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RESEARCH ARTICLE

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Knowledge of the human papilloma virus and acceptance of its vaccine among male and female young adults in Jeddah, Saudi Arabia: A cross-sectional study

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ABSTRACT

This study assessed university students' awareness and knowledge of human papillomavirus (HPV) and its vaccine and willingness to accept vaccination in Jeddah, Saudi Arabia, and identified factors associated with these outcomes. This cross-sectional study was conducted in Jeddah, Saudi Arabia. The study population included university-level male and female students. During the first term of the 2023–2024 academic year, eligible participants were sent an online questionnaire. The study variables included measures of sociodemographic factors, awareness and knowledge of HPV and its vaccine, and vaccine acceptance. We conducted descriptive analysis of awareness, good knowledge, and willingness to accept vaccination, and multivariable logistic regression analyses to determine predictors of these outcomes. The study included 400 participants with a mean age of 21.4years, predominantly female and of Saudi nationality (93%). Awareness of HPV infection was reported by 49.3% of participants, while 44% were aware of the HPV vaccine. Among those aware of HPV, 82.2% recognized its link to cervical cancer, but misconceptions about HPV exist. Only 3.8% of participants had been vaccinated for HPV, and 33.5% expressed willingness to accept the vaccine. Age (per 1year increment; OR: 1.42, 95% CI: 1.25 to 1.62, $P < .001$), mother's education level (doctorate or advanced degree vs. pre-high school; OR: 4.65, 95% CI: 1.51 to 14.32, $P = .007$), and COVID-19 vaccine (received 3 doses vs.<3; OR: 3.12, 95% CI: 1.78 to 5.45, $P < .001$) were significant predictors of better HPV awareness. Living abroad was significantly associated with higher HPV vaccination rates (OR: 4.39, 95% CI: 1.27 to 15.1, $P = .02$). Male students were less likely to be willing to accept vaccination than females (OR: 0.38, 95% CI: 0.20 to 0.72, $P = .003$). HPV awareness, knowledge, and vaccine acceptance remain low among Saudi university students, with very limited uptake. Older age, maternal education, and prior COVID-19 vaccination were key predictors of awareness, highlighting important targets for future public health strategies. Targeted university-based and digital interventions are urgently needed to address these gaps and support national and regional HPV vaccination strategies. Future research should evaluate the effectiveness of such interventions and explore cultural and gender-specific barriers to HPV vaccine uptake.

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HPV vaccine; HPV vaccine acceptance; human papillomavirus (HPV)

Introduction

Human papillomaviruses (HPVs) are small, non-enveloped, double-stranded DNA viruses. They include more than 200 genotypes. Warts and other benign lesions are typically linked to low-risk genotypes, whereas malignancies and cancers, such as cervical cancer, are often associated with high-risk genotypes.[1] HPV is also one of the leading causes of infection-related cancer in both men and women. Moreover, high-risk HPV genotypes are partially responsible for malignancies of the vulva, vagina, penis, anus, and head and neck.[2]

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HPV infection is considered the most prevalent sexually transmitted infection (STI) that affects both adolescents and adults in their early twenties.[3] In Saudi Arabia, the reported prevalence of cervical HPV varies between 5.6% and 31.6% across regions.[4–7]

Current evidence indicates that behavioral modifications, such as condom use, are associated with limited effectiveness in preventing HPV infection. However, prophylactic vaccinations against HPV infection are highly effective.[8] Critical preventive approaches to decrease the incidence of HPV and related complications include screening and HPV vaccination.[3] HPV vaccines are available as bivalent, quadrivalent and nonavalent formulations. The Advisory Committee on Immunization Practices (ACIP) recommends routine vaccination at 11–12 years, with catch-up up to 26 years.[9] For males aged 11 or 12, ACIP advises regular HPV4 immunization. Vaccination is also recommended for males aged 13 to 21 who have never been vaccinated.[10]

In 2010, the Saudi Food and Drug Authority approved HPV vaccines, including the bivalent vaccine (Cervarix) and the quadrivalent vaccine (Gardasil), for females aged 11 and 26 years, and they became available for use.[11,12] The Saudi National Immunization Schedule now includes HPV vaccines in its list of required female immunizations. HPV vaccinations were added to the standard vaccination regimens for girls in the 2019 revision of the Saudi National Immunization Schedule. However, in Saudi Arabia, HPV vaccination is optional for men.[13,14]

Levels of acceptance, knowledge, and awareness of the HPV vaccine have been assessed in various studies worldwide. Previous studies conducted in Saudi Arabia have highlighted a significant lack of understanding and awareness regarding HPV infection and its vaccination.[15] Predictors of HPV vaccine knowledge and acceptance also appear to vary significantly across different regions of Saudi Arabia.[3,16]

This cross-sectional study aimed to assess awareness, knowledge, and acceptance of the HPV vaccine among two understudied groups: female and male university students aged 18 years or older, who are not currently prioritized in the mandatory Saudi national immunization schedule, which primarily targets young females. The focus on university students was intentional, as they represent a key demographic for assessing HPV awareness and vaccination knowledge. University students are often at a critical stage for healthcare decision-making and vaccination uptake. Many are entering adulthood, forming long-term health habits, and may be more receptive to educational campaigns about HPV prevention. Despite this, university students have been relatively understudied in Saudi Arabia, as most prior HPV research has focused on school-aged girls, healthcare professionals, or parents, with limited attention to young adults navigating independent healthcare choices. Moreover, university campuses offer a practical and accessible setting for implementing vaccine campaigns and conducting research, given students' institutional affiliations and the feasibility of structured data collection. Understanding levels of willingness to receive vaccines and identifying potential barriers among university students can help guide future campaigns and interventions aimed at extending HPV vaccination to young adults in Saudi Arabia. Our main objectives were to assess HPV and HPV vaccine awareness, knowledge, and acceptance among university-level young adults in Jeddah, Saudi Arabia, and to identify sociodemographic, lifestyle, health, and knowledge-related factors associated with HPV vaccine acceptance.

Methods

We followed the *Strengthening the Reporting of Observational Studies in Epidemiology* (STROBE) guidelines to report this study.[17]

Study design and setting

This cross-sectional study was conducted in the city of Jeddah, Saudi Arabia. The city of Jeddah is the second-largest city in Saudi Arabia and a major educational center, housing several universities that attract students from around the country. The diverse population and large student body enrolled across its universities make it a particularly suitable setting for exploring awareness and acceptance of the HPV vaccine among young adults, as findings are likely to capture perspectives from diverse backgrounds. Ethical approval was obtained from the research ethics committee at the Faculty of Medicine, King Abdulaziz University (Ref No. 490–23). Participants were informed that participation was voluntary, and completing

the questionnaire indicated their consent to participate. All data were collected anonymously. Confidentiality of participant data was strictly maintained throughout the study.

Participants

The study sample consisted of university-level male and female students enrolled in universities in Jeddah, Saudi Arabia. Inclusion criteria were university students of any nationality and sex, aged 18 to 26, enrolled in a university in Jeddah during the data collection period. Those currently not enrolled in any university program were excluded. Students were recruited through university group leaders and student representatives who used university-affiliated WhatsApp groups for recruitment, and through publicly available social media accounts of university student organizations, primarily X (formerly Twitter).

Questionnaire administration

All data were collected via an online questionnaire administered in Arabic. Questionnaire links were distributed by group leaders and student representatives on the same platforms mentioned above, namely, university-affiliated WhatsApp groups and student organizations on X (formerly Twitter). The digital questionnaire was prepared using Google Forms. Prior to questionnaire administration, it was piloted on thirty students to identify and resolve any potential conceptual or technical difficulties. Technical issues were addressed by improving the questionnaire's navigation between sections and clarity. Pilot responses were not included in the final analysis. The final questionnaire was made available online to participants during the first term of the 2023–2024 academic year.

The internal consistency (Cronbach's α) of the HPV knowledge scale was measured and excellent (11 items; $\alpha = 0.97$). The internal consistency (Cronbach's α) of the HPV vaccination knowledge scale was good (7 items; $\alpha = 0.8$). The validity of the used questionnaires was not evaluated in the current study, however, some sections were obtained from previously validated instruments.[18]

Sample size calculation

The sample size was calculated based on requirements for precise estimation of the proportion of vaccine acceptance among university students in Jeddah. Two previous studies conducted among dental and medical university students in Jeddah, Saudi Arabia, showed that acceptance ranged between 45% and 48.9%.[14,19] After setting the expected acceptance proportion at 50% and aiming for a 95% confidence level with a margin of error of 5%, the required sample size was determined to be 385. The sample size was increased to 400 to account for potential missing data.

Variables

The questionnaire collected data on the following variables: (1) demographic information, (2) knowledge of human papillomavirus (HPV), (3) knowledge of HPV vaccination, and (4) willingness to accept the HPV vaccine. The study data collection tool was modified from previous publications.[14,19]

The questionnaire included four sections (with 41 questions/items). The first section asked about socio-demographic information and lifestyle and health status factors, including sex, age, nationality, and smoking. The second section asked questions about HPV knowledge and included questions like: "Have you ever heard of HPV infection?" and "What is the source of your HPV knowledge?" The third section asked about HPV vaccine knowledge, such as: "Have you ever heard of the HPV vaccine?" and "Have you ever received an HPV vaccine?" Finally, in the fourth section, the questionnaire asked about HPV vaccine acceptance. This section included questions like: "Would you have been interested in getting the HPV vaccine?" "What were the reasons you would not have wanted to get the vaccine?" and "Did you plan to discuss the HPV vaccine with your siblings and colleagues?"

The primary outcome variables in this study were (1) awareness of HPV infection, (2) good knowledge of HPV infection, (3) awareness of the HPV vaccine, (4) good knowledge about the HPV vaccine, (5) HPV vaccination status, and (6) willingness to accept the HPV vaccine. A continuous variable was

constructed to measure knowledge using eleven HPV infection and seven HPV vaccine knowledge questions included in the questionnaire. A score of 1 was assigned for correct answers and 0 for incorrect or "don't know" responses, giving a maximum score of eleven for HPV infection knowledge and seven for HPV vaccine knowledge, and a minimum score of zero for both variables. Higher scores indicated better knowledge. We further dichotomized the outcomes into having good vs. poor knowledge, considering those who scored 75% correct or higher as having good knowledge. Two binary variables were created to measure awareness of HPV infection and HPV vaccine. A score of 1 in each variable was given if the participant answered "yes" to the question, "Have you ever heard of the Human Papilloma Virus or its infection?" and "Have you ever heard of the HPV vaccine?" Two binary variables were also created to measure vaccination status, in which participants were considered as vaccinated if they answered "yes" to the question: "Have you ever received an HPV vaccine?" and vaccine acceptance in which participants were considered to accept the vaccine if they indicated "yes" to the question, "Would you be interested in getting the HPV vaccine?"

Statistical analysis

Continuous variables were visually inspected to examine distribution and assessed for normality using the Shapiro-Wilk test. Variables with a normal distribution were summarized as mean (standard deviation, SD). Continuous variables with a non-normal distribution were presented as median (interquartile range IQR). Categorical variables were presented as numbers (percentages).

We examined associations between socio-demographic and clinical characteristics (independent variables) and six dichotomous outcome variables: awareness of HPV infection, good knowledge of HPV infection, awareness of the HPV vaccine, good knowledge of the HPV vaccine, HPV vaccination status, and acceptance of HPV vaccination. For each outcome, two models were fitted: a univariable logistic regression model, where each predictor was tested individually, and a multivariable logistic regression model, in which all predictors were included simultaneously. The independent variables included across all models were sex, age, nationality, marital status, parental status, university affiliation, GPA, mother's education, father's education, COVID-19 vaccination status, smoking status, presence of chronic disease, and history of living abroad. We assessed collinearity and examined the models for outliers or influential observations in our multivariable models, and did not find any issues.[20] Given the low number of participants reporting a positive HPV vaccination status, we employed exact logistic regression[21] for the univariable model and penalized maximum likelihood logistic regression for the multivariable model[22] to examine the associations with HPV vaccination status. All other dependent variables (awareness of HPV infection, good knowledge of HPV infection, awareness of the HPV vaccine, good knowledge about the HPV vaccine, and acceptance of the HPV vaccine) were modeled using standard unconditional logistic regression. Association results were presented as odds ratios with 95% confidence intervals (95% CIs). To describe proportions, whenever appropriate, we used exact (Clopper-Pearson) 95% CIs.[23] Two-sided P-values $< .05$ were considered statistically significant. With the exception of one question regarding whether HPV always presents with visible signs (48 missing responses; 12%), no other missing data were observed. We used complete case analysis in descriptive statistics, and imputed the missing values as 0 "wrong answer" in regression analysis. All analyses were conducted in Stata (version 18, College Station, TX, USA).

Results

Participant characteristics

Four hundred students were included in the current study. The mean age was 21.4 years, ranging from 18 to 26 years. Of the 400 participants surveyed, 320 (80%) were female, 372 (93%) were of Saudi nationality and 391 (97.8%) were single. Nearly all participants reported strong academic performance, with 49% achieving an excellent GPA (4.50–5.00) and 42.5% a very good GPA (3.75–4.49). Three-quarters of students had taken 3 doses of the COVID-19 vaccine (300 of 400, 75%). Table 1 summarizes the socio-demographic characteristics of the examined participants.

Table 1. Socio-demographic characteristics of the study sample of university students in Jeddah, Saudi Arabia (2023–2024) (N = 400).

Characteristic	N = 400
Age, mean (SD)	21.4 (2.0)
Female, no. (%)	320 (80)
Saudi nationality, no. (%)	372 (93)
Marital status (single), no.(%)	391 (97.8)
Has children, no. (%)	6 (1.5)
University – KAU, no. (%)	308 (77)
GPA score, no. (%)	
Excellent (4.50 – 5.00)	196 (49)
Very Good (3.75 – 4.49)	170 (42.5)
Good (2.75 – 3.49)	28 (7)
Pass (2.00 – 2.74)	6 (1.5)
Mother's education, no. (%)	
Pre-high school	46 (11.5)
High school	104 (26)
Bachelor's degree	195 (48.8)
Master's degree	23 (5.8)
Doctorate/advanced degree	32 (8)
Father's education, no (%)	
Pre-high school	36 (9)
High school	80 (20)
Bachelor's degree	166 (41.5)
Master's degree	60 (15)
Doctorate/advanced degree	58 (14.5)
COVID-19 vaccination, no. (%)	
1 dose	4 (1)
2 doses	95 (23.8)
3 doses	300 (75)
Unvaccinated	1 (0.3)
Smoking status, no. (%)	
Never smoker	260 (65)
Former smoker	16 (4)
Current smoker	32 (8)
Passive/social smoker	92 (23)
One or more chronic diseases, no. (%)	39 (9.8)
Lived abroad, no. (%)	64 (16)

SD denotes standard deviation. KAU denotes King Abdulaziz University. GPA stands for Grade Point Average.

Having heard of (i.e., awareness of) HPV infection and associated factors

Approximately 1 in 2 participants (49.3%; 197 of 400) reported having heard of HPV and its infection (see Table 2). Table 3 shows the association between 13 clinical and sociodemographic characteristics and awareness of HPV infection. Age was statistically significantly associated with the odds of being aware of HPV infection, with older individuals showing a higher likelihood of reporting awareness. Mother's education was also a strong predictor of awareness of HPV infection. For example, in a multivariable model, students whose mothers held a doctorate or other advanced degrees had 4.65 times higher odds of reporting awareness of HPV infection compared to students whose mothers had pre-high school education (multivariable OR: 4.65, 95% CI: 1.51 to 14.32, $P = .007$). The number of COVID-19 vaccine doses was also an independently significant predictor of HPV infection awareness. Individuals who received three doses of the COVID-19 vaccine were associated with 3.1 to 3.8 times higher odds of being aware of HPV infection (univariable OR: 3.77, 95% CI: 2.28 to 6.23, $P < .001$; multivariable OR: 3.12, 95% CI: 1.78 to 5.45, $P < .001$) compared to individuals who received fewer doses.

Good knowledge of HPV infection and associated factors

Among the entire study population, 121 individuals (30.3%) had good knowledge of HPV infection (i.e., scored 75% or higher on the knowledge score) – see Table 2. Figure 1 (panel A) indicates that, among the 197 respondents who reported having heard of HPV or its infection, a large proportion recognize the potential of HPV to cause cervical cancer (162 of 197, 82.2%). Additionally, 85.3% are

Table 2. Awareness, knowledge, and attitudes related to HPV infection and vaccination among university students in Jeddah, Saudi Arabia (2023–2024) (N = 400).

Variable	N = 400
Having heard of (i.e., awareness of) HPV or its infection, no. (%)	197 (49.3)
Good knowledge of HPV infection, no. (%)	121 (30.3)
Having heard of (i.e., awareness of) HPV vaccination, no (%)	176 (44)
Good knowledge of HPV vaccination, no. (%)	50 (12.5)
Received HPV vaccine, no. (%)	
Yes	15 (3.8)
No	300 (75)
I don't know	85 (21.3)
Willingness to accept the HPV vaccine, no. (%)	
Yes	134 (33.5)
No	129 (32.3)
I don't know	137 (34.3)
Vaccine awareness programs deemed helpful in deciding to get vaccinated, no. (%)	
Yes	281 (70.3)
No	44 (11)
I don't know	75 (18.8)
Willingness to discuss HPV vaccination with sisters or female friends, no. (%)	
Yes	230 (57.5)
No	68 (17)
I don't know	102 (25.5)
Willingness to discuss HPV vaccination with brothers or male friends, no. (%)	
Yes	125 (31.3)
No	136 (34)
I don't know	127 (31.8)

HPV denotes Human papilloma virus.

aware that HPV spreads during intercourse, and 77.7% understand that it can cause genital warts. The majority also recognized that HPV is not a rare condition, with 142 of 197 participants answering correctly (72.1%, 95% CI: 65.3 to 78.2%). Other statements on HPV infection can be found in Figure 1 (panel A). Figure 2 (panel A) summarizes the main sources of knowledge on HPV reported by the surveyed students. The most frequently reported sources were the internet and media (233 out of 400 participants, 58.3%) and formal education through the university (224 out of 400 participants, 56%).

Predictors of good knowledge of HPV infection followed a similar pattern to predictors of awareness of HPV infection, with age and COVID-19 vaccination being key factors associated with good knowledge of HPV infection (see Table 4).

Having heard of (i.e., awareness of) HPV vaccination and associated factors

Awareness of the HPV vaccine was reported by 176 of 400 participants (44%, 95% CI: 39 to 49%), see Table 2. Table 5 shows that age, mother's education, and COVID-19 vaccine doses remained consistently significant factors associated with awareness of the HPV vaccine. For example, in a univariable model, individuals who received three doses of the COVID-19 vaccine were associated with 2.50 times higher odds of being aware of the HPV vaccine than those who had fewer doses (OR: 2.50, 95% CI: 1.53 to 4.09, $P < .001$). This association was attenuated in the multivariable model but remained statistically significant after controlling for all variables in the model (multivariable OR: 1.91, 95% CI: 1.09 to 3.36, $P = .02$).

Good knowledge of HPV vaccination and associated factors

Among the entire study population, 50 individuals (12.5%) had good knowledge of HPV vaccination (i.e., scored 75% or higher on the knowledge score) – see Table 2. Figure 1 (panel B) depicts the participants' statements on the HPV vaccine. Among students who self-reported being aware of the HPV vaccine, 101 of 173 students (58.4%, 95% CI: 50.7 to 65.8%) correctly identified that it does not protect against all STIs. Further, 81 of 173 participants (46.8%) recognized that the vaccine is most effective when administered before the onset of sexual activity. Other statements on HPV vaccine can be found in Figure 1 (panel B).

Table 3. Odds ratios (95% CI) from univariable and multivariable models for the association between socio-demographic factors and awareness of HPV infection among university students in Jeddah, Saudi Arabia (2023–2024) (N = 400).

	Univariable		Multivariable	
Predictor	OR (95% CI)	*P*	OR (95% CI)	*P*
Sex (male *versus* female)	0.98 (0.60, 1.59)	.92	0.69 (0.38, 1.24)	.21
Age (per 1 year increment)	1.40 (1.26, 1.57)	<.001	1.42 (1.25, 1.62)	<.001
Nationality (Saudi *versus* non-Saudi)	0.89 (0.41, 1.91)	.76	1.39 (0.57, 3.42)	.47
Marital status (married *versus* single)	1.30 (0.34, 4.90)	.70	1.45 (0.11, 18.66)	.78
Children				
Yes vs No	1.13 (0.22, 5.81)	.88	0.50 (0.02, 11.25)	.66
Not applicable* *versus* No	1.15 (0.75, 1.75)	.52	1.26 (0.76, 2.10)	.37
University (KAU *versus* others)	1.21 (0.76, 1.92)	.43	1.26 (0.72, 2.20)	.41
GPA (ref.:Excellent [4.50 – 5.00])				
Very Good (3.75 – 4.49)	0.96 (0.64, 1.45)	.85	1.10 (0.68, 1.79)	.70
Good (2.75 – 3.49)	0.62 (0.28, 1.39)	.25	0.91 (0.36, 2.29)	.84
Pass (2.00 – 2.74)	0.19 (0.02, 1.67)	.14	0.15 (0.01, 2.55)	.19
Mother education (ref.: Pre-high school)				
High school	1.38 (0.67, 2.83)	.39	1.92 (0.83, 4.48)	.13
Bachelor's degree	2.28 (1.17, 4.45)	.02	3.38 (1.49, 7.67)	.004
Master's degree	1.44 (0.52, 4.01)	.48	2.64 (0.76, 9.15)	.12
Doctorate/advanced degree	3.12 (1.22, 7.99)	.02	4.65 (1.51, 14.32)	.007
Father education (ref.: Pre-high school)				
High school	0.51 (0.23, 1.12)	.09	0.25 (0.09, 0.66)	.005
Bachelor's degree	0.76 (0.37, 1.57)	.46	0.45 (0.18, 1.11)	.08
Master's degree	0.80 (0.35, 1.83)	.60	0.44 (0.16, 1.23)	.12
Doctorate/advanced degree	1.22 (0.52, 2.83)	.65	0.83 (0.30, 2.31)	.72
COVID-19 doses (3 *versus* <3)**	3.77 (2.28, 6.23)	<.001	3.12 (1.78, 5.45)	<.001
Smoking (ref.: Never smoker)				
Former smoker	0.57 (0.20, 1.62)	.29	0.62 (0.20, 1.91)	.40
Current smoker	1.08 (0.52, 2.26)	.83	1.11 (0.45, 2.73)	.82
Passive/social smoker	0.77 (0.48, 1.24)	.28	0.75 (0.43, 1.32)	.32
Chronic diseases (yes *versus* no)	1.23 (0.63, 2.38)	.55	1.48 (0.68, 3.21)	.32
Lived abroad (yes *versus* no)	0.89 (0.52, 1.53)	.68	0.74 (0.39, 1.41)	.36

HPV denotes Human Papilloma Virus; KAU denotes King Abdulaziz University.

*Not applicable means participants who were not married at the time of the survey.

**To mitigate the occurrence of zero events, we categorized COVID-19 vaccine doses into two groups: 3 doses versus fewer than 3 doses, given the low frequency of receiving 0 or 1 dose.

Univariable models assessed the association of a single predictor with the response variable, while multivariable models evaluated the association of all variables simultaneously. In the multivariable model, the odds ratio represents the comparison between the category on the left-hand side and the reference category on the right-hand side, while controlling for all other covariates included in the model.

Table 6 presents the association results for good knowledge about the HPV vaccine, where only age remained a statistically significant predictor.

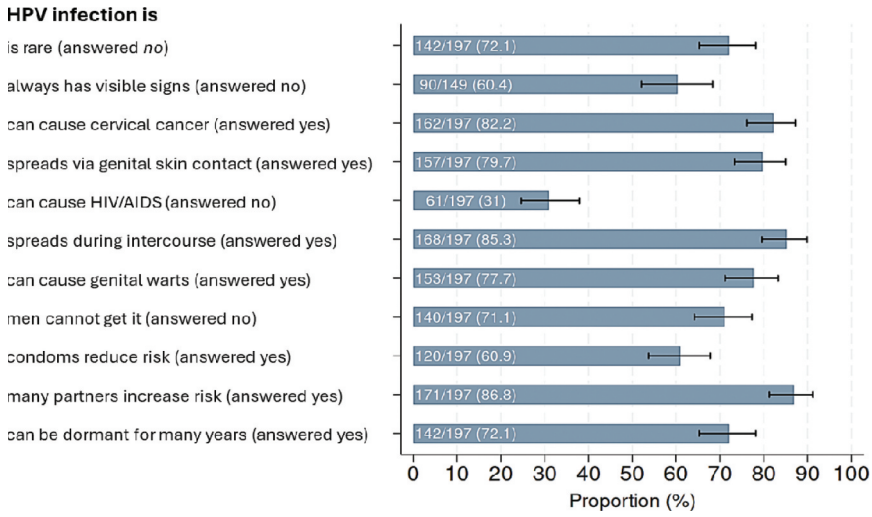
Having received the HPV vaccine (i.e., vaccination status) and associated factors

The proportion of HPV vaccination was low, with only 15 of 400 students reporting having been vaccinated (3.8%, 95% CI: 2.1 to 6.1%) – see Table 2. Table 7 indicates that among the 13 predictors analyzed, living abroad was the only factor consistently linked to a higher chance of participants being vaccinated for HPV, with the univariable odds ratio being 3.74 (95% CI: 1.05–12.3, $P = .04$) and the multivariable odds ratio being 4.39 (95% CI: 1.27–15.1, $P = .02$). While there were other suggestive associations, the small sample size led to significant uncertainty around the point estimates (Table 7).

Willingness to accept HPV vaccination and associated factors

Overall, only 134 (33.5%) of 400 students expressed interest in receiving the HPV vaccine (Table 2). Figure 2 (panel B) displays the reasons cited by participants for not wanting or hesitating to receive the HPV vaccine. The most prevalent reason was the belief that the vaccine was unnecessary (100 of 266 participants, 37.6%). This was followed by a lack of sufficient knowledge about the vaccine (97 participants, 36.5%) and the perception of not being sexually active (62 of 266 participants, 23.3%). For more information about reasons

A) Proportion of respondents who gave the correct answer to statements about HPV infection n/N(%).



B) Proportion of respondents who gave the correct answer to statements about the HPV vaccine n/N(%).

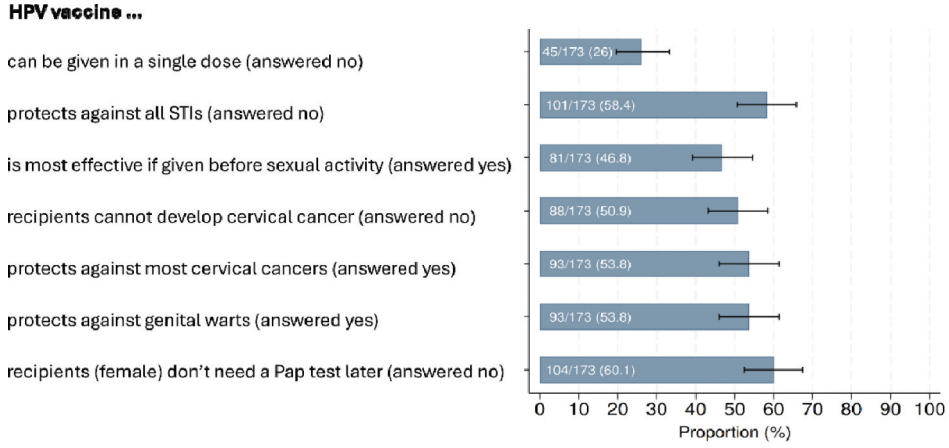


Figure 1. Awareness and knowledge of HPV infection and HPV vaccine among university students in Jeddah, Saudi Arabia (2023–2024). Panel A shows the proportion of students who provided correct answers to knowledge statements about HPV infection, limited to 197 participants who reported being aware of HPV. Panel B shows correct responses to HPV vaccine statements among 176 participants who reported awareness of the vaccine (denominator = 173 due to 3 missing responses). Responses are presented as n/N (%) with horizontal bars representing exact (Clopper – Pearson) 95% confidence intervals. Overall, recognition of HPV as a cause of cervical cancer and its sexual transmission was high, while knowledge of vaccine eligibility and limitations was notably lower. HPV = Human papillomavirus; HIV/AIDS = Human immunodeficiency virus/Acquired immune deficiency syndrome; STI = Sexually transmitted infection.

for hesitancy, see Figure 2 (Panel B). Regarding vaccine awareness programs, a majority of participants (281 of 400, 70.3%) believed them to be helpful in deciding to get vaccinated. Participants' willingness to discuss the HPV vaccine varied by social group. Of the 400 participants, 230 (57.5%) were willing to discuss the vaccine with their sisters or female friends, whereas a smaller proportion, 125 (31.3%), were willing to discuss it with their brothers or male friends (Table 2).

Table 8 shows that both sex and age were significant predictors of willingness to accept HPV vaccination in both univariable and multivariable analyses. Male students were notably less likely to accept the HPV vaccine compared to their female counterparts. Specifically, 19 out of 80 male students (23.7%) expressed

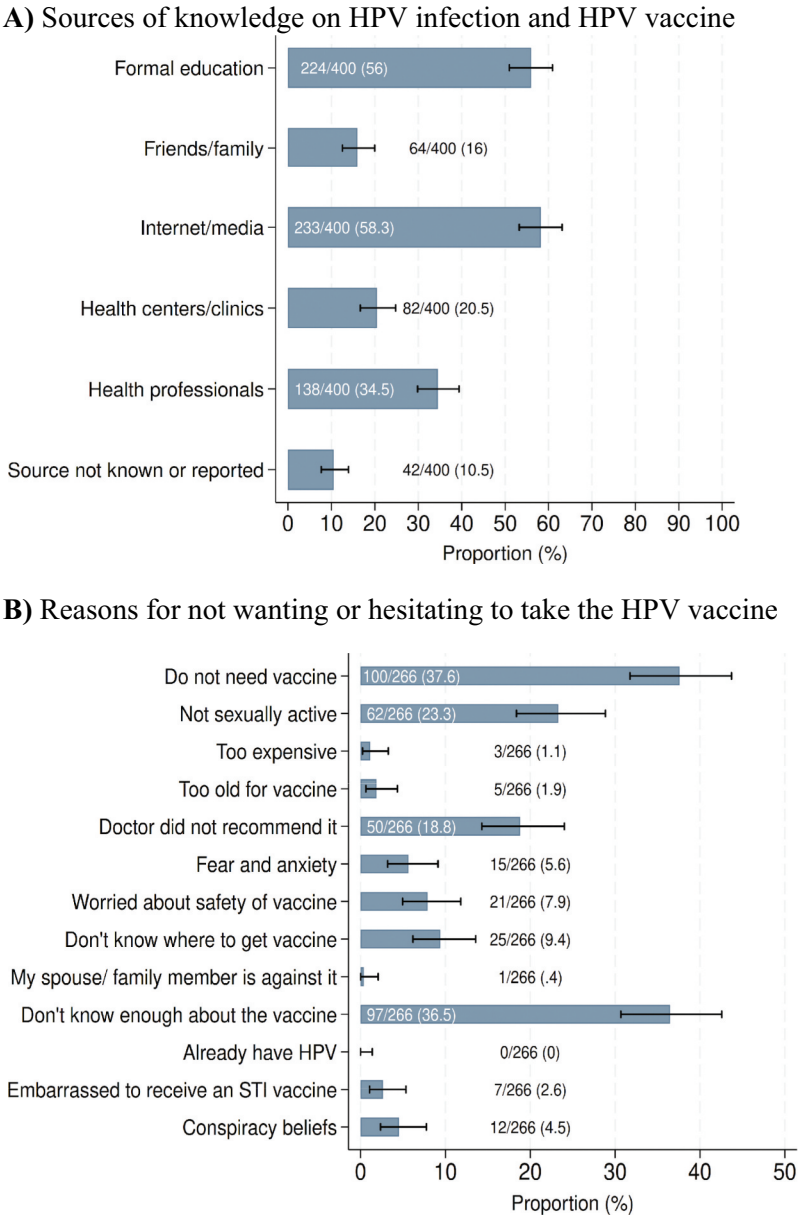


Figure 2. Sources of HPV information and reasons for HPV vaccine hesitancy among university students in Jeddah, Saudi Arabia (2023–2024). Panel A displays the main reported sources of HPV-related knowledge, including internet/media and university education. Panel B shows reasons for not wanting or hesitating to take the HPV vaccine, based on responses from 266 participants who expressed uncertainty or refusal. Responses are presented as n/N (%) with exact 95% confidence intervals. Lack of perceived necessity and insufficient knowledge were the most common reasons for hesitancy. HPV = Human papillomavirus; STI = Sexually transmitted infection.

willingness to be vaccinated for HPV, while 115 out of 320 female students (35.9%) reported the same. The OR for willingness to be vaccinated among male students compared to female students was 0.56 (95% CI: 0.32 to 0.98, $P = .04$), and the multivariable OR was 0.38 (95% CI: 0.20 to 0.72, $P = .003$).

Discussion

This study aimed to examine awareness, knowledge, and acceptance of HPV infection and vaccination among university students in Jeddah, Saudi Arabia, and to identify sociodemographic and health-related factors associated with these outcomes. Our findings reveal four key points. First, only half of participants had heard of HPV infection, and less than one-third demonstrated good knowledge. Second, awareness of

Table 4. Odds ratios (95% CI) from univariable and multivariable models for the association between socio-demographic factors and good knowledge of HPV infection among university students in Jeddah, Saudi Arabia (2023–2024) (N = 400).

	Univariable		Multivariable[¶]	
Predictor	OR (95% CI)	*P*	OR (95% CI)	*P*
Sex (male *versus* female)	1.31 (0.78, 2.21)	.30	0.98 (0.53, 1.80)	.95
Age (per 1 year increment)	1.55 (1.36, 1.76)	<.001	1.53 (1.33,1.78)	<.001
Nationality (Saudi *versus* non-Saudi)	0.92 (0.39, 2.14)	.84	1.70 (0.63, 4.58)	.29
Marital status (married *versus* single)	0.65 (0.13, 3.19)	.60	0.81 (0.09, 7.48)	.85
Children				
Yes *versus* No	0.39 (0.04, 3.45)	.40	0.52 (0.02, 12.8)	.69
Not applicable* *versus* No	0.79 (0.50, 1.24)	.31	0.77 (0.45, 1.33)	.35
University (KAU *versus* others)	0.89 (0.79, 0.98)	.02	0.63 (0.33, 1.19)	.15
GPA (ref.:Excellent [4.50 – 5.00])[‡]				
Very Good (3.75 – 4.49)	0.84 (0.52, 1.34)	.51	0.79 (0.46,1.35)	.39
Good (2.75 – 3.49)	0.55 (0.17, 1.49)	.30	0.75 (0.26, 2.17)	.60
Pass (2.00 – 2.74)	0.25 (0.01, 1.77)	.19	0.06 (0.01, 4.74)	.20
Mother education (ref.: Pre-high school)				
High school	1.02 (0.44, 2.37)	.96	1.14 (0.45, 2.91)	.78
Bachelor's degree	2.02 (0.94, 4.31)	.07	2.39 (0.99, 5.77)	.05
Master's degree	1.00 (0.30, 3.37)	>.99	1.38 (0.35, 5.54)	.65
Doctorate/advanced degree	2.46 (0.91, 6.66)	.08	3.20 (0.98, 10.4)	.05
Father education (ref.: Pre-high school)				
High school	0.62 (0.26, 1.48)	.28	0.43 (0.15,1.21)	.11
Bachelor's degree	0.86 (0.40, 1.86)	.70	0.67 (0.26,1.74)	.41
Master's degree	1.00 (0.42, 2.40)	>.99	0.77 (0.26,2.26)	.64
Doctorate/advanced degree	1.05 (0.44, 2.54)	.91	0.77 (0.26,2.28)	.63
COVID-19 doses (3 *versus* <3)**	5.29 (2.64, 10.6)	<.001	4.22 (2.01, 8.86)	<.001
Smoking (ref.: Never smoker)				
Former smoker	0.28 (0.06, 1.26)	.10	0.41 (0.10, 1.72)	.22
Current smoker	1.34 (0.63, 2.83)	.45	1.49 (0.61, 3.66)	.38
Passive/social smoker	0.48 (0.27, 0.85)	.01	0.43 (0.22, 0.83)	.01
Chronic diseases (yes *versus* no)	1.17 (0.58, 2.37)	.66	1.33 (0.59, 3.03)	.49
Lived abroad (yes *versus* no)	1.06 (0.59, 1.88)	.85	0.96 (0.48, 1.92)	.91

HPV denotes Human Papilloma Virus; KAU denotes King Abdulaziz University.

*Not applicable means participants who were not married at the time of the survey.

**To mitigate the occurrence of zero events, we categorized COVID-19 vaccine doses into two groups: 3 doses versus fewer than 3 doses, given the low frequency of receiving 0 or 1 dose.

Univariable models assessed the association of a single predictor with the response variable, while multivariable models evaluated the association of all variables simultaneously. In the multivariable model, the odds ratio represents the comparison between the category on the left-hand side and the reference category on the right-hand side, while controlling for all other covariates included in the model. [‡]Results based on exact logistic regression due to sparse data. [¶]Results based on penalized maximum likelihood logistic regression due to sparse data.

the HPV vaccine was similarly low, at 44%, with good knowledge observed in just 12.5%. Third, uptake of HPV vaccination was very limited, reported by fewer than 4% of participants. Finally, acceptance of HPV vaccination was also low, with just one-third expressing willingness, and significant differences were observed by sex, age, and perceptions of vaccine necessity.

Awareness and knowledge of HPV infection were suboptimal, with only half of students having heard of HPV and less than one-third achieving good knowledge. Older age, higher maternal education, and receipt of three COVID-19 vaccine doses were significant predictors. These findings align with prior Saudi studies, including those in Jazan and among medical and dental students, which consistently demonstrate major knowledge gaps despite participants' educational backgrounds.[16,24,25] Similar trends are reported across the MENA region, including in Morocco, Algeria, and Jordan, where university students frequently show limited recognition of HPV and its link to cervical cancer.[26–29] In contrast, somewhat higher awareness has been documented in parts of Asia, particularly among health-related majors.[30,31] Our study is novel in demonstrating that, within Saudi Arabia, COVID-19 vaccination uptake may serve as a proxy for openness to health information and preventive care.

HPV vaccine awareness and knowledge were even lower, with fewer than half of students aware of the vaccine and only a small minority showing good knowledge. Predictors mirrored those for HPV infection, though only age remained significant for good knowledge. These results are consistent with earlier Saudi findings of low HPV vaccine awareness among female and dental students[25,32] and with regional evidence from Qatar, Morocco, and Jordan, where misconceptions around safety, efficacy, and necessity

Table 5. Odds ratios (95% CI) from univariable and multivariable models for the association between socio-demographic factors and awareness of HPV vaccination among university students in Jeddah, Saudi Arabia (2023–2024) (N = 400).

	Univariable		Multivariable	
Predictor	OR (95% CI)	*P*	OR (95% CI)	*P*
Sex (male *versus* female)	0.93 (0.56, 1.52)	.76	0.57 (0.31, 1.03)	.06
Age (per 1 year increment)	1.43 (1.28, 1.60)	<.001	1.46 (1.28, 1.67)	<.001
Nationality (Saudi *versus* non-Saudi)	0.49 (0.21, 1.13)	.09	0.64 (0.24, 1.70)	.37
Marital status (married *versus* single)	0.63 (0.16, 2.56)	.52	3.21 (0.24, 42.7)	.38
Children				
Yes *versus* No	0.21 (0.02, 1.81)	.15	0.03 (0.00, 0.88)	.04
Not applicable* *versus* No	0.75 (0.49, 1.14)	.18	0.81 (0.49, 1.35)	.42
University (KAU *versus* others)	1.46 (0.90, 2.36)	.12	1.36 (0.77, 2.41)	.29
GPA (ref.:Excellent [4.50 – 5.00])				
Very Good (3.75 – 4.49)	1.04 (0.69, 1.57)	.85	1.12 (0.69, 1.84)	.64
Good (2.75 – 3.49)	0.58 (0.25, 1.35)	.21	0.69 (0.27, 1.81)	.46
Pass (2.00 – 2.74)	0.25 (0.03, 2.14)	.20	0.34 (0.03, 3.45)	.36
Mother education (ref.: Pre-high school)				
High school	1.72 (0.81, 3.65)	.16	2.40 (1.01, 5.71)	.05
Bachelor's degree	2.41 (1.20, 4.86)	.01	3.39 (1.48, 7.81)	.004
Master's degree	1.63 (0.57, 4.69)	.36	2.25 (0.64, 7.98)	.21
Doctorate/advanced degree	2.88 (1.12, 7.41)	.03	3.69 (1.21, 11.2)	.02
Father education (ref.: Pre-high school)				
High school	0.71 (0.32, 1.58)	.40	0.53 (0.20, 1.40)	.20
Bachelor's degree	1.06 (0.51, 2.18)	.88	0.80 (0.32, 1.96)	.62
Master's degree	0.89 (0.39, 2.06)	.79	0.60 (0.21, 1.68)	.33
Doctorate/advanced degree	1.34 (0.58, 3.09)	.49	1.18 (0.43, 3.27)	.75
COVID-19 doses (3 *versus* <3)**	2.50 (1.53, 4.09)	<.001	1.91 (1.09, 3.36)	.02
Smoking (ref.: Never smoker)				
Former smoker	0.35 (0.11, 1.13)	.08	0.38 (0.11, 1.35)	.14
Current smoker	1.21 (0.58, 2.52)	.62	1.37 (0.57, 3.31)	.48
Passive/social smoker	0.49 (0.30, 0.81)	.005	0.42 (0.24, 0.76)	.004
Chronic diseases (yes *versus* no)	1.10 (0.57, 2.14)	.78	1.12 (0.52, 2.42)	.77
Lived abroad (yes *versus* no)	1.07 (0.62, 1.82)	.82	1.03 (0.54, 1.97)	.93

HPV denotes Human Papilloma Virus; KAU denotes King Abdulaziz University.

* Not applicable means participants who were not married at the time of the survey.

**To mitigate the occurrence of zero events, we categorized COVID-19 vaccine doses into two groups: 3 doses versus fewer than 3 doses, given the low frequency of receiving 0 or 1 dose. Univariable models assessed the association of a single predictor with the response variable, while multivariable models evaluated the association of all variables simultaneously. In the multivariable model, the odds ratio represents the comparison between the category on the left-hand side and the reference category on the right-hand side, while controlling for all other covariates included in the model.

persist.[26,29,33] Global systematic reviews similarly note limited vaccine knowledge among university students, with female students typically more informed than males.[34] The novelty of our findings lies in documenting particularly poor HPV vaccine knowledge among non – health science students in Saudi Arabia and in highlighting COVID-19 vaccination as a novel correlate of vaccine awareness.

HPV vaccine uptake was extremely low, with only a few students reporting prior vaccination. Living abroad was the only significant predictor, likely reflecting exposure to contexts where school-based vaccination programs are established. These findings are consistent with previous Saudi reports of near-absent uptake[24,25] and mirror MENA studies where coverage remains limited despite moderate awareness.[26,28] Higher uptake has been documented in countries such as Lebanon, though barriers remain,[35] while coverage in high-income countries with national programs regularly exceeds 60%.[36] Willingness to accept vaccination in our sample was also low, with hesitancy most often linked to beliefs of low necessity, limited knowledge, and perceptions of low risk due to sexual inactivity. Male students were significantly less likely than females to accept vaccination, echoing findings from Qatar and international reviews.[33,34] Our study is unique in quantifying sex differences in vaccine acceptance among university students and in identifying specific misconceptions underlying hesitancy.

Strengths and limitations

This study has several strengths that enhance the credibility of its findings. It is one of the first mixed-gender, multi-center investigations of HPV awareness and vaccine acceptance among university students, broadening

Table 6. Odds ratios (95% CI) from univariable and multivariable models for the association between socio-demographic factors and good knowledge of HPV vaccination among university students in Jeddah, Saudi Arabia (2023–2024) (N = 400).

	Univariable		Multivariable[¶]	
Predictor	OR (95% CI)	*P*	OR (95% CI)	*P*
Sex (male *versus* female)	1.00 (0.48, 2.10)	>.99	1.03 (0.47, 2.27)	.94
Age (per 1 year increment)	1.39 (1.18, 1.63)	<.001	1.32 (1.12, 1.58)	.001
Nationality (Saudi *versus* non-Saudi)	1.58 (0.57, 4.36)	.38	2.05 (0.65, 6.50)	.22
Marital status (married *versus* single)	0.87 (0.11, 7.13)	.90	3.35 (0.28, 39.7)	.34
Children[‡]				
Yes *versus* No	0.97 (0.01, 7.18)	.98	0.12 (0.03, 5.30)	.27
Not applicable* *versus* No	1.17 (0.61, 2.23)	.63	1.17 (0.58, 2.34)	.66
University (KAU *versus* others)	1.97 (0.85, 4.54)	.11	1.93 (0.79, 4.72)	.15
GPA (ref.:Excellent [4.50 – 5.00])[‡]				
Very Good (3.75 – 4.49)	0.51 (0.25, 1.00)	.05	0.59 (0.30, 1.17)	.13
Good (2.75 – 3.49)	0.18 (0.01, 1.20)	.10	0.39 (0.07, 2.13)	.28
Pass (2.00 – 2.74)	0.61 (0.01, 4.40)	.68	0.68 (0.04, 13.3)	.80
Mother education (ref.: Pre-high school)				
High school	1.04 (0.37, 2.89)	.94	1.19 (0.40, 3.53)	.76
Bachelor's degree	0.85 (0.32, 2.23)	.74	1.00 (0.35, 2.86)	.99
Master's degree	0.63 (0.12, 3.42)	.60	1.24 (0.22, 6.93)	.80
Doctorate/advanced degree	1.54 (0.45, 5.29)	.49	1.73 (0.45, 6.60)	.42
Father education (ref.: Pre-high school)				
High school	0.99 (0.32, 3.09)	.98	1.11 (0.33, 3.73)	.87
Bachelor's degree	0.71 (0.24, 2.06)	.53	0.81 (0.25, 2.56)	.72
Master's degree	1.09 (0.34, 3.56)	.88	1.17 (0.31, 4.36)	.82
Doctorate/advanced degree	0.99 (0.30, 3.31)	.99	0.97 (0.26, 4.36)	.82
COVID-19 doses (3 *versus* <3)**	2.69 (1.11, 6.53)	.03	1.87 (0.77, 4.65)	.18
Smoking (ref.: Never smoker)[‡]				
Former smoker	0.25 (0.01, 1.50)	.15	0.15 (0.75,4.65)	.21
Current smoker	0.37 (0.04 1.55)	.25	0.47 (0.12, 1.92)	.30
Passive/social smoker	0.53 (0.20, 1.20)	.15	0.55 (0.24, 1.28)	.16
Chronic diseases (yes *versus* no)	0.78 (0.27, 2.30)	.66	1.12 (0.38, 3.26)	.84
Lived abroad (yes *versus* no)	1.00 (0.45, 2.24)	>.99	1.05 (0.43, 2.59)	.91

HPV denotes Human Papilloma Virus; KAU denotes King Abdulaziz University.

* Not applicable means participants who were not married at the time of the survey.

** To mitigate the occurrence of zero events, we categorized COVID-19 vaccine doses into two groups: 3 doses versus fewer than 3 doses, given the low frequency of receiving 0 or 1 dose. Univariable models assessed the association of a single predictor with the response variable, while multivariable models evaluated the association of all variables simultaneously. In the multivariable model, the odds ratio represents the comparison between the category on the left-hand side and the reference category on the right-hand side, while controlling for all other covariates included in the model. [‡]Results based on exact logistic regression due to sparse data. [¶]Results based on penalized maximum likelihood logistic regression due to sparse data.

the representativeness of the findings. The sample size, which was calculated a priori and achieved, ensured sufficient precision in the main estimates. The questionnaire demonstrated good reliability, and results were consistent with previous national and regional studies, supporting the validity of our conclusions. However, the study has some limitations. First, the use of convenience sampling and the predominance of female participants may have introduced selection bias and limited the generalizability of our findings The prevalence of awareness, knowledge, and acceptance may be over- or underestimated compared to a more balanced sample. To mitigate this, we included participants from multiple universities and both sexes, but future studies should aim for probability-based sampling strategies. Further, an important limitation is that we do not have information from non-responders to be able to compare them to responders and assess how representative the study population is of the target population. Second, although we relied on self-reported data, which eliminated the risk of interviewer bias, recall bias remains possible. In particular, relying on single questions to measure awareness and acceptance could have led to overestimation of awareness and underestimation of hesitancy. This limitation underscores the need for future research using validated, multidimensional instruments. Third, some estimates were associated with imprecise confidence intervals, suggesting that our study may have been underpowered to detect small to moderate effects that could nonetheless be clinically meaningful and of public health significance. This indicates that larger studies are required to more precisely estimate these associations. Fourth, our study focused exclusively on university students, which may not fully represent the broader population. While targeting university students allowed for a more accessible and convenient sample, this limitation means that our conclusions cannot be generalized to adolescents or non-student young adults. We recommend future

Table 7. Odds ratios (95% CI) from univariable and multivariable models for the association between socio-demographic factors and HPV vaccination status among university students in Jeddah, Saudi Arabia (2023–2024) (N = 400).

	Univariable*		Multivariable**	
Predictor	OR (95% CI)	*P*	OR (95% CI)	*P*
Sex (male *versus* female)	0.60 (0.07, 2.76)	.79	0.31 (0.06, 1.54)	.15
Age (per 1 year increment)	1.23 (0.93, 1.63)	.15	1.17 (0.88, 1.55)	.28
Nationality (Saudi *versus* non-Saudi)	0.61 (0.00, 3.78)	.66	0.35 (0.02, 6.02)	.47
Marital status (married *versus* single)	8.19 (0.76, 49.3)	.08	12.7 (0.28, 588)	.19
Children				
Yes *versus* No	11.9 (0.88, 111)	.06	0.30 (0.005, 17.0)	.56
Not applicable[¶] *versus* No	0.78 (0.22, 3.1)	.87	0.95 (0.29, 3.18)	.94
University (KAU *versus* others)	0.81 (0.25, 2.62)	.73	0.72 (0.22, 2.33)	.59
GPA (ref.:Excellent [4.50 – 5.00])				
Very Good (3.75 – 4.49)	0.71 (0.18, 2.52)	.77	0.76 (0.24, 2.33)	.65
Good (2.75 – 3.49)	0.87 (0.02, 6.94)	.99	0.86 (0.10, 7.09)	.89
Pass (2.00 – 2.74)	4.63 (0.09, 49.5)	.48	2.16 (0.18, 25.4)	.54
Mother education (ref.: Pre-high school)				
High school or higher***	4.25 (0.25, 72.2)	.32	6.08 (0.31, 118.9)	.23
Father education (ref.: Pre-high school)				
High school	0.66 (0.07, 8.29)	.99	0.74 (0.12, 4.74)	.75
Bachelor's degree	0.42 (0.05, 4.84)	.33	0.34 (0.06, 2.02)	.23
Master's degree	0.29 (0.005, 5.80)	.63	0.25 (0.02, 2.46)	.23
Doctorate/advanced degree	1.60 (0.24, 17.6)	.91	0.82 (0.13, 5.07)	.83
COVID-19 doses (3 *versus* <3)[‡]	0.66 (0.20, 2.51)	.62	0.62 (0.19, 1.98)	.46
Smoking (ref.: Never smoker)				
Former smoker	1.85 (0.04, 15.0)	.91	1.74 (0.21, 14.3)	.61
Current smoker	2.87 (0.47, 12.4)	.27	2.15 (0.48, 9.62)	.32
Passive/social smoker	0.62 (0.06, 3.08)	.84	0.55 (0.12, 2.53)	.44
Chronic diseases (yes *versus* no)	2.42 (0.42, 9.54)	.34	1.67 (0.41, 6.86)	.48
Lived abroad (yes *versus* no)	3.74 (1.05, 12.3)	.04	4.39 (1.27, 15.1)	.02

HPV denotes Human Papilloma Virus; KAU denotes King Abdulaziz University.
*Results based on exact logistic regression.
**Results based on penalized maximum likelihood logistic regression.
***Categories merged due to sparse data.
[¶]Not applicable means participants who were not married at the time of the survey.
[‡]To mitigate the occurrence of zero events, we categorized COVID-19 vaccine doses into two groups: 3 doses versus fewer than 3 doses, given the low frequency of receiving 0 or 1 dose.
Univariable models assessed the association of a single predictor with the response variable, while multivariable models evaluated the association of all variables simultaneously. In the multivariable model, the odds ratio represents the comparison between the category on the left-hand side and the reference category on the right-hand side, while controlling for all other covariates included in the model.

work targeting younger populations, ideally prior to sexual initiation, where HPV vaccination would have the greatest long-term impact on awareness and prevention efforts in Saudi Arabia.

Implications for policy and practice, recommendations

Our study highlights potential areas where HPV-related education and immunization campaigns could be strengthened. With less than half of the participants familiar with HPV and its vaccine, targeted educational activities are necessary to raise awareness and understanding of the disease and its vaccine. These initiatives could be implemented in school or college settings. Addressing current beliefs regarding the rarity of HPV is essential. This can be accomplished by including accurate HPV information in the curricula and rectifying misconceptions that might be causing low vaccination rates. Additionally, since the media and the internet are the primary sources of information, these channels can be used to spread trustworthy and interesting content that refutes false information. Furthermore, gender differences in vaccine acceptance suggest that future campaigns should consider gender-specific messaging to raise vaccination rates among male students.

Conclusion and future research

In summary, this study highlights persistently low levels of awareness, knowledge, and acceptance of HPV vaccination among university students in Saudi Arabia, with only a small minority having received the vaccine. By integrating predictors such as maternal education, age, and COVID-19

Table 8. Odds ratios (95% CI) from univariable and multivariable models for the association between socio-demographic factors and willingness to accept HPV vaccination among university students in Jeddah, Saudi Arabia (2023–2024) (N = 400).

	Univariable		Multivariable	
Predictor	OR (95% CI)	*P*	OR (95% CI)	*P*
Sex (male *versus* female)	0.56 (0.32, 0.98)	.04	0.38 (0.20, 0.72)	.003
Age (per 1 year increment)	1.22 (1.10, 1.36)	<.001	1.27 (1.12, 1.45)	<.001
Nationality (Saudi *versus* non-Saudi)	0.94 (0.41, 2.13)	.87	1.03 (0.40, 2.62)	.96
Marital status (married *versus* single)	0.99 (0.24, 4.03)	.99	0.91 (0.07, 12.2)	.94
Children				
Yes *versus* No	1.12 (0.20, 6.40)	.89	0.52 (0.02, 11.9)	.68
Not applicable* *versus* No	1.20 (0.77, 1.89)	.42	1.13 (0.68, 1.90)	.63
University (KAU *versus* others)	0.87 (0.54, 1.42)	.58	0.90 (0.51, 1.57)	.70
GPA (ref.:Excellent [4.50 – 5.00])				
Very Good (3.75 – 4.49)	0.91 (0.59, 1.40)	.66	1.06 (0.65, 1.73)	.82
Good (2.75 – 3.49)	0.49 (0.19, 1.27)	.14	0.57 (0.21, 1.58)	.28
Pass (2.00 – 2.74)	0.36 (0.04, 3.14)	.36	0.46 (0.05, 4.61)	.51
Mother education (ref.: Pre-high school)				
High school	1.83 (0.81, 4.11)	.15	2.15 (0.88, 5.25)	.09
Bachelor's degree	2.25 (1.05, 4.80)	.04	2.63 (1.12, 6.18)	.03
Master's degree	0.54 (0.13, 2.19)	.39	0.47 (0.10, 2.21)	.34
Doctorate/advanced degree	1.89 (0.69, 5.18)	.22	1.59 (0.51, 4.94)	.42
Father education (ref.: Pre-high school)				
High school	0.81 (0.35, 1.88)	.62	0.58 (0.22, 1.52)	.27
Bachelor's degree	0.96 (0.45, 2.07)	.93	0.74 (0.31, 1.79)	.51
Master's degree	1.00 (0.42, 2.40)	>.99	0.94 (0.34, 2.63)	.91
Doctorate/advanced degree	1.52 (0.64, 3.60)	.35	1.89 (0.70, 5.14)	.21
COVID-19 doses (3 *versus* < 3)**	1.41 (0.86, 2.31)	.18	1.02 (0.58, 1.77)	.96
Smoking (ref.: Never smoker)				
Former smoker	2.60 (0.94, 7.22)	.07	3.48 (1.14, 10.67)	.03
Current smoker	1.38 (0.65, 2.93)	.40	1.78 (0.74, 4.26)	.20
Passive/social smoker	0.80 (0.47, 1.34)	.39	0.75 (0.42, 1.33)	.32
Chronic diseases (yes *versus* no)	1.12 (0.56, 2.24)	.74	1.01 (0.48, 2.16)	.97
Lived abroad (yes *versus* no)	0.74 (0.41, 1.34)	.32	0.72 (0.36, 1.41)	.33

HPV denotes Human Papilloma Virus; KAU denotes King Abdulaziz University.

*Not applicable means participants who were not married at the time of the survey.

**To mitigate the occurrence of zero events, we categorized COVID-19 vaccine doses into two groups: 3 doses versus fewer than 3 doses, given the low frequency of receiving 0 or 1 dose.

Univariable models assessed the association of a single predictor with the response variable, while multivariable models evaluated the association of all variables simultaneously. In the multivariable model, the odds ratio represents the comparison between the category on the left-hand side and the reference category on the right-hand side, while controlling for all other covariates included in the model.

vaccination, our study adds to regional evidence and underscores the urgent need for targeted educational and awareness programs. The novelty of our work lies in its focus on males and females, its identification of COVID-19 vaccination as a marker of HPV-related awareness, and its documentation of profound knowledge gaps despite the strategic importance of this age group for HPV vaccine expansion in Saudi Arabia and the wider MENA region.

Future research should build on these findings by testing targeted interventions to improve HPV knowledge and vaccine uptake among university students, including educational campaigns integrated into university curricula and digital health platforms. Qualitative research could further explore cultural and gender-specific barriers, particularly around perceptions of sexual activity and vaccine necessity, which emerged strongly in our data.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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