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RESEARCH ARTICLE

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## Medical students' knowledge of HPV, HPV vaccine, and HPV-associated head and neck cancer

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### ABSTRACT

On the basis of their training, medical students are considered “the best case scenario” among university students in knowledge of the human papillomavirus (HPV). We evaluated differences in knowledge of HPV, HPV vaccine, and head and neck cancer (HNC) among medical students. A previously validated questionnaire was completed by 247 medical students at a Midwestern university. Outcomes of interest were knowledge score for HPV and HPV vaccine, and HNC, derived from combining questionnaire items to form HPV knowledge and HNC scores, and analyzed using multivariate linear regression. Mean scores for HPV knowledge were 19.4 out of 26, and 7.2 out of 12 for HNC knowledge. In the final multivariate linear regression model, sex, race, and year of study were independently associated with HPV and HPV vaccine knowledge. Males had significantly lower HPV vaccine knowledge than females ( $\beta = -1.53$ ; 95% CI:  $-2.53, -0.52$ ), as did nonwhite students ( $\beta = -1.05$ ; 95% CI:  $-2.07, -0.03$ ). There was a gradient in HPV vaccine knowledge based on the year of study, highest among fourth year students ( $\beta = 6.75$ ; 95% CI:  $5.17, 8.33$ ). Results were similar for factors associated with HNC knowledge, except for sex. HNC knowledge similarly increased based on year of study, highest for fourth year students ( $\beta = 2.50$ ; 95% CI:  $1.72, 3.29$ ). Among medical students, gaps remain in knowledge of HPV, HPV vaccine, and HPV-linked HNC. Male medical students have significantly lower knowledge of HPV. This highlights the need to increase medical student knowledge of HPV and HPV-linked HNC.

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Medical students; HPV vaccine; HPV knowledge; HPV-associated cancers; head and neck cancer; Medical education

## Introduction

Human papillomavirus (HPV) is the most prevalent sexually transmitted infection in the United States.<sup>1</sup> In addition to several anogenital and second primary malignancies,<sup>2–4</sup> HPV is linked to at least 72% of oropharyngeal cancer cases, a subset of head and neck cancer (HNC).<sup>5</sup> HPV-associated oropharyngeal cancer has increased in incidence between 57% and 225% in the last three decades and has now exceeded cervical cancer as the most common HPV-associated cancer in the United States.<sup>6–8</sup> All approved vaccines are effective against HPV 16 and 18 which together are responsible for about 95% of HPV-associated oropharyngeal cancer.<sup>7</sup> Five years after the initial recommendation for adolescent girls, the HPV vaccine recommendation was expanded to include boys by the Advisory Committee on Immunization Practices in 2011 with the goal of preventing HPV-associated cancer. Furthermore, indications for the HPV vaccine were recently expanded to include prevention of HPV-associated oropharyngeal cancer.<sup>6,9</sup>

Although the HPV vaccine is safe and effective,<sup>10,11</sup> it has had limited uptake in the United States, especially in the

eligible young adult population.<sup>12–15</sup> There is strong evidence that poor provider knowledge of HPV and inadequate physician vaccine recommendations are contributors.<sup>16–20</sup> Clinician knowledge, communication ability, and comfort in providing strong recommendations are critical to effective recommendation of the vaccine.<sup>16,17,19,20</sup>

The medical student population is a unique population in the context of HPV. They comprise the next generation of pediatricians, family medicine physicians, and other primary care clinicians who will lead conversations about the HPV vaccine. However, they are also personally connected to the HPV vaccine discourse as they are eligible for the vaccine themselves. In fact, they often fall within the highest-risk age group for HPV infection, an age group in which individuals are more likely to experiment with oral sex, a primary risk factor for oral HPV.<sup>21–24</sup> Therefore, it is important to characterize medical students' understanding of HPV and its sequelae. However, there remains a paucity of research investigating or characterizing the gaps in HPV knowledge in this population, particularly regarding HNC.

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Most of the HPV-related literature on medical and college students in general has focused on knowledge and attitudes about HPV and HPV vaccines without assessing knowledge of HPV-associated HNC.<sup>25–28</sup> Studies that focused on HNC had limited study populations and sociodemographic analyses.<sup>29,30</sup> Building on these previous studies, we aimed to (1) characterize knowledge of HPV, HPV vaccine, and HPV-associated HNC among medical students, and (2) determine demographic and educational factors associated with differences in knowledge.

## Materials and methods

A cross-sectional study was conducted at a medical school in the Midwest using a previously validated questionnaire designed to elicit sociodemographic information and data regarding HPV, the HPV vaccine, and HNC. This was administered via Qualtrics, a secure, web-based application designed for data capture in research studies.<sup>31,32</sup> The survey was distributed online to all medical students 26 years or younger. The age range was selected based on eligibility for HPV vaccination at the time of survey, when recommendations for the HPV vaccine were limited to the age of 26 years. Also, previous studies have evaluated HPV vaccination with this age cutoff.<sup>20,33</sup> Participants were informed of the study objectives, and informed consent was obtained. Responses to the questionnaire were recorded anonymously. Participation was non-mandatory, but monetary compensation (20.00 USD) was offered to those who completed the survey and elected to receive compensation. The questionnaire was administered to 311 medical students. Of these, 247 completed the survey, yielding a response rate of 79%. This study was approved by the university's institutional review board.

## Measures

The outcome measures were (1) knowledge about HPV and the HPV vaccine, and (2) knowledge about HPV-associated HNC. Knowledge about HPV and the HPV vaccine was assessed with 26 questions. Survey answers were scored as 1 for correct responses and 0 for incorrect responses. Scores were then summed to derive an HPV and HPV vaccine knowledge score, for which the maximum score was 26 and the minimum was 0. HPV-associated HNC knowledge was measured using 12 questions. These responses were scored as 1 for correct responses and as 0 for incorrect responses. Scores were summed to create an HPV-associated HNC knowledge score, which ranged from 0 to 12. For both outcome measures, a higher score represented higher knowledge. In addition, specific knowledge questions regarding HPV's association with HNC and HPV's association with cervical cancer (dichotomized as yes/no) were analyzed.

The independent variables included year of study (first, second, third, or fourth year), age, sex (male, female), race (white, nonwhite [combining low-frequency responses]), marital status (married, single but dating, single, and not dating), and number of lifetime oral partners and number of lifetime vaginal partners (zero, one,  $\geq$  two), physician recommendation of HPV vaccine (yes, no), HPV vaccine initiation

(recipient of at least one dose), HPV vaccine completion (recipient of at least three doses), and specialty of interest (pediatrics, family medicine, internal medicine, surgery, other specialties).

## Statistical analysis

Descriptive statistics were used to analyze the characteristics of the respondents. Sociodemographic characteristics and sexual behavioral risk factors were compared by year of study using Pearson's chi-square for categorical variables and one-way ANOVA for continuous variables. Two multivariable linear regression models were used to examine the association between the two outcomes (HPV and HPV vaccine knowledge and HPV-associated HNC knowledge) and sociodemographic and sexual behavioral risk factors including year of study, sex, race, marital status, number of oral sexual partners, and number of vaginal sexual partners. Age was not included in the adjusted model because it was highly correlated with year of study. Adjusted  $\beta$  coefficients with corresponding 95% confidence intervals were reported for each variable. In addition, two multivariable logistic regression models were used to examine associations between knowledge of HPV's association with HNC or cervical cancer, and the same sociodemographic and sexual behavioral risk factors listed above. Analyses were performed using SAS statistical software version 9.4 (SAS Institute Inc., Cary, NC). All statistical analyses were two-tailed and used an alpha level of 0.05 to determine statistical significance.

## Results

### Sample characteristics

A summary of the characteristics of the respondents in the study sample is provided in Table 1. A total of 247 medical students completed the questionnaire, of which 36.4% were first-years, 26.7% were second-years, 24.7% were third-years, and 12.2% were fourth-years. The mean (SD) age of respondents was 24.0 (1.3), and the range was 23.0 (1.2) to 25.5 (0.6). More than half of study respondents were female (56.1%,  $n = 139$ ) and white (60.1%,  $n = 149$ ). Almost half 48.0% ( $n = 119$ ) were married, 53% ( $n = 130$ ) had multiple oral sexual partners, and 39% ( $n = 96$ ) had multiple vaginal sexual partners. There was a statistically significant difference in marital status ( $p = .0026$ ), and provider recommendation to receive HPV vaccine ( $p = .0336$ ), based on year of study. There was no statistical difference observed in sex, race, number of oral sexual partners, number of vaginal sexual partners, initiation of the HPV vaccine series, completion of the HPV vaccine series, or specialty choice by year of study.

### HPV and HPV vaccine knowledge

The mean (SD) HPV and HPV vaccine knowledge score was 19.4 (4.6) (Table 1). There was a gradient in HPV and HPV vaccine knowledge score based on year of study: first-years had score of 16.2 (4.6) and fourth-years had the highest score of 23.3 (1.6) (Figure 1a). This was a statistically significant difference ( $p < .001$ ) (Figure 1a). There was no difference in

Table 1. Sample characteristics.

	Mean $\pm$ SD or n (%)					P-value
	Total n=247	Year of study				
		First Year 90 (36.4)	Second Year 66 (26.7)	Third Year 61 (24.7)	Fourth Year 30 (12.2)	
<b>HPV and the Vaccine Knowledge</b>	19.4 $\pm$ 4.6	16.2 $\pm$ 5.1	19.1 $\pm$ 3.6	22.2 $\pm$ 1.9	23.3 $\pm$ 1.6	<.0001
<b>HPV-associated HNC Knowledge</b>	7.2 $\pm$ 2.1	6.0 $\pm$ 1.9	7.4 $\pm$ 1.8	8.0 $\pm$ 1.8	8.7 $\pm$ 1.9	<.0001
<b>HPV causes HNC</b>						<.0001
Yes	53 (21.5)	6 (6.7)	16 (24.2)	20 (32.8)	11 (36.7)	
No	194 (78.5)	84 (93.3)	50 (75.8)	41 (67.2)	19 (63.3)	
<b>HPV causes Cervical Cancer</b>						<.0001
Yes	179 (72.5)	48 (53.3)	51 (77.3)	56 (91.8)	24 (80.0)	
No	68 (27.5)	42 (46.7)	15 (22.7)	5 (8.2)	6 (20.0)	
<b>Age</b>	24.0 $\pm$ 1.3	23.0 $\pm$ 1.2	23.8 $\pm$ 1.1	24.8 $\pm$ 0.8	25.5 $\pm$ 0.6	<.0001
<b>Sex</b>						.1107
Female	139 (56.1)	54 (60.0)	41 (62.1)	26 (42.6)	17 (56.7)	
Male	109 (43.9)	36 (40.0)	25 (37.9)	35 (57.4)	13 (43.3)	
<b>Race</b>						.2138
White	149 (60.1)	52 (57.8)	36 (54.5)	37 (60.7)	23 (76.7)	
Nonwhite	99 (39.9)	38 (42.2)	30 (45.5)	24 (39.3)	7 (23.3)	
<b>Marital status</b>						.0026
Married	119 (48.0)	39 (43.3)	37 (56.1)	33 (54.1)	10 (33.3)	
Single but Dating	50 (20.2)	18 (20.0)	11 (16.7)	6 (9.8)	14 (46.7)	
Single and not Dating	79 (31.8)	33 (36.7)	18 (27.3)	22 (36.1)	6 (20.1)	
<b>Number of oral sexual partners</b>						.6735
None	57 (23.1)	25 (27.8)	13 (19.7)	15 (24.6)	4 (13.3)	
One	60 (24.3)	18 (20.0)	18 (27.3)	16 (26.2)	8 (26.7)	
$\geq$ Two	130 (52.6)	47 (52.2)	35 (53.0)	30 (49.2)	18 (60.0)	
<b>Number of vaginal sexual partners</b>						.5188
None	82 (33.2)	36 (40.0)	20 (30.3)	19 (31.2)	7 (23.3)	
One	69 (27.9)	19 (21.1)	22 (33.3)	18 (29.5)	10 (33.3)	
$\geq$ Two	96 (38.9)	35 (38.9)	24 (36.4)	24 (39.3)	13 (43.3)	
<b>Physician recommendation of HPV vaccine</b>						.0336
Yes	129 (52.0)	54 (60.0)	36 (54.5)	22 (36.1)	16 (53.3)	
No	119 (48.0)	36 (40.0)	30 (45.5)	39 (63.9)	14 (46.7)	
<b>HPV vaccine initiation</b>						.4235
Yes	124 (50.0)	46 (51.1)	35 (53.0)	25 (41.0)	17 (56.7)	
No	124 (50.0)	44 (48.9)	31 (47.0)	36 (59.0)	13 (43.3)	
<b>HPV vaccine completion</b>						.3199
Yes	102 (41.1)	40 (44.4)	29 (43.9)	19 (31.2)	14 (46.7)	
No	146 (58.9)	50 (55.6)	37 (56.1)	42 (68.8)	16 (53.3)	
<b>Specialty</b>						.3562
Pediatrics	48 (19.4)	19 (21.1)	10 (15.2)	11 (18.0)	8 (26.7)	
Family Medicine	26 (10.5)	8 (9.1)	6 (9.1)	9 (14.8)	3 (10.0)	
Internal Medicine	64 (25.9)	23 (25.6)	15 (22.7)	16 (26.2)	10 (33.3)	
Surgery	41 (16.6)	17 (18.9)	8 (12.1)	10 (16.4)	6 (20.0)	
Other specialties	68 (27.5)	23 (25.6)	27 (40.9)	15 (24.6)	3 (10.0)	

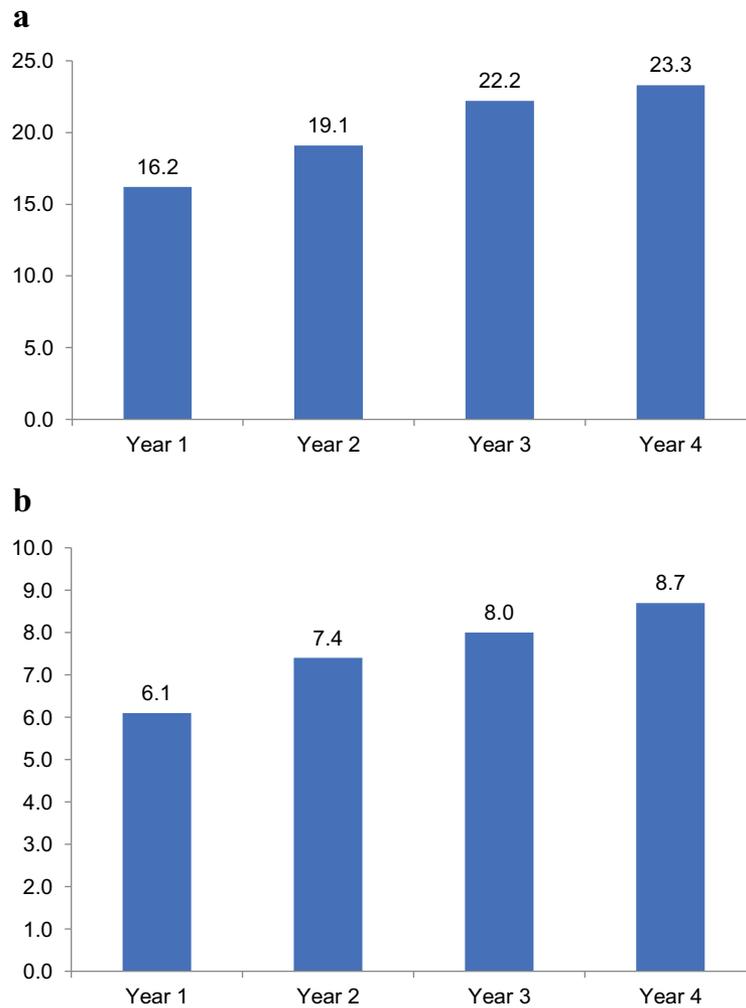
HPV = Human Papillomavirus; HNC = Head and Neck Cancer.

HPV and HPV vaccine knowledge by choice of specialty (Table 2). A summary of the adjusted linear regression results estimating HPV and HPV vaccine knowledge is presented in Table 3. Compared with first-year students, the second year ( $\beta = 2.62$ ; 95% CI: 1.42, 3.82), third-year ( $\beta = 6.19$ ; 95% CI: 4.96, 7.41) and fourth-year ( $\beta = 6.75$ ; 95% CI: 5.17, 8.33) students had higher HPV and HPV vaccine knowledge. Males ( $\beta = -1.53$ ; 95% CI:  $-2.53$ ,  $-0.52$ ) and nonwhite ( $\beta = -1.05$ ; 95% CI:  $-2.07$ ,  $-0.03$ ) medical students had lower HPV and HPV vaccine knowledge in comparison to their female and white counterparts. Marital status, number of oral sexual partners, and number of vaginal sexual partners had no significant association with HPV and HPV vaccine knowledge.

### HPV-associated HNC knowledge

The mean (SD) HPV-associated HNC knowledge was 7.2 (2.1) out of a maximum score of 12 (Table 1). There was

a statistically significant difference in HPV and HPV vaccine knowledge ( $p < .001$ ) (Figure 1b). First-year students had the lowest mean score at 6.0 (1.9), while fourth-year students had the highest at 8.7 (1.9) (Figure 1b). There was no difference in HPV-associated HNC knowledge by choice of specialty (Table 2). A summary of the adjusted linear regression results estimating HPV-associated HNC knowledge is presented in Table 3. In the multivariable analyses, second-year ( $\beta = 1.37$ ; 95% CI: 0.78, 1.96), third-year ( $\beta = 1.84$ ; 95% CI: 1.24, 2.45), and fourth-year ( $\beta = 2.50$ ; 95% CI: 1.72, 3.29) students had higher HPV-associated HNC knowledge compared with first-year students. Nonwhite medical students had lower HPV-associated HNC knowledge ( $\beta = -0.86$ ; 95% CI:  $-1.37$ ,  $-0.36$ ) compared with whites. There was no difference observed in HPV-associated HNC knowledge by sex, marital status, number of lifetime oral sexual partners, and number of lifetime vaginal sexual partners.



**Figure 1.** The average (a) HPV and HPV vaccine knowledge (b) HPV-associated HNC knowledge by year of study (n = 247).

**Table 2.** HPV and the vaccine knowledge, HPV-associated HNC cancer knowledge, and specific knowledge questions assessing HPV's association with HNC or cervical cancer by specialty.

	Mean $\pm$ SD or n (%)						P-value
	Total n=247	Specialty					
		Pediatrics 48 (19.4)	Family Medicine 26 (10.5)	Internal Medicine 64 (25.9)	Surgery 41 (16.6)	Other specialties 68 (27.5)	
<b>HPV and the Vaccine Knowledge</b>	19.4 $\pm$ 4.6	20.2 (3.4)	20.0 (5.2)	19.2 (4.8)	18.3 (5.8)	19.4 (4.3)	.3633
<b>HPV-associated HNC Knowledge</b>	7.2 $\pm$ 2.1	7.1 (2.0)	7.5 (2.3)	7.0 (2.2)	7.3 (2.2)	7.3 (1.8)	.8386
<b>HPV causes HNC</b>							.1065
Yes	53 (21.5)	5 (10.4)	5 (19.2)	12 (18.8)	10 (24.4)	21 (30.9)	
No	194 (78.5)	43 (89.6)	21 (80.8)	52 (81.2)	31 (75.6)	47 (69.1)	
<b>HPV causes Cervical Cancer</b>							.8021
Yes	179 (72.5)	35 (72.9)	21 (80.8)	45 (70.3)	31 (75.6)	47 (69.1)	
No	68 (27.5)	13 (27.1)	5 (19.2)	19 (29.7)	10 (24.4)	21 (30.9)	

HPV = Human Papillomavirus; HNC = Head and Neck Cancer.

### HPV association specific knowledge questions

Similar to the two aggregate knowledge scores, specific questions assessing knowledge of HPV's association with HNC and HPV's association with cervical cancer exhibited increased rate of correct responses with increasing year of study ( $p < .001$ ) (Table 1). There were no significant differences in either knowledge by specialty choice (Table 2). Table 4 summarizes logistic regression results of individual

knowledge questions regarding HPV's association with HNC or cervical cancer. No statistically significant differences were observed by any covariate analyzed, with the exception that first-year students show a decreased odds as compared to fourth year students of identifying either HPV's association with HNC or HPV's association with cervical cancer (aOR = 0.11; 95% CI: 0.03, 0.36; aOR = 0.29; 95% CI: 0.10, 0.83, respectively).

**Table 3.** Linear regression estimating relative risks of HPV and the vaccine, and HPV-associated HNC cancer knowledge.

	Adjusted $\beta$ (95% CI)	
	HPV & the Vaccine	HPV-associated HNC
<b>Year of study</b>		
First Year	Ref	Ref
Second Year	<b>2.62 (1.42, 3.82)</b>	<b>1.37 (0.78, 1.96)</b>
Third Year	<b>6.19 (4.96, 7.41)</b>	<b>1.84 (1.24, 2.45)</b>
Fourth Year	<b>6.75 (5.17, 8.33)</b>	<b>2.50 (1.72, 3.29)</b>
<b>Sex</b>		
Female	Ref	Ref
Male	<b>-1.53 (-2.53, -0.52)</b>	0.18 (-0.32, 0.68)
<b>Race</b>		
White	Ref	Ref
Nonwhite	<b>-1.05 (-2.07, -0.03)</b>	<b>-0.86 (-1.37, -0.36)</b>
<b>Marital status</b>		
Married	Ref	Ref
Single but Dating	0.28 (-1.05, 1.61)	0.16 (-0.50, 0.82)
Single and not Dating	-0.45 (-1.64, 0.74)	0.17 (-0.43, 0.76)
<b>Number of oral sexual partners</b>		
None	Ref	Ref
One	0.51 (-1.11, 2.14)	0.61 (-0.20, 1.42)
$\geq$ Two	0.44 (-1.21, 2.08)	-0.04 (-0.85, 0.78)
<b>Number of vaginal sexual partners</b>		
None	Ref	Ref
One	0.46 (-1.00, 1.93)	0.02 (-0.70, 0.75)
$\geq$ Two	<0.01 (-1.63, 1.63)	0.15 (-0.66, 0.96)
<b>Specialty</b>		
Pediatrics	Ref	Ref
Family Medicine	-0.50 (-2.27, 1.28)	0.30 (-0.58, 1.18)
Internal Medicine	-0.46 (-1.91, 1.00)	<0.01 (-0.72, 0.72)
Surgery	-1.00 (-2.64, 0.63)	0.37 (-0.44, 1.18)
Other specialties	0.30 (-1.18, 1.79)	0.30 (-0.44, 1.04)

CI = Confidence Interval; HPV = Human Papillomavirus; HNC = Head and Neck Cancer.

## Discussion

This study aimed to identify differences in knowledge of HPV, HPV vaccine, and head HNC among medical students. Our results indicate that there are gaps in knowledge of both HPV vaccine and HPV-associated HNC among medical students. While we observed a pattern of increased knowledge levels with increasing training from first year to fourth, we also observed differences in HPV vaccine knowledge based on sex and race and differences in knowledge of HPV's association with HNC based on race. Our results provide some evidence that, as primary stakeholders in HPV vaccine communication, education, and uptake,<sup>18</sup> this next generation of clinical providers may need more education about the HPV vaccine themselves.

The current literature regarding prevention and outcomes of HPV-associated cancer is rapidly evolving. In the current study, the mean score for HPV and HPV vaccine knowledge was 19.4 out of 24, and knowledge HPV-associated HNC was 7.2 out of 12. In a previous study of university students, 81% had less than average knowledge scores. However, participants were university without a medical background.<sup>34</sup> In another survey of medical students in Alabama, participants had similar knowledge levels as the current study, but the study focused mainly on knowledge of HPV and HPV vaccine, not HPV's

**Table 4.** Logistic regression estimating odds ratio of individual knowledge questions regarding HPV's association with HNC or cervical cancer.

	Adjusted OR (95% CI)	
	HPV causes HNC	HPV causes Cervical Cancer
<b>Year of study</b>		
First Year	<b>0.11 (0.03, 0.36)</b>	<b>0.29 (0.10, 0.83)</b>
Second Year	0.48 (0.16, 1.42)	0.96 (0.31, 3.01)
Third Year	0.93 (0.32, 2.71)	3.63 (0.95, 13.80)
Fourth Year	Ref	Ref
<b>Sex</b>		
Female	Ref	Ref
Male	0.94 (0.46, 1.95)	0.54 (0.28, 1.05)
<b>Race</b>		
White	Ref	Ref
Nonwhite	0.57 (0.26, 1.23)	0.62 (0.32, 1.21)
<b>Marital status</b>		
Married	Ref	Ref
Single but Dating	1.77 (0.66, 4.75)	1.23 (0.51, 2.94)
Single and not Dating	1.11 (0.45, 2.76)	0.93 (0.43, 2.01)
<b>Number of oral sexual partners</b>		
None	Ref	Ref
One	2.07 (0.58, 7.44)	0.76 (0.25, 2.31)
$\geq$ Two	3.07 (0.85, 11.04)	1.06 (0.35, 3.24)
<b>Number of vaginal sexual partners</b>		
None	Ref	Ref
One	0.39 (0.13, 1.18)	0.94 (0.35, 2.56)
$\geq$ Two	0.42 (0.13, 1.37)	0.53 (0.18, 1.56)
<b>Specialty</b>		
Pediatrics	0.46 (0.11, 1.97)	0.66 (0.19, 2.36)
Family Medicine	Ref	Ref
Internal Medicine	1.26 (0.34, 4.72)	0.67 (0.20, 2.29)
Surgery	1.89 (0.47, 7.57)	1.36 (0.35, 5.24)
Other specialties	3.33 (0.92, 12.04)	0.74 (0.22, 2.52)

CI = Confidence Interval; HPV = Human Papillomavirus; HNC = Head and Neck Cancer.

association with HNC.<sup>26</sup> We found in the current study that medical student knowledge of both outcome measures remained inadequate, even among senior (4th year) medical students.

We observed a "dose-response" association between year of study and both HPV and HPV vaccine knowledge and HPV-associated HNC knowledge. Second, third- and fourth-year medical students had higher knowledge scores than first-year students. Similar associations between HPV knowledge, HPV vaccine knowledge, and medical school year of study have been described in recent literature.<sup>26</sup> Likewise, the differences in HPV-associated HNC knowledge by year of study in this report are supported by a recent study reporting that medical students identify incorrect HPV oncological associations as often as its correct association with HNC.<sup>29</sup> Unlike the current study, however, a recent survey of 10 medical schools in New York reported similar knowledge levels between third- and fourth-year medical students regarding HNC.<sup>35</sup> Taken together, our findings from the Midwest, the study from Alabama,<sup>26</sup> a report from New York,<sup>35</sup> as well as a national survey of medical trainees (medical students and residents),<sup>29</sup> all suggest that there might be an opportunity to improve the medical school curricula with regard to HPV, HPV vaccine, and HPV's association with HNC. It seems at present that

medical students may not be adequately prepared to address an issue like HPV vaccine uptake, which is a national imperative.<sup>36</sup> Given the poor rate of HPV vaccine uptake and increasing incidence of HPV-related cancers, we suggest that providing adequate knowledge about HPV, HPV-related cancers, and the HPV vaccine should be addressed in medical school curricula across the United States.

This study revealed lower HPV and HPV vaccine knowledge in male medical students. These results contrast with the observations made in a previous study, which did not find any difference in knowledge based on sex.<sup>26</sup> Studies have consistently shown that despite a higher incidence of HNC in men, they have both lower HPV vaccine uptake, and HPV vaccination knowledge than women.<sup>37–42</sup> Many men consider HPV to be a female issue as public health vaccination campaigns have largely highlighted the vaccine as a preventive measure for cervical cancer. In addition to differences in sex, we also found a gap in knowledge by race, and nonwhite medical students had significantly lower knowledge of HPV, HPV vaccine, and HPV's association with HNC. While differences in HPV-associated HNC knowledge by race have been shown in the general population, this trend has not been investigated in the medical student population.<sup>37–39–43,44</sup> This is important because minorities are less likely to receive HPV vaccine recommendations from providers despite more often relying on primary care provider as a primary source of health information.<sup>45–47</sup> It is important to recognize these differences in knowledge by race and sex in developing interventions for these groups, and in improving the medical curricula. It is particularly important as a physician's recommendation of the HPV vaccine remains one of the most important predictors of uptake,<sup>18</sup> and patient-physician racial concordance is associated with improved patients' communication and overall satisfaction with care provided.<sup>48,49</sup> Thus, it is important that future healthcare providers that are from minority racial background receive training that equips them to engage in conversations that would increase HPV vaccine uptake, especially when they provide care for racially concordant patients. This might help mitigate the racial inequality in HPV vaccine uptake.<sup>45,46</sup>

### Limitations and strengths

This study has several limitations. First, as the sample includes medical students from a single Midwestern academic institution, generalizability is limited regarding medical students across the United States. However, two national surveys reported overall similar results, which supports the external validity of our conclusions.<sup>19,29</sup> Second, the cross-sectional study design precludes causal conclusions. There is also a limited sample size of fourth-year medical students due to the inclusion criteria of a maximum age of 26 years. Recently, with increased enrollment of non-traditional medical students, the average age of medical students has risen. The increasing number of medical students over 26 years is not included in our study; however, we believe their exclusion should not affect our findings as a majority of medical students as our cutoff age of 26 years falls within the average of matriculating into medical school in the United States within

the last two decades.<sup>50</sup> Lastly, our physician recommendation of HPV vaccine assessment may not be reliable as it is possible that a subset of respondents to this question may have been vaccinated as children.

Despite these limitations, our study is one of few to examine HPV-associated HNC knowledge in the medical student population, in addition to knowledge of HPV and HPV vaccine. The study included comparable numbers of both male and female participants, which contrasts with most previous studies which included only females.

### Implications

HPV vaccination for all below the age of 26 years and for those between 27 and 45 years with certain risk factors, based on a patient-physician shared decision-making. Thus, there is a need for provider knowledge and recommendation of the vaccine. Evidence is growing regarding inadequate physician communication and recommendation of the HPV vaccine.<sup>21–24</sup> Knowledge of HPV's link to oropharyngeal cancer is particularly important as HPV-associated oropharyngeal cancer has surpassed cervical cancer as the leading HPV-associated cancer in the United States.<sup>51</sup> Unlike cervical cancer, HPV vaccine is the only primary prevention for oropharyngeal cancer, and the Food and Drug Administration only recently extended the indications for HPV vaccination to include preventing oropharyngeal cancer.<sup>6</sup> However, more individuals may be aware of the link between HPV and cervical cancer than the link between HPV and HNC.<sup>38</sup> There are several reasons driving this lack of knowledge of HPV's link to HNC relative to cervical cancer. For example, the natural history of cervical cancer is more understood than oropharyngeal cancer. Also, the HPV vaccine was first approved and heavily marketed toward females for preventing cervical cancer, and it was not until 2011 that the vaccine was approved for use among males. Thus, it might be that even among medical students, there may still be some lingering perception of HPV being primarily an issue for women.

Thus, there is a need for improved knowledge regarding HPV-related associations and interventions in healthcare providers today. Our study showed that there are inadequate HPV knowledge levels among medical students. Improving gaps in HPV vaccine coverage, reducing HPV infection rates, and advancing primary prevention of HPV-associated oropharyngeal cancer all rely on new and robust educational interventions that begin with medical students, especially in males and racial/ethnic minorities.

### Conclusion

Our study shows that medical students have low knowledge of HPV, the HPV vaccine, and the association between HPV and HNC. There are pronounced disparities in knowledge by medical school year, sex, and race. Educational interventions must address medical student knowledge to improve HPV vaccine coverage and address the increasing incidence of HPV-associated oropharyngeal cancer.

## Disclosure statement

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