (91)
HPV can cause anal and penile cancers	69 (66)
HPV can spread through oral sex	88 (84)
The HPV vaccine is recommended for routine vaccination at an age of 11 or 12 years, for both girls and boys	88 (84)
The recommended time between the first and second HPV vaccine dose for adolescents at an age of 11 or 12 years is 6–12 months	45 (44)

Note: The first item listed had one missing data point and the item listed last had three missing data points, and thus, the valid percent was used in calculations.
[a]Correct answer is false.

that the rate of HPV-related oropharyngeal cancer is higher among men (22%) and that most HPV infections clear within 2 years (35%). Only 44% knew that the recommended time between the first and second HPV vaccine dose for adolescents at ages 11 or 12 years was 6–12 months (Table V). Despite some knowledge, only 24% of medical students surveyed thought the HPV-related education they have received in their medical program thus far is adequate for clinical practice. However, when separated by year in medical school, 57% of second-fourth year medical students thought their education was adequate for clinical practice as compared with 8% of first-year medical students. The majority (82%) reported being interested in receiving a brief training on the newest HPV vaccine guidelines and information.

Medical students were also asked about HPV vaccine communication (comfort/confidence) and recommendation practices. In terms of comfort, 27% of respondents anticipated having an uncomfortable conversation when recommending the HPV vaccine to adolescents, and similarly, 31% felt uncomfortable or neutral in talking with adolescents about STIs (Table VI). Only 18% of medical students knew the most effective communication 'provider-driven' CDC-recommended style when discussing the HPV vaccine with parents (informing the patient their child is due for the HPV vaccine, providing them information and making the decision to order the HPV vaccine unless the parent has an objection). In terms of confidence, 72% of medical students reported being confident in recommending HPV vaccines for patients, and 63% reported confidence in talking about HPV risk factors with patients. Last, most students believe that the vaccine should be recommended more often for adolescents at higher risk for getting HPV (78%) (Table VI). Students 24–25 years old (compared with 22–23 and 26 years old) and 2nd–4th year (compared with 1st year) medical students felt more confident in recommending HPV vaccines for patients ($P < 0.05$). White (compared with other race/ethnicities) students and 2nd–4th year (compared with 1st year) students were more

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Table VI. *Self-efficacy in HPV vaccine communication and recommendation practices among medical students (n = 105)*

Item	*n* (%)
When I think about recommending the HPV vaccine to adolescents, I anticipate having an uncomfortable conversation	
Agree	28 (27)
Disagree/not sure	77 (73)
The HPV vaccine should be recommended more often for adolescents at higher risk for getting HPV	
Agree	80 (78)
Disagree/not sure	23 (22)
How comfortable are you talking with adolescents about STIs?	
Comfortable	72 (69)
Uncomfortable/neutral	33 (31)
How confident are you in recommending HPV vaccines for patients?	
Confident	75 (71)
Not at all confident/not sure	30 (29)
How confident are you talking about HPV risk factors with patients?	
Confident	66 (63)
Not at all confident/not sure	39 (37)

confident talking about HPV risk factors with patients ($P < 0.05$).

Discussion

This study sought to assess HPV health literacy and HPV prevention practices of practicing pediatrics and family medicine physicians in NC and medical students attending a medical school in NC. Overall, we found gaps and variations in HPV health literacy and HPV prevention practices among students and physicians. Gaps in knowledge that were found call for improvement in understanding the recommendation time between HPV vaccine doses, how HPV infections clear within the body and the epidemiologic patterns of HPV-related oropharyngeal cancer. Although practicing physicians had higher rates of HPV and HPV vaccine knowledge than the medical students surveyed, both groups had lower levels of knowledge in the same areas. Because knowledge was linked to compliance with ACIP HPV vaccine age recommendation guidelines, these gaps in knowledge highlight a need for medical student and physician HPV education and training to increase HPV vaccination guideline compliance.

In terms of HPV prevention, we found that female physicians were more often in compliance with ACIP HPV vaccine age recommendation guidelines, with the 'provider-driven' CDC-recommended style and with the bundling of vaccinations as compared with their male counterparts. Providers with less years in practice were more likely to comply with HPV vaccine age recommendation guidelines, and perhaps significant differences would have been detected in this relationship with a larger sample size. Less than a third of physicians surveyed, and only 18% of medical students surveyed followed or knew the most effective communication 'provider-driven' CDC-recommended style when discussing the HPV vaccine with parents (informing the patient their child is due for the HPV vaccine, providing them information and making the decision to order the HPV vaccine unless the parent has an objection). Thus, there is a need for education and training around effective ways to deliver HPV vaccine messaging to patients.

Because we found that male physicians were less comfortable in talking with adolescents about STIs as compared with female physicians and almost a third of medical students felt uncomfortable or neutral about talking to adolescents about STIs, further education and training may lead to greater comfort in having these conversations. Generally, older students were more confident in recommending HPV vaccines for patients and talking about HPV risk factors, perhaps because they have more education than their younger peers. In this study, white students were more confident talking about HPV risk factors with patients than students from other racial/ethnic backgrounds. Although it is unclear why this was significant, perhaps white students being trained by faculty that are also demographically similar to them disproportionally increased their confidence [26].

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Only 46% of second-fourth year medical students surveyed thought the HPV-related education they have received in their medical program thus far is adequate for clinical practice which also lends itself to the need for greater education and training. Because 82% of medical students surveyed wanted training in the newest HPV vaccine guidelines and information, it seems they are open to this sort of education.

These findings are in line with other research findings around knowledge and HPV vaccination recommendation practices. A systematic review that reviewed over 100 studies on provider HPV vaccine communication published in 2016 found mixed evidence on whether HPV-related knowledge influenced providers' communication about HPV vaccination, but overall reported a modest association [27]. Mixed findings on knowledge were also found in this study where provider knowledge was related to provider compliance with ACIP HPV vaccine age recommendation guidelines for both women and men but not significantly related to comfort in recommending the HPV vaccine to patients or in talking with adolescents about STIs.

In terms of provider sex and HPV vaccine recommendation, the systematic review found that most studies did not find differences in HPV vaccine recommendations by provider sex, however, those that did most often favored female providers [27]. Unlike most studies in the systematic review, this study did find that provider sex was related to compliance with ACIP HPV vaccine age recommendation guidelines, as well as a provider-driven recommendation style and bundling of vaccinations. This study's findings were similar to those reported in the systematic review where when provider sex was related to vaccine recommendations, female providers were favored [27].

One main limitation of this study is the physician response rate. Given the low response, no data are available for nonresponders, and therefore, no calculations can be performed to evaluate responder bias. A second limitation is generalizability; we cannot generalize our findings to all pediatric and family medicine physicians who provide adolescent vaccinations in NC or similarly all medical students at the medical school, and thus, there may be alternate levels of knowledge, HPV vaccine recommendation practices and perceptions not captured in this study. Additionally, the physician sample was largely white in racial/ethnic composition, and this lack of diversity further limits generalizability. A third limitation is that the medical student survey was cross-sectional and thus may not be a representative sample of all medical students in the medical school where surveyed or in NC as a whole. Furthermore, the medical student respondents were largely first-year medical students and, in most cases, would presumably have limited clinical experience. This inexperience may have affected their HPV knowledge and intended prevention practice responses. Last, a limitation of both the provider and medical student survey methodology is that all respondents were self-selected to participate in the survey, and thus, the sample could be biased based on this self-selection.

Even considering these weaknesses, this study still has important implications for practice and provider education and training. In terms of HPV health literacy, this study highlights areas of improvement for both medical students and practicing physicians. In terms of HPV vaccine communication and recommendation practices, this study points to opportunities to improve the best HPV vaccine recommendation practices, especially among male providers and older providers with more years in practice. Next steps for practicing physicians include quality improvement efforts that should be developed, tested and delivered to strengthen communication about HPV vaccination in terms of its importance, effective recommendation style ('provider-driven' and bundling recommendation) and the need to deliver routine recommendations to all 11- and 12-year olds. Given that gender was significantly related to differential practices around HPV prevention (compliance with HPV vaccine age recommendations, communication style and comfort), there is a need to specifically target male physicians in intervention development and promulgation. It

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would also be important to better understand how these gender-related practice patterns affect vaccine uptake and other patient health outcomes. These findings can raise awareness of gender differences in HPV prevention and fuel intervention development for male providers. Next, steps for medical students include curriculum development, testing and delivery in medical programs around effective recommendation practices and HPV prevention communication and practice for students. Interventions are needed to support providers in recommending HPV vaccination effectively and efficiently. This study has the potential to catalyze future research by the development of effective curricula for medical students and intervention strategies for practicing physicians in effective and best practices around HPV vaccine recommendations. In fact, findings from this study prompted the development and evaluation of a theory-driven digital health intervention for medical students to increase their intention to provide a high-quality HPV vaccine recommendation. The research team developed a 15-min digital educational module which included slides with voiceover, pertinent video clips and a toolbar at the bottom where participants could move forward or backward in the module at their own pace. Module development was guided by the Theory of Reasoned Action/Planned Behavior [28], by the gaps in knowledge and curriculum identified among physicians and medical students found in this formative work and by existing educational videos and communication tools from reputable sources like the Centers for Disease Control and Prevention, the American Academy of Pediatrics and the Academic Pediatric Association such as Same Way, Same Day™ [29–32]. A paper demonstrating the findings is currently under review for publication. Study findings could also be used to develop an online training module for practicing physicians. Improving healthcare professionals' HPV knowledge, prevention practices and effective patient communication is a critical step toward increasing HPV vaccination rates and reducing the deleterious effects of HPV-related disease.

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Conflict of interest statement

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Appendix: HPV vaccine survey (practicing physicians)

1. What is your medical specialty?

   ☐ Pediatrics
   ☐ Family Medicine
   ☐ Medicine/Pediatrics
   ☐ Internal Medicine
   ☐ Obstetrics and Gynecology
   ☐ Other_____

2. Do you provide vaccinations to adolescents?

   ☐ Yes
   ☐ No (Please skip to question 23)

3. I start routinely recommending the HPV vaccine when a 'female' patient is between the ages of …

   ☐ 9 and 10
   ☐ 11 and 12

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☐ 13 and 17
☐ 18 and 26
☐ 27+
☐ I don't base recommendations on age.
☐ I don't routinely recommend the HPV vaccine.

4. I start routinely recommending the HPV vaccine when a 'male' patient is between the ages of …

☐ 9 and 10
☐ 11 and 12
☐ 13 and 17
☐ 18 and 26
☐ 27+
☐ I don't base recommendations on age.
☐ I don't routinely recommend the HPV vaccine.

5. Which of the following best describes your communication style when discussing the HPV vaccine?

☐ I inform the parent their child is due for the HPV vaccine, provide them information and leave the decision-making to the parent.
☐ I inform the parent their child is due for the HPV vaccine, provide them information and make the decision to order the HPV vaccine unless the parent has an objection.
☐ I inform the parent their child is due for the HPV vaccine, provide them information and have a joint discussion and come to the decision about the HPV vaccine together.
☐ I only discuss the HPV vaccine with the parent if they express interest in vaccinating their child.
☐ I don't usually have a discussion with parents about the HPV vaccine.

Please check whether you agree or disagree with the following statements:

	Strongly agree	Somewhat agree	Neither agree or disagree	Somewhat disagree	Strongly disagree
6. When I think about recommending the HPV vaccine to adolescents, I anticipate having an uncomfortable conversation.					
7. I recommend the HPV vaccine more often for adolescents at higher risk for getting HPV.					

Please check your level of comfort regarding the following questions:

	Very comfortable	Comfortable	Neutral	Uncomfortable	Not comfortable
8. How comfortable are you talking with adolescents about STIs?					
9. How comfortable are you in recommending the HPV vaccines for patients?					

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10. During a pre-adolescent's wellness visit, I usually…

☐ Recommend the adolescent get all their pre-teen vaccinations (per vaccination guidelines) during the current visit
☐ Recommend the adolescent get the vaccines required for school entry
☐ Inform the parent their child is due for their pre-teen vaccines, provide them with information and let them decide what is best for their child
☐ None of the above

11. Which of these would help you when discussing the HPV vaccine with hesitant parents? (check all that apply)

☐ Scripted answers to common concerns
☐ A communication strategy to structure the conversation
☐ An educational brochure
☐ A vaccine information sheet that is easy to understand
☐ A website parents can access
☐ Office policy that supports a vaccination policy
☐ I don't know

Please check whether you think the following statement is true, false or if you are not sure:

	True	False	Not sure
12. Most HPV infections clear up within 2 years.			
13. The rate of HPV-related oropharyngeal cancer is the highest among women.			
14. HPV can spread by oral sex.			
15. Vaccination is recommended through age 26 for gay, bisexual and MSM.			
16. Most females and males will be infected with at least one type of mucosal HPV at some point in their lives.			

17. What is the recommended time between the first and second dose of the HPV vaccine for an 11–12-year-old?

☐ 3–6 months
☐ 6–12 months
☐ 12–18 months
☐ 18–24 months

18. Would you be interested in receiving a brief training on the newest HPV vaccine guidelines and information?

☐ Yes
☐ No (Skip to question 20)

19. Good ways to attend 1-h communication training for continuing education credit on recommending the HPV vaccine are … (Check all that apply)

☐ At my practice or clinic's regular meetings
☐ At a national or regional medical conference
☐ Online at my pace
☐ None of the above

20. How many years have you been practicing medicine? (Count only years after residency/fellowship)

☐ <5 years
☐ 5–9 years
☐ 10–14 years
☐ 15–19 years
☐ 20+ years

21. Which of the following 'best' describes your practice or clinic?

☐ Private practice, including solo, group practice or Health Maintenance Organization
☐ Federally qualified health center, including community, migrant, rural or Indian health center
☐ Hospital-based clinic, including university clinic or residency teaching practice
☐ Public health department-operated clinic
☐ Military clinic
☐ Other _____

22. Does your practice have an HPV vaccination policy?

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☐ Yes _____ (Please describe)
☐ No

23. What is your sex?

☐ Male
☐ Female

24. What is your race/ethnicity?

☐ White
☐ Hispanic or Latino
☐ Black or African American
☐ Native American or American Indian
☐ Asian/Pacific Islander
☐ Other_____
☐ Prefer to no disclose

25. How old are you?

☐ 18–24 years old
☐ 25–34 years old
☐ 35–44 years old
☐ 45–54 years old
☐ 55–64 years old
☐ 65–74 years old
☐ ≥75 years old

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