

Human papillomavirus (HPV) infection and vaccination: A cross-sectional study of college students' knowledge, awareness, and attitudes in Villanova, PA



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ARTICLE INFO

Article history:

Received 17 June 2021

Received in revised form 2 January 2022

Accepted 11 January 2022

Available online 17 January 2022

Keywords:

Human papillomavirus (HPV)

Gardasil

Vaccination

Vaccine hesitancy

ABSTRACT

Human papillomaviruses are major causative agents of multiple cancers including cervical, vulvar, penile, anal, and oropharyngeal cancers. Almost all sexually active individuals are exposed to HPV in their lifetime and although not all HPV genotypes are capable of causing cancers, several high-risk subtypes widely circulate. Several HPV vaccines have been developed and successfully utilized to limit the spread of these viruses and reduce rates of associated cancers. Despite their success, HPV vaccination rates in the United States remain low. Studies estimate the highest prevalence of HPV in the United States is among college students. This makes college students an important target for interventions that promote HPV vaccination and prevention. To this end, we were interested in investigating the relationship between low HPV vaccine uptake and attitudes and awareness about HPV vaccination among college aged students. We designed a survey to assess knowledge and perception of HPV and HPV vaccination that could help identify correlations between this knowledge and vaccination status. Overall, the data suggest that factors beyond basic knowledge about HPV infections, such as vaccine safety and social acceptance of vaccination, may have important impacts on vaccination rates. More robust education in these areas, supplemented with education about the benefits of HPV vaccination could be utilized to improve vaccination rates.

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1. Introduction

Human papillomaviruses are non-enveloped double stranded DNA viruses in the *Papillomaviridae* family. There are over 170 human papillomaviruses and at least 40 are capable of infecting the reproductive tract (among other tissues). High risk genotypes of HPV are the most concerning since these are linked to cancer development, causing upwards of five percent of all cancers globally [1]. HPV is the cause of almost all cervical cancer (>99%) and causes most anal cancers (90%), vulvar cancers (70%), vaginal cancers (70%), penile cancers (60%), and oropharyngeal cancers (70%). In total, HPV is estimated to cause 570,000 cases of cancer in women and 60,000 cases of cancer in men worldwide every year [1].

Vaccination is a highly effective intervention that protects against HPV infection and prevents the majority of cancers that these viruses cause. Three vaccines against high-risk HPV geno-

types have been licensed in the United States, although only one of these vaccines is currently in use. Each of these HPV vaccines contains virus like particles with the major capsid protein L1 assembling into HPV virions that lack DNA and that are unable to establish infection. [2]. Two of the earliest HPV vaccines were Cervarix, a bivalent vaccine developed by GSK protecting against HPV 16 and 18, and Gardasil, a quadrivalent vaccine developed by Merck protecting against HPV 6, 11, 16, and 18 [2]. Although Cervarix and Gardasil are successful at preventing infections and are used globally [3], they are no longer distributed in the United States. The current preferred vaccine in the US is Gardasil-9, a non-avalent vaccine developed by Merck that protects against nine distinct HPV genotypes [4]. This vaccine is estimated to prevent 32,000 of the 35,000 cancers caused by HPV per year [5].

Despite the importance of vaccination against HPV, HPV vaccine uptake lags behind that of other vaccines recommended to be administered around the same age. For example, according to the 2019 National Immunization Survey (NIS-Teen), 90.2% of adolescents between 13 and 18 years of age were vaccinated against tetanus, diphtheria, and pertussis (Tdap), 91.6% were vaccinated against HBV, and 88.9% were vaccinated against meningococcus

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(MenACWY) [6]. In stark contrast, only 71.5% of adolescents in this age group were vaccinated with at least one dose of HPV vaccine. What's more, only 54.2% of adolescents were up to date on their HPV vaccine series, although coverage rates vary by state with the lowest rate in Mississippi (30.5%) and the highest rate in Rhode Island (78.9%). In Pennsylvania, the site of the current study, the numbers are similar to national levels, with 77% of adolescents being vaccinated with at least one dose of the HPV vaccine and only 60.1% being up to date in the vaccine series [6].

Studies estimate the highest prevalence of HPV in the United States to be among women visiting STD clinics and college students [7]. This, combined with the lower vaccine uptake in adolescence, makes college students an important target for interventions that promote HPV vaccination and prevention. Surveys among college students similar to the one we conducted have occurred throughout the United States including in Florida [8], Southern California [9], South Carolina [10], Michigan [11], Mississippi [12], Pennsylvania [13], and Utah [14]. Similar studies have also been conducted outside of the United States in India [15,16], Turkey [17], and Vietnam [14].

In an effort to boost HPV vaccination rates, it is necessary to investigate the relationship between low HPV vaccine uptake and the public's attitudes and awareness about HPV vaccination. This is likely a multifaceted issue and there may be multiple reasons why HPV vaccination rates are lower than those of other vaccines, for example the Td/Tdap and MenACWY vaccination rates recommended for the same age group. Our survey focused on the college population to assess college students' knowledge and awareness of HPV infection and HPV vaccination along with their HPV vaccination status. We sought to identify possible correlations between knowledge, awareness, and/or perceptions of HPV infection and HPV vaccination that may be linked to vaccination status. These results can be used to better educate individuals, dispel myths and stigmas, and increase awareness surrounding HPV infection and HPV vaccination. From this knowledge, we can also create initiatives to promote HPV vaccination not only among college students, but possibly among the recommended HPV vaccination age demographic (11–12) by considering what college students stated as obstacles or aversions to vaccination.

2. Materials and methods

In order to better understand the knowledge, awareness, and attitudes of college-aged students towards the HPV vaccine, we conducted a cross-sectional study among university students at Villanova University (Villanova, PA) between February 13th and March 9th, 2020. A convenience sampling method was used to recruit undergraduate and graduate students at least 18 years of age who were current students of Villanova at the time of survey completion. The survey was distributed through email, promotional flyers, and word-of-mouth and was hosted on a secure Google Forms account (G-Suite). All respondents provided informed consent before completing the survey and survey responses were collected in an anonymous manner. This study was approved by the Villanova University Institutional Review Board (IRB-FY2020-62).

The survey consisted of 32 multiple choice questions and one open ended question, similar to previous studies [8–17]. Questions asked participants about demographic information, general knowledge of HPV infection, perceived vulnerability of HPV infection, general knowledge of HPV vaccines, perceptions about HPV vaccine effectiveness and safety, and a question about HPV vaccination status. The open-ended question asked students to identify any information that could be helpful to convince them to get the vaccine.

Data were analyzed using chi-squared analyses to look for significant associations between: a) biological sex and response to survey questions Q6 through Q32; b) awareness of the existence of HPV and being vaccinated for HPV; c) perception of HPV vaccination as safe and being vaccinated for HPV; d) approval by family/friends of Gardasil 9 vaccination and being vaccinated for HPV; e) correct response to knowledge section of the questionnaire (Q11 through Q21) and being vaccinated for HPV; f) perceived risk for HPV infection (no risk, low risk, moderate risk, high risk) and being vaccinated for HPV. P-values < 0.05 were considered statistically significant in this study.

3. Results

3.1. General demographic information

Table 1 summarizes the demographic characteristics of the study population. We collected responses from 217 participants (n = 217). Forty-nine individuals reported as male (22.59%), 167 individuals reported as female (76.95%), and 1 individual preferred not to say (0.46%). Data from the respondent who preferred not to state biological sex were removed in an effort to maintain anonymity of individual responses. Participants ranged in age from 18 to 25 + with the majority of students being between 18 and 22 years old (88.89%). Since the undergraduate population of Villanova is much larger than the graduate population (6711 undergraduates vs. 3823 graduate students at the time of the study), it was not surprising that most respondents were undergraduate students (92.59% vs. 6.48% graduate students and 0.92% of students who preferred not to identify their year). Similarly, respondents were largely white and non-Hispanic (80.55%) which coincides with the full-time student enrollment demographics for Villanova University (White/Caucasian 75%). As expected since Villanova University is a Catholic institution, most participants identified as Christian (80.55%) [18].

3.2. Safe sex practices and routine screenings

Fig. 1 illustrates the respondents behavior surrounding safe sex and routine STD screening. At the time of the survey, 69.5% of females (n = 116) and 71.4% of males (n = 35) reported that they were currently sexually active or had been sexually active in the past 12 months. Additionally, 31.5% of females (n = 51) and 30.6% of males (n = 15) reported having four or more sexual partners in their lifetime. Although there was no significant statistical difference between females and males with respect to sexual history, number of partners, or history of sexually transmitted disease/infection (STD/STI), females were more likely than males to be routinely screened for STDs/STIs (p < 0.05). A remarkably low number of participants in this survey indicated that they are routinely screened for these diseases (35.9% for females, 14.3% for males). Only 1.7% (n = 6) of sexually active men reported being routinely screened for STDs.

3.3. Knowledge about HPV infection, vaccination, and vaccine safety

The choice to be vaccinated is multifaceted, and factors that are thought to play a role include knowledge about the vaccine and disease, health care provider recommendations, perceptions about the risks of diseases, perceptions about vaccination effectiveness, and socioeconomic status [19–21]. We were interested in understanding more about these factors as they specifically relate to HPV vaccination status among college students. Therefore, we designed our survey to assess several potential factors that may drive these decisions. One such factor was knowledge about HPV

Table 1
Demographic characteristics of participants. Q2 of the survey asked respondents to state their gender. This data is located in the column headings.

Question Number	Demographic Variables	Total, n (%) (n = 216)	Female, n (%) (n = 167)	Male, n (%) (n = 49)
Q1	Age			
	18	30 (13.9)	22 (13.2)	8 (16.3)
	19	49 (22.7)	38 (22.8)	11 (22.4)
	20	47 (21.8)	38 (22.8)	9 (18.4)
	21	47 (21.8)	32 (19.2)	15 (30.6)
	22	19 (8.8)	16 (9.6)	3 (6.1)
	23	3 (1.4)	2 (1.2)	1 (2.0)
	24	5 (2.3)	3 (1.8)	2 (4.1)
Q3	25+	16 (7.4)	16 (9.6)	0 (0.0)
	Ethnicity			
	White, non-Hispanic	174 (80.6)	135 (80.8)	39 (80.0)
	Black, non-Hispanic	5 (2.3)	5 (3.0)	0 (0.0)
Q4	Hispanic or Latino	17 (7.9)	13 (7.8)	4 (8.2)
	Other	20 (9.3)	14 (8.4)	6 (12.2)
	Religion			
	Christian	174 (80.6)	135 (80.8)	39 (79.6)
Q5	Jewish	2 (0.9)	1 (0.6)	1 (2.0)
	Not religious	34 (15.7)	26 (15.6)	8 (16.3)
	Other	4 (1.9)	3 (1.8)	1 (2.0)
	Prefer not to say	2 (0.9)	2 (1.2)	0 (0.0)
	Academic Year			
Freshman	52 (24.1)	36 (21.6)	16 (32.7)	
Sophomore	52 (24.1)	45 (26.9)	7 (14.3)	
Junior	35 (16.2)	25 (15.0)	10 (20.4)	
Senior	61 (28.2)	48 (28.7)	13 (26.5)	
Graduate student	14 (6.5)	11 (6.7)	3 (6.1)	
Prefer not to say	2 (0.9)	2 (1.2)	0 (0.0)	

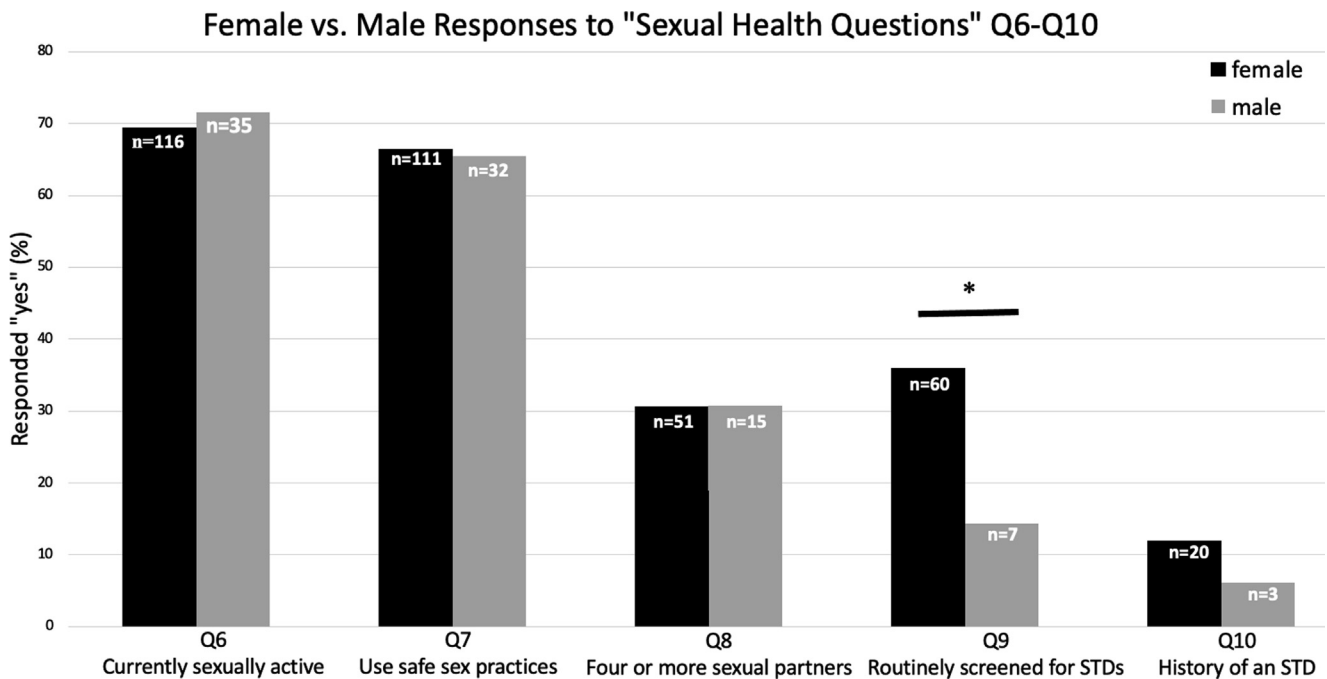


Fig. 1. Females are more likely than males to be routinely screened for STDs/STIs. However, no other significant differences exist between males and females with respect to sexual health. * $p < 0.05$.

infection itself, and to this end participants were surveyed on their knowledge and awareness about HPV infection (Q11-16, Q19-20, Fig. 2 and Table 2). The majority of participants correctly identified that HPV affects both male and females (95.8%), is a sexually transmitted disease (69.9%), and is capable of causing cancer (76.9%). However, a much lower percentage of participants understood that HPV can be spread by skin-to-skin contact with only 29.6% of participants responding correctly to this question (55.1% incorrectly) and 15.3% of participants unsure. Interestingly, participants (both

male and female) who responded correctly to all eight knowledge questions were not significantly more likely to be vaccinated for HPV (with at least one dose; $p = 0.12$).

3.4. Perception on HPV vaccination safety

We were also interested in understanding how participants viewed the HPV vaccine itself in terms of safety and protection from infection (Table 2). Females were more likely than males to

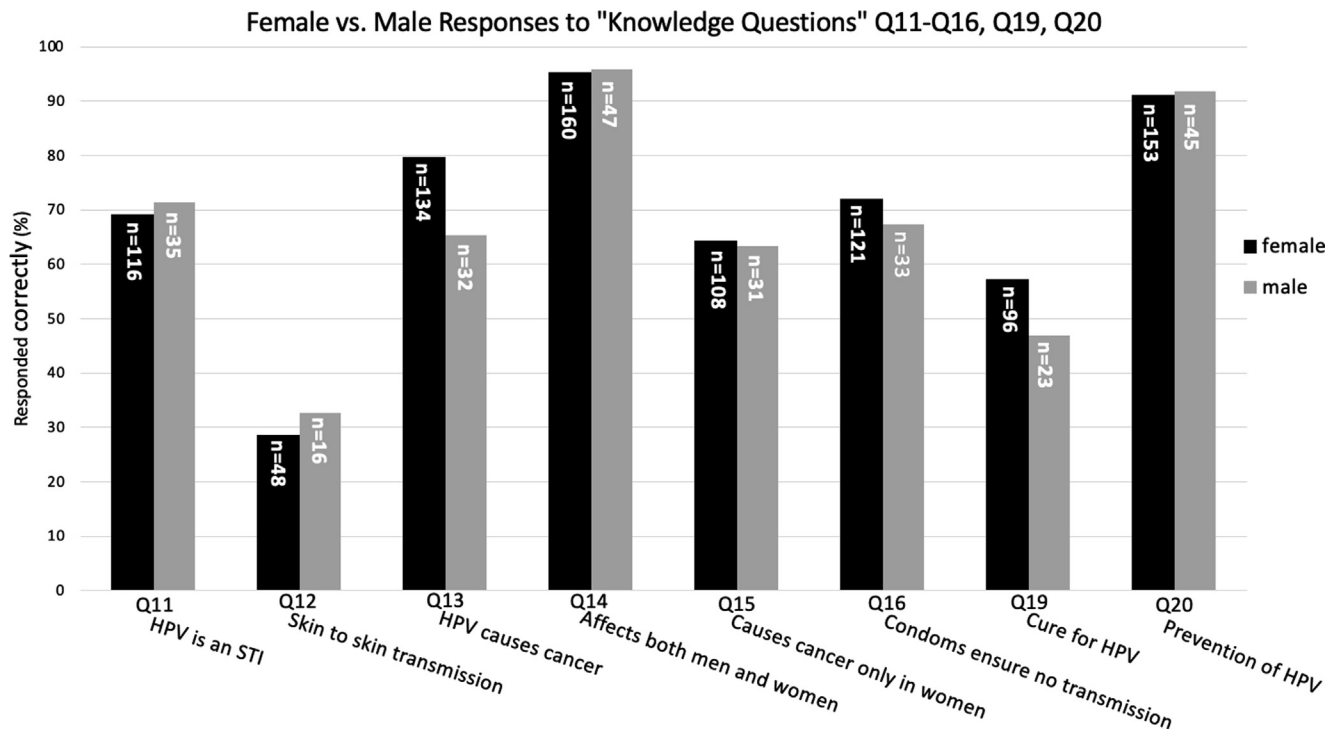


Fig. 2. Knowledge about HPV does not play a significant role in influencing vaccination status. The correct response choices to these questions are listed in Table 2.

be aware of the existence of a vaccine for HPV ($p < 0.05$). However, there was no significant difference between female and male response with respect to the knowledge that the newest HPV vaccine, Gardasil-9, approved age range for administration has been expanded. This might not be surprising since this approval is somewhat recent but nevertheless highlights the need to make this information more widespread. Importantly however, participants (both female and male) who responded that they were aware of the existence of an HPV vaccination were more likely to be vaccinated with at least one dose (responding “yes” to Q23; $p < 0.05$).

Females were more likely than males to believe that an individual cannot get HPV from receiving an HPV vaccine ($p < 0.05$). 61.1% of females ($n = 102$) and only 36.7% of males ($n = 18$) responded that an individual cannot get HPV from vaccination. Interestingly, there was no significant difference between biological sex and perception about HPV vaccine safety and side effects. Greater than 50% of both females and males believed HPV vaccination is safe (Q27) and does not have significant side effects (Q26). Importantly, participants (both male and female) who believed vaccination is safe, effective, without significant side effects, and cannot result in HPV infection were more likely to be vaccinated with at least one dose ($p < 0.05$).

3.5. Knowledge about HPV vaccination and sexual activity

HPV vaccines are usually administered to adolescents between 11 and 12 years old. At this stage of their lives, it is likely that the decision to vaccinate is made by parents or guardians. One major objection voiced by these parents or guardians is the belief that a vaccine for an STD would make their child more sexually active and/or promiscuous [22]. We were interested in determining if college aged students shared those beliefs about the HPV vaccine (Table 2). 85.0% of females ($n = 142$) and 75.5% of males ($n = 37$) responded that they would not be more inclined to be sexually active after getting the HPV vaccine. A higher proportion of male participants were unsure if the vaccination would incline them

to be sexually active (16.3% of males vs. 4.8% of females). Despite the high proportion of both females and males who believe that vaccination would not impact their sexual activity, females were more likely to believe that the vaccine would not make them inclined to be more sexually active ($p < 0.05$). This result is also in line with other data indicating that HPV vaccine does not increase sexual promiscuity in recipients [23-26].

3.6. Approval by family/friends and being vaccinated for HPV

Because HPV is spread, in part, by sexual encounters, some have argued that the vaccine suffers from being sexualized [22] which suggests that vaccine uptake may be linked to approval from family and friends. We were interested if this kind of ‘approval’, may play a role in the decision to get the HPV vaccine. Interestingly, participants (both male and female) who believed their family/friends would disapprove of the vaccination (responding “yes” to Q30) were less likely to be vaccinated for HPV with at least one dose (responding “no” to Q23), whereas individuals who did not believe their family/friends would disapprove (responding “no” to Q30) were more likely to be vaccinated (responding “yes” to Q23; $p < 0.05$) (Fig. 3).

4. Discussion

HPV vaccine uptake remains remarkably low in the United States, with only 71.5% of adolescents being vaccinated with at least one dose and only 54.2% of adolescents being up to date with the HPV vaccine schedule [6]. Although these rates are comparable to most other developed nations, they are significantly lower than Australia, where a strong nationalized, school-based HPV vaccination program has resulted in >75% of adolescents up to date with the HPV vaccine schedule [27]. As college students have the highest prevalence of HPV in the United States [7], we set out to investigate the factors that may influence the decision to be vaccinated in a college aged cohort of students at Villanova University (located

Table 2
Total, female, and male responses to study questions. *p < 0.05 **What was deemed to be the correct response if there was one.

Question Number	Questions Pertaining to Sexual Health	Total, n (%) (n = 216)	Female, n (%) (n = 167)	Male, n (%) (n = 49)
Q6	Are you currently sexually active or have you been sexually active in the past 12 months?			
	Yes	151 (70.0)	116 (69.5)	35 (71.4)
	No	64 (29.6)	50 (29.9)	14 (28.6)
	Prefer not to say	1 (0.5)	1 (0.6)	0 (0.0)
Q7	Do you commonly use safe sex practices (i.e. condoms, contraceptives)?			
	Yes	143 (66.2)	111 (66.5)	32 (65.3)
	No	18 (8.3)	12 (7.2)	6 (12.2)
	This does not apply to me	55 (25.35)	44 (26.3)	11 (22.4)
Q8	Have you had four or more sexual partners in your lifetime so far?			
	Yes	66 (30.6)	51 (30.5)	15 (30.6)
	No	148 (68.5)	114 (68.3)	34 (69.4)
	Prefer not to say	1 (0.5)	1 (0.6)	0 (0.0)
	Left question unanswered	1 (0.5)	1 (0.6)	0 (0.0)
Q9	Are you routinely (around once per year) screened for sexually transmitted diseases or infections?*			
	Yes	67 (31.0)	60 (35.9)	7 (14.3)
	No	146 (67.6)	104 (62.3)	42 (85.7)
	Prefer not to say	1 (0.5)	1 (0.6)	0 (0.0)
	Left question unanswered	2 (0.9)	2 (1.2)	0 (0.0)
Q10	Have you ever been diagnosed with a sexually transmitted disease or infection?			
	Yes	23 (10.6)	20 (12.0)	3 (6.1)
	No	192 (88.9)	146 (87.4)	46 (93.9)
	Prefer not to say	0 (0.0)	0 (0.0)	0 (0.0)
	Left question unanswered	1 (0.5)	1 (0.6)	0 (0.0)
	Questions Pertaining to Knowledge/Awareness of HPV infection	Total, n (%) (n = 217)	Female, n (%) (n = 168)	Male, n (%) (n = 49)
Q11	"HPV is a sexually transmitted infection"			
	True**	151 (69.9)	116 (69.5)	35 (71.4)
	False	64 (29.6)	50 (29.9)	14 (28.6)
	I don't know	1 (0.5)	1 (0.6)	0 (0.0)
Q12	Can a person get HPV from skin to skin contact with a person infected with HPV?			
	Yes**	64 (29.6)	48 (28.7)	16 (32.7)
	No	119 (55.1)	96 (57.5)	23 (46.9)
	I don't know	33 (15.3)	23 (13.8)	10 (20.4)
Q13	Can HPV cause cancer?			
	Yes**	166 (76.9)	134 (80.2)	32 (65.3)
	No	10 (4.6)	6 (3.6)	4 (8.2)
	I don't know	40 (18.5)	27 (16.1)	13 (26.5)
Q14	Does HPV affect both women and men?			
	Yes**	207 (95.8)	160 (95.8)	47 (96.0)
	No	2 (0.9)	0 (0.0)	2 (4.1)
	I don't know	6 (2.8)	6 (3.6)	0 (0.0)
	Left question unanswered	1 (0.5)	1 (0.6)	0 (0.0)
Q15	Does HPV cause cancer only in women?			
	Yes	23 (10.6)	20 (12.0)	3 (6.1)
	No**	139 (64.4)	108 (64.7)	31 (63.3)
	I don't know	53 (24.5)	39 (23.4)	14 (28.6)
	Left question unanswered	1 (0.5)	0 (0.0)	1 (2.0)
Q16	Can condoms ensure you will not get HPV?*			
	Yes	29 (13.4)	26 (15.6)	3 (6.1)
	No**	154 (71.3)	121 (72.5)	33 (67.3)
	I don't know	33 (15.3)	20 (12.0)	13 (26.5)
Q17	In which category do you believe your risk falls for getting HPV?			
	High risk	10 (4.6)	8 (4.8)	2 (4.1)
	Moderate Risk	37 (17.1)	32 (19.2)	5 (10.2)
	Low risk	139 (64.4)	103 (61.8)	36 (73.5)
	No risk	30 (13.9)	24 (14.4)	6 (12.2)
Q18	Which statement do you identify with the strongest?			
	Having HPV would significantly affect my health in a negative way	137 (63.4)	106 (63.5)	31 (63.3)
	Having HPV would slightly affect my health in a negative way	77 (35.6)	59 (35.3)	18 (36.7)
	Having HPV would not affect my health	1 (0.5)	1 (0.6)	0 (0.0)
	Having HPV would improve my health	0 (0.0)	0 (0.0)	0 (0.0)
	Left question unanswered	1 (0.5)	1 (0.6)	0 (0.0)

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Table 2 (continued)

Question Number	Questions Pertaining to Sexual Health	Total, n (%) (n = 216)	Female, n (%) (n = 167)	Male, n (%) (n = 49)
Q19	Is there a cure for HPV?			
	Yes	16 (7.4)	12 (7.2)	4 (8.2)
	No**	119 (55.1)	96 (57.5)	23 (46.9)
	I don't know	81 (37.5)	59 (35.3)	22 (44.9)
Q20	Can HPV infection be prevented?			
	Yes**	198 (91.7)	153 (91.6)	45 (91.8)
	No	4 (1.9)	4 (2.4)	0 (0.0)
	I don't know	14 (6.5)	10 (6.0)	4 (8.2)
	Questions Pertaining to HPV Vaccination	Total, n (%) (n = 217)	Female, n (%) (n = 168)	Male, n (%) (n = 49)
Q21	Did you know there is a vaccine for HPV?*			
	Yes	190 (88.0)	152 (91.0)	38 (77.6)
	No	24 (11.1)	13 (7.8)	11 (22.4)
	Left question unanswered	2 (0.9)	2 (1.2)	0 (0.0)
Q22	If you were aware that there is a vaccine for HPV, did you know it can be given until age 40?			
	Yes	79 (36.6)	65 (38.9)	14 (28.6)
	No	137 (63.4)	102 (61.1)	35 (71.4)
Q23	Are you vaccinated against HPV (at least one dose)?			
	Yes	168 (77.8)	134 (80.2)	34 (69.4)
	No	47 (21.8)	32 (19.2)	15 (30.6)
	Left question unanswered	1 (0.5)	1 (0.6)	0 (0.0)
Q24	If you are vaccinated against HPV who recommended this vaccination to you?			
	Pediatrician or other healthcare provider	146 (67.6)	116 (69.5)	30 (61.2)
	Parent or guardian	22 (10.2)	17 (10.2)	5 (10.2)
	Friend	1 (0.5)	1 (0.6)	0 (0.0)
	Teacher	0 (0.0)	0 (0.0)	0 (0.0)
	Other	2 (0.9)	2 (1.2)	0 (0.0)
	This does not apply to me because I am not vaccinated for HPV	44 (20.4)	30 (18.0)	14 (28.6)
	Left question unanswered	1 (0.5)	1 (0.6)	0 (0.0)
Q25	The HPV vaccination is only needed if you have multiple sexual partners?*			
	Yes	3 (1.4)	2 (1.2)	1 (2.0)
	No**	194 (89.8)	158 (94.6)	36 (73.5)
	I don't know	19 (8.8)	7 (4.2)	12 (24.5)
Q26	"The HPV vaccine has significant side effects"			
	True	10 (4.6)	6 (3.6)	4 (8.2)
	False**	147 (68.1)	120 (71.9)	27 (55.1)
	I don't know	59 (27.3)	41 (24.6)	18 (36.7)
Q27	"The HPV vaccine is safe"			
	True**	178 (82.4)	140 (83.8)	38 (77.6)
	False	4 (1.9)	3 (1.8)	1 (2.0)
	I don't know	34 (15.7)	24 (14.4)	10 (20.4)
Q28	Can you get HPV from receiving the HPV vaccination?*			
	Yes	4 (1.9)	2 (1.2)	2 (4.1)
	No**	120 (55.6)	102 (61.1)	18 (36.7)
	Almost never	66 (30.6)	47 (28.1)	19 (38.8)
	I don't know	26 (12.0)	16 (9.6)	10 (20.4)
Q29	The HPV vaccine (specifically Gardasil 9) is effective at preventing HPV infection?*			
	Yes**	175 (81.0)	140 (83.8)	35 (71.4)
	No	4 (1.9)	4 (2.4)	0 (0.0)
	I don't know	37 (17.1)	23 (13.8)	14 (28.6)
Q30	Do you agree with this statement? "My family and/or friends would disapprove if they knew I was vaccinated for HPV"			
	Yes	12 (5.6)	8 (4.8)	4 (8.2)
	No	194 (89.8)	154 (92.2)	40 (81.6)
	I don't know	10 (4.6)	5 (3.0)	5 (10.2)
Q31	If someone is vaccinated for HPV are safe sex practices (i.e. condoms, contraception) still needed?*			
	Yes**	209 (96.8)	164 (98.2)	45 (91.8)
	No	3 (1.4)	1 (0.6)	2 (4.1)
	I don't know	3 (1.4)	1 (0.6)	2 (4.1)
	Left question unanswered	1 (0.5)	1 (0.6)	0 (0.0)
Q32	Do you think by getting the HPV vaccine you will be more inclined to be sexually active?*			
	Yes	21 (9.7)	17 (10.2)	4 (8.2)
	No	179 (82.9)	142 (85.0)	37 (75.5)
	I don't know	16 (7.4)	8 (4.8)	8 (16.3)

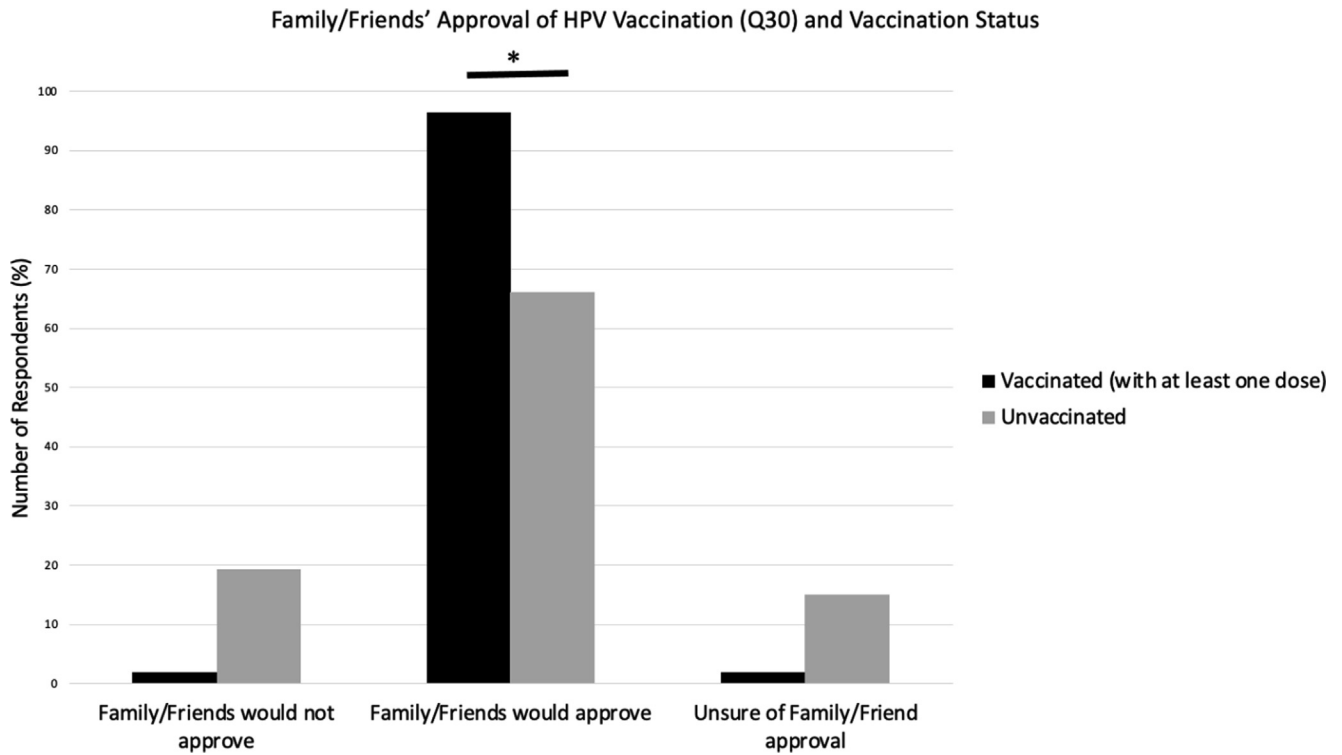


Fig. 3. Individuals who feel their family and friends would approve of HPV vaccination are more likely to be vaccinated for HPV. * $p < 0.05$.

in Villanova, PA). We designed a survey to assess knowledge, attitudes, and awareness surrounding HPV infection and HPV vaccination along with self-reported HPV vaccination rates. Our findings indicate that lower vaccination rates for HPV are not explained by overall knowledge about HPV and infection, but more likely involve concerns about vaccine safety and social stigmas associated with HPV vaccination.

Participants (both male and female) who responded correctly to all eight knowledge questions were not more likely to be vaccinated for HPV. This does not preclude the possibility that knowledge is an important factor in the decision to become vaccinated, but our data suggest that factors beyond basic knowledge of HPV may play more important roles in this decision. For example, although there were no significant differences between males and females with respect to knowledge about HPV, there was a general lack of knowledge about transmission and treatments. Only a small percentage of participants correctly responded that HPV can be spread by skin-to-skin contact. Although skin to skin contact is not the most common route of transmission of HPV infection, it is a possible route for transmission and more than half of the study population is misinformed about it. Small subsets of participants also believed that there is a cure for HPV and/or were unsure if HPV causes cancer in only women. Despite being small subsets, the responses identify a population of individuals in need of better education about HPV which may directly impact their decision to vaccinate. Overall, the data suggest that factors beyond knowledge of the infectious disease play more significant roles in the decision to vaccinate, in line with what has previously been reported for HPV vaccination [20].

Several factors may play significant roles in these decisions including risk awareness, vaccine safety, and vaccine disapproval by parents, family, and friends. The majority of participants (both male and female) responded that they were at a low-risk for being infected with HPV and only a small percentage felt that they were high-risk for infection. Therefore, although HPV is the most

commonly transmitted STI in the United States and a significant proportion of sexually active men and women will be infected by some genotype of HPV in their lifetime [29], the majority of respondents in our study feel they are at low risk for contracting the virus. Although a conclusive statement cannot be made about the true risk of our study population, the majority of participants reported being currently sexually active, including participants who have had multiple sexual partners, as well as those who have not practiced safe sex. Therefore, it is likely that individuals are at greater risk for contracting HPV than they perceive. In support of this data, Holman et al. cite a low perceived risk of HPV infection to be a potential barrier among parents getting their children vaccinated [30]. This highlights the importance of educating children, adults, and parents alike about the widespread prevalence of HPV and the likelihood of contracting some type of HPV in a person's lifetime.

Individuals who believed HPV vaccination is safe, effective, without significant side effects, and cannot result in HPV infection were significantly more likely to be vaccinated in at least one dose than participants who believed vaccination is unsafe. Scientific data prove the safety and efficacy of HPV vaccines [4,31,32], but a divide exists between these facts and the public's understanding of them.

There is a perception held by some parents that getting their child vaccinated for HPV will incline the child to become sexually active. This is commonly linked to a feeling that vaccination encourages sexual behavior [33]. Our findings add evidence to dispel this notion. We found that the majority of respondents indicated that they would not be more inclined to be sexually active after getting the HPV vaccine. This unsupported perception has the potential to be a detriment to the health of the child through not vaccinating him or her against HPV or waiting until an older age to vaccinate which is inadvisable. What's more, the data indicate that individuals who believe their family or friends would disapprove of the HPV vaccination were significantly less likely to be

vaccinated. It is imperative that repeated educational conversations occur between parents, children, and healthcare providers about HPV vaccination to eradicate its stigma with sexual promiscuity or inclination. A physician's recommendation for the HPV vaccine has been shown to promote uptake and acceptance of HPV vaccination [30]. Therefore, physicians can be an important target to promote HPV vaccination and alleviate concerns about its link to sexual activity which is widely disproven [23–26].

There are several limitations to our study that highlight the need for further investigation. First, although the total population of Villanova is over 8000 students, only 217 students responded. Although these numbers are similar to response rates in other studies [9,11], a larger sampling population may have been more informative and may eliminate bias in students who respond to the survey (i.e., respondents who are science majors vs. non-science majors; vaccinated vs. non-vaccinated etc.) Secondly, we did not stratify our responses based on age over 25 years old and it is possible that expanding the age stratification would provide more information about knowledge and vaccination rate that was not captured in this current study. Finally, we did not investigate economic impact of HPV vaccination—namely cost to the student—and it is possible that vaccination status is impacted by health care plan and out of pocket expenses related to obtaining the vaccine.

Taken together, the data presented in this study indicate that factors beyond basic knowledge of the infectious disease play more significant roles in the decision to vaccinate, in line with what has previously been reported for HPV vaccination [20]. Since the recommended age range for HPV vaccination is 11–12 years of age, clinicians should discuss the virus and vaccine with both parents and children and, if possible, dispel the myths that surround HPV vaccination. With the wide availability of HPV vaccines in the US including at physicians' offices, urgent care clinics, and pharmacies, education about the vaccine must include ways to obtain the vaccine safely and with reasonable cost to the individual. As individuals move through the health care system, particularly into early adulthood, there continues to be opportunities to educate about the benefits of HPV vaccination.

Data Statement

Due to the sensitive nature of the questions and the perception by students that their responses may be used to identify them, it was agreed between the authors and the IRB of Villanova University that any raw data will not be published or shared.

CRediT authorship contribution statement

Jennifer A. Goldfarb: Conceptualization, Methodology, Formal analysis, Data curation, Writing – original draft, Writing – review & editing, Visualization. **Joseph D. Comber:** Conceptualization, Writing – review & editing, Funding acquisition, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We would like to thank Dr. Carol Weingarten for her guidance and suggestions during and after the data collection process, and Dr. Carla NavarezDiaz for helpful comments and discussion about the statistical tests used to analyze the collected data. We would

also like to thank Dr. Carol Weingarten, Dr. John Olson, the Villanova Honors Department, and the Office of Health Professions Advising for help in disseminating the survey. This work received funding from Villanova University's Falvey Memorial Library Scholarship Open Access Reserve (SOAR) Fund.

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