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Human papillomavirus vaccination readiness, uptake, and perceived barriers among university students in the Pearl River Delta Region: A cross-sectional study

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Abstract

Introduction: Human papillomavirus (HPV) vaccination prevents cervical cancer and other HPV-related diseases, yet uptake among Chinese university students is uneven.
Objective: We examined HPV vaccination readiness, uptake, and perceived barriers among university students in the Pearl River Delta.
Methods: We conducted a cross-sectional survey in May–June 2026. Outcomes were classified as no definite short-term intention, intention to vaccinate within six months, or vaccinated. We used multinomial and binary logistic regression, a 13-item knowledge score, and an 8-item barrier index.
Results: Of 429 students, 175 (40.8%) lacked definite short-term intention, 89 (20.7%) intended to vaccinate within six months, and 165 (38.5%) were vaccinated. Short-term intention was associated with sexual activity with (adjusted OR [aOR] = 4.14, 95% confidence interval [CI]: 2.20–7.79) or without (aOR = 3.06, 95% CI: 1.12–8.35) a regular partner and senior undergraduate/postgraduate status (aOR = 1.83, 95% CI: 1.01–3.31); being vaccinated was additionally associated with female sex (aOR = 4.17, 95% CI 2.41–7.19) and medical major (aOR = 3.58, 95% CI: 2.15–5.95). HPV knowledge was not independently associated with either outcome. Among the unvaccinated (n = 264), the leading barriers were insufficient vaccine information, safety concerns, appointment difficulty, and cost; the barrier index was not significantly associated with definite intention (aOR = 0.63, 95% CI: 0.39–1.03) and was composition-sensitive.
Conclusion: Intention and uptake had distinct correlates: intention was associated with sexual experience and grade level, and being vaccinated was additionally associated with female sex and medical major; knowledge showed no independent association. Interventions should offer practical guidance, gender-inclusive communication, and access support.

Keywords: Human papillomavirus vaccine; University students; Vaccination intention; Vaccination uptake; Perceived barriers; China

1. Introduction

Human papillomavirus (HPV) is one of the most common sexually transmitted infections worldwide and is causally linked to cervical cancer, anogenital cancers, oropharyngeal cancers, and genital warts.[1,2] Cervical cancer remains a major global public health burden, particularly in settings where vaccination and screening coverage are insufficient.[3,4] Persistent infection with high-risk HPV types is a cause of most cervical cancers, making HPV vaccination an important primary prevention strategy.[5]

Real-world evidence has also shown population-level reductions in HPV infection, anogenital warts, high-grade cervical lesions, and invasive cervical cancer following the implementation of HPV vaccination programs.[6,7] The World Health Organization identifies HPV vaccination, cervical cancer screening, and treatment of precancerous lesions as core components of the global strategy to accelerate cervical cancer elimination.[8]

In China, HPV vaccine availability has improved in recent years, partly driven by the introduction of domestically produced vaccines such as the bivalent vaccine Cecolin, which may potentially improve affordability and access.[9] Nevertheless, HPV vaccine uptake among young adults often lags behind awareness or stated willingness, suggesting a persistent intention–behavior gap.[10,11] A recent national survey of Chinese young adults aged 18–30 years reported an HPV awareness rate of 70.4%, but actual vaccination coverage was only 13.6%. The discrepancy between willingness and uptake was substantial among both females (71.4% vs. 22.2%) and males (36.0% vs. 5.0%).[12] Regional variation is also notable, with reported vaccination rates among university students ranging from 3.5% in western China to more than 19.78% in some eastern coastal provinces.[13,14] These differences suggest that local economic conditions, health resources, and policy environments may shape HPV vaccine uptake.

University students are an important target population for HPV prevention. This stage of life often involves increasing autonomy, romantic relationships, sexual activity, and independent health-related decision-making. HPV vaccination behavior in this population may be influenced by sex, academic major, perceived susceptibility, vaccine confidence, affordability, appointment convenience, service accessibility, and peer or partner communication.[10,11,15] A systematic review of barriers to and facilitators of HPV vaccination among people aged 9 to 26 years identified cost, access difficulties, safety concerns, and insufficient recommendation as major influences on vaccine uptake.[15] These findings indicate that structural and social-contextual factors, beyond individual knowledge, may play important roles in vaccination decisions.

Given the substantial regional heterogeneity in HPV vaccination coverage across China and the limited application of stage-based readiness frameworks in this population, this study focused on university students in the Pearl River Delta region. The Pearl River Delta is one of China's most economically developed regions, with dense university resources and comparatively good access to health services. Studying this population may help clarify whether vaccination gaps remain even in settings with relatively favorable access conditions.

Most previous studies have used binary outcomes, such as vaccinated versus unvaccinated or willing versus unwilling. Such classifications may obscure meaningful differences between students who are uncertain, those preparing to vaccinate in the near future, and those who have already been vaccinated. A readiness-based framework informed by the Transtheoretical Model may provide a more nuanced understanding of vaccination decision-making.[16,17] Although HPV vaccination is an episodic preventive behavior rather than a repeated lifestyle behavior, a staged approach can still help distinguish students without a definite short-term plan from those intending to vaccinate and those already vaccinated. This differentiation may help design stage-appropriate interventions.

Perceived barriers also warrant careful examination. Prior studies have identified cost, safety concerns, lack of practical information, appointment difficulty, limited vaccine confidence, and social norms as common barriers to HPV vaccination.[15,18] However, these barriers may represent different underlying dimensions, including structural access, cognitive beliefs, perceived necessity, and family or partner influence. Composite barrier indices should therefore be interpreted cautiously, especially when internal consistency is modest.

This study aimed to (i) describe HPV vaccination readiness and uptake among university students in the Pearl River Delta region; (ii) identify factors associated with short-term vaccination intention and vaccination status; (iii) examine perceived barriers among unvaccinated students; (iv) evaluate the internal consistency and exploratory structure of the knowledge and barrier measures; and (v) assess the robustness of the findings through sensitivity analyses.

2. Methods

2.1. Study design and participants

This cross-sectional study was conducted among university students in the Pearl River Delta region between

May and June 2026. Participants were recruited through convenience and snowball sampling via selected university networks; the questionnaire was distributed exclusively online through the WeChat platform via university organizations and student groups.

We collected 492 questionnaires; 488 were valid after excluding four submissions that failed an embedded quality-control (instructed-response) item requiring selection of a specified option. Forty-five respondents studying at universities outside the Pearl River Delta were excluded, leaving 443 eligible respondents. Fourteen respondents were excluded because of missing key variables (sex, n = 3; sexual status, n = 11). The final analytic sample included 429 students. Of these, 264 unvaccinated students were included in analyses of perceived barriers and short-term vaccination intention. Age was not collected as a separate variable; the inclusion criterion of being aged 18 years or older was based on self-report.

The inclusion criteria were: (i) those aged 18 years or older; (ii) currently enrolled in a university in the Pearl River Delta region; (iii) undergraduate or postgraduate students; (iv) completed the core HPV vaccination-related questions; and (v) provided electronic informed consent.

This study followed the Strengthening the Reporting of Observational Studies in Epidemiology reporting guideline for cross-sectional studies.[19] The study protocol was reviewed and approved as exempt research by the Medical Ethics Committee of Zhongshan School of Medicine, Sun Yat-sen University (Approval No. ZSYLL[2026]085; dated March 26, 2026). Electronic informed consent was obtained from all participants prior to questionnaire administration.

2.2. Questionnaire development and quality control

The research team designed the self-administered questionnaire in Chinese based on the study objectives. The initial item pool, including the 18 knowledge items and the nine barrier items, was reviewed for content relevance, clarity, and face validity by faculty experts in obstetrics and gynecology and in epidemiology, and the items were revised accordingly. The questionnaire was not formally pretested before deployment. The survey was programmed on the Wenjuanxing online survey platform and distributed through WeChat. Quality-control measures included an embedded instructed-response (attention-check) item, restriction to one submission per account, and platform-recorded completion times (median 161 seconds). Four submissions failing the instructed-response item were excluded, and no duplicate submissions from the same account were identified. Because the knowledge and barrier measures were self-designed and not validated against external criteria, they were interpreted as exploratory instruments throughout this study.

2.3. Sample size estimation

The required sample size was estimated using the formula for a single population proportion (**Equation 1**):

$$n = Z^2 p(1 - p) / d^2 \quad (1)$$

With Z = 1.96 (two-sided 95% confidence level), an expected proportion of p = 0.5, and a margin of error of d = 0.05, the minimum sample size was approximately 384. After allowing for approximately 10% invalid or incomplete responses, the target sample size was 427. The final analytical sample of 429 met this requirement. The number of outcome events was also adequate for the planned multivariable models: the events-per-parameter values were 11.1 for the intention outcome and 20.6 for the vaccination outcome, based on eight slope parameters per outcome contrast in the multinomial model, and 9.9 in the binary model among unvaccinated students, based on nine slope parameters, all close to or above the commonly cited minimum of approximately 10 events per parameter.

2.4. Outcome variables

2.4.1. Human papillomavirus vaccination readiness and uptake

Throughout this article, "vaccination intention" and "vaccination readiness" refer to the prospective intention states, whereas "vaccination status," "uptake," and "vaccination initiation" refer to the observed behavioral outcome (self-reported receipt of at least one dose). The original HPV vaccination outcome included four categories: (i) no intention to vaccinate; (ii) uncertain or considering vaccination; (iii) intending to vaccinate within six months; and (iv) vaccinated.

The original four-category distribution was: no intention to vaccinate (n = 11), uncertain or considering vaccination (n = 164), intending to vaccinate within six months (n = 89), and vaccinated (n = 165). Because the no-intention group was very small (n = 11), it was combined with the uncertain/considering group into "no definite short-term vaccination intention" (n = 175); this merging decision was made after inspecting the observed category distribution and should be considered exploratory. The primary analysis used a three-category outcome: (i) no definite short-term vaccination intention; (ii) intending to vaccinate within six months; and (iii) vaccinated. The "no definite short-term vaccination intention" category combined students who reported no intention to vaccinate and those who were uncertain or considering vaccination.

Vaccinated status was defined as self-reported receipt

of at least one dose of any HPV vaccine, regardless of the number of doses completed or the vaccine type received. This outcome therefore represents vaccination initiation rather than series completion. Dose-completion status was based on self-report and the respondent's own judgment, as recommended schedules vary by age at initiation and vaccine product.

2.4.2. Short-term intention among unvaccinated students

Among unvaccinated students, short-term vaccination intention was coded as a binary outcome: 0 = no definite intention to vaccinate within six months; 1 = definite intention to vaccinate within six months.

2.4.3. Human papillomavirus knowledge index

Human papillomavirus knowledge was assessed using 18 true/false items. Correct answers were scored as 1, while incorrect or uncertain answers were scored as 0. Five items were sex-specific (three items on cervical cancer and cervical screening were applicable only to female respondents, and two items on male HPV-related disease were applicable only to male respondents). Because the maximum attainable score on the full item set differed between male (15 applicable items) and female (16 applicable items) respondents, an aggregate 18-item score would not be comparable across sexes; therefore, no 18-item total score was constructed. The primary knowledge score was based on the 13 general items answered by all respondents (range 0–13), and the Kuder–Richardson Formula 20 (KR-20) was used to evaluate its internal consistency (KR-20 = 0.80). The 13-item knowledge score was included as a continuous variable in the primary regression models. The five sex-specific items were summarized descriptively at the item level only.

2.4.4. Perceived barriers to human papillomavirus vaccination

Among unvaccinated students, perceived barriers were assessed using nine Likert-type items, each scored from 1 to 5, with higher scores indicating stronger perceived barriers. The original nine-item barrier index showed moderate internal consistency. The item "belief that vaccination is unnecessary without sexual experience" had the lowest corrected item-total correlation, and its removal improved internal consistency. Therefore, the primary analysis of barriers used an eight-item exploratory barrier index, calculated as the mean score of the eight items (possible range 1–5, with higher scores indicating stronger overall perceived barriers), while the original nine-item index was retained for descriptive reporting and sensitivity analysis.

Because the barrier items were designed to capture heterogeneous practical, cognitive, and social barriers rather than a strictly unidimensional psychological construct, and because exploratory factor analysis (EFA) confirmed a two-factor structure, the overall barrier score was interpreted as an exploratory index rather than a validated scale. The composite barrier index was included in the binary logistic regression as an exploratory predictor, and its results are reported with appropriate caution. The primary interpretation of barriers relies on item-level descriptive analysis.

Exploratory factor analysis was performed for the barrier items using a polychoric correlation matrix, principal axis factoring, and oblimin rotation. Sampling adequacy and factorability were assessed using the Kaiser–Meyer–Olkin statistic and Bartlett's test of sphericity. The EFA sample comprised all 275 eligible unvaccinated respondents with complete responses to all nine barrier items, including 11 respondents excluded from the regression analyses because of missing covariate information (sexual status, n = 8; sex, n = 3). The number of factors was determined using the eigenvalue-greater-than-one criterion, scree plot inspection, parallel analysis, and interpretability of the rotated solution.

2.5. Covariates

Covariates included sex, academic major, grade level, monthly living expenses, sexual status, and the HPV knowledge index. Sex was categorized as male or female. Academic major was categorized as medical or non-medical. Grade level was collapsed into junior undergraduate and senior undergraduate/postgraduate because the number of postgraduate students was small. Sexual status was categorized as no sexual experience, sexually active with a regular partner, and sexually active without a regular partner. Monthly living expenses were categorized as ≤2,000 RMB, 2,001–3,000 RMB, and >3,000 RMB.

School level was collected using four categories (Double First-Class/Project 985/211 or ministerial key universities, provincial key universities, regular public universities, and private universities) but was excluded from the primary multinomial model because cross-tabulation of school level by the three-category vaccination outcome revealed sparse cells (fewer than 5 respondents in several strata) and potential model separation, particularly among private university students (n = 10, 2.3% of the analytic sample). Including school level would have compromised model stability and produced unreliable estimates.

2.6. Missing data

Complete-case analysis was performed. Three respondents had missing sex information, and 11 had missing sexual status information. These 14 respondents (3.2% of the 443 eligible respondents) were excluded from the primary analysis. No statistically significant differences were detected between the 14 excluded and the 429 included participants in academic major ($p = 0.53$) or vaccination status ($p = 0.07$), although selection bias due to missing covariate data cannot be excluded. Because age was not collected, age could not be compared between included and excluded participants.

2.7. Statistical analysis

Categorical variables were summarized as frequencies and percentages. Continuous variables were summarized as mean ± standard deviation (SD) or median and interquartile range, as appropriate. Group comparisons were performed using Pearson's chi-square test, Fisher's exact test, Wilcoxon rank-sum test, or Kruskal–Wallis test.

The primary analysis used multivariable multinomial logistic regression, with no definite short-term vaccination intention as the reference outcome. The model included sex, academic major, sexual status, the 13-item HPV knowledge score, grade level, and monthly living expenses.

Among unvaccinated students, multivariable binary logistic regression was used to identify factors associated with definite intention to vaccinate within six months. The model included sex, academic major, sexual status, the 13-item HPV knowledge score, grade level, monthly living expenses, and the eight-item exploratory barrier index. Because the barrier measure was ad hoc and unvalidated, the barrier-index component of this model was considered an exploratory secondary analysis.

Multicollinearity among covariates was assessed using variance inflation factors. The independence of irrelevant alternatives (IIA) assumption of the multinomial logistic model was assessed using Hausman–McFadden tests: the model was re-estimated on subsamples that excluded each outcome category in turn, and the differences between the full-model and subsample coefficients were compared with their covariance matrix using a chi-square test. Negative test statistics, which arise when the covariance-difference matrix is not positive definite, were treated as inconclusive rather than as evidence supporting the IIA assumption.

Three sensitivity analyses were conducted: (i) ordinal logistic regression using the original four-stage outcome, with the proportional odds assumption assessed using the Brant test; (ii) replacing the eight-item exploratory barrier index with the original nine-item index; and (iii) sex-stratified multinomial logistic regression among male and female students. All tests were two-sided, with $p < 0.05$ considered statistically significant. Analyses were performed using R version 4.3.2.

3. Results

3.1. Participant characteristics

Among the 429 students included in the primary analysis, 254 (59.2%) were female, and 175 (40.8%) were male. Medical students accounted for 174 (40.6%) of the sample. Regarding sexual status, 228 students (53.1%) reported no sexual experience, 164 (38.2%) reported being sexually active with a regular partner, and 37 (8.6%) reported being sexually active without a regular partner. By institution type, 209 students (48.7%) were enrolled in Double First-Class/Project 985/211 or ministerial key universities, 119 (27.7%) in regular public universities, 91 (21.2%) in provincial key universities, and 10 (2.3%) in private universities.

The original four-category outcome distribution was: no intention to vaccinate ($n = 11$; 2.6%); uncertain or considering vaccination ($n = 164$; 38.2%); intending to vaccinate within six months ($n = 89$; 20.7%); and vaccinated ($n = 165$; 38.5%). After merging the first two categories, 175 students (40.8%) had no definite short-term vaccination intention, 89 (20.7%) intended to vaccinate within six months, and 165 (38.5%) had already been vaccinated. Among the 264 unvaccinated students, 89 (33.7%) reported definite intention to vaccinate within six months. Among the 165 vaccinated students, 106 (64.2%) reported having completed all scheduled doses, and 59 (35.8%) had received at least one dose without completing the series; the most commonly reported vaccine type was the 9-valent vaccine ($n = 125$), followed by the 4-valent ($n = 31$) and 2-valent ($n = 7$) vaccines, while 2 students could not recall the vaccine type. The mean 13-item HPV knowledge score (range 0–13) was 10.08 ± 2.75 (KR-20 = 0.80).

The 13-item score did not differ between male and female students (10.08 ± 2.72 vs. 10.08 ± 2.77, $p = 0.99$). The five sex-specific items were summarized descriptively at the item level among respondents to whom they applied (correct response rates were 59.2%, 87.2%, and 84.8% for the three female-specific items and 74.9% and 82.8% for the two male-specific items). Participant characteristics by vaccination readiness and uptake status are shown in Table 1.

3.2. Internal consistency and exploratory factor analysis

The 13 general HPV knowledge items showed good

Table 1. Participant characteristics by human papillomavirus vaccination readiness and uptake status

Characteristic	Overall (*n* = 429)	No definite short-term intention (*n* = 175)	Intending within six months (*n* = 89)	Vaccinated (*n* = 165)	*p*-value
Sex					
Male	175 (40.8%)	81 (46.3%)	51 (57.3%)	43 (26.1%)	<0.001
Female	254 (59.2%)	94 (53.7%)	38 (42.7%)	122 (73.9%)	
Grade level					
Junior undergraduate	168 (39.2%)	84 (48.0%)	26 (29.2%)	58 (35.2%)	0.005
Senior undergraduate or postgraduate	261 (60.8%)	91 (52.0%)	63 (70.8%)	107 (64.8%)	
Academic major					
Non-medical	255 (59.4%)	127 (72.6%)	56 (62.9%)	72 (43.6%)	<0.001
Medical	174 (40.6%)	48 (27.4%)	33 (37.1%)	93 (56.4%)	
Sexual status					
No sexual experience	228 (53.1%)	122 (69.7%)	32 (36.0%)	74 (44.8%)	
Sexually active with regular partner	164 (38.2%)	42 (24.0%)	48 (53.9%)	74 (44.8%)	<0.001
Sexually active without a regular partner	37 (8.6%)	11 (6.3%)	9 (10.1%)	17 (10.3%)	
Monthly living expenses					
≤2,000 RMB	218 (50.8%)	93 (53.1%)	51 (57.3%)	74 (44.8%)	0.013
2,001–3,000 RMB	167 (38.9%)	72 (41.1%)	31 (34.8%)	64 (38.8%)	
>3,000 RMB	44 (10.3%)	10 (5.7%)	7 (7.9%)	27 (16.4%)	
Human papillomavirus knowledge score (13 items, range 0–13)	10.08 ± 2.75	9.90 ± 2.62	10.47 ± 2.63	10.06 ± 2.93	0.063

Notes: Values are shown as *n* (%) or mean ± standard deviation. *p*-values were calculated using Pearson's chi-square tests for categorical variables and Kruskal–Wallis tests for continuous variables.

internal consistency (KR-20 = 0.80) and did not differ between male and female students ($p = 0.99$). The five sex-specific items were summarized descriptively at the item level, and no aggregate 18-item score was constructed because the number of applicable items differed by sex. The original nine-item barrier index showed moderate internal consistency (Cronbach's α = 0.66; standardized α = 0.68).

The item "belief that vaccination is unnecessary without sexual experience" had the lowest corrected item-total correlation. Deleting this item increased Cronbach's α to 0.70 and standardized α to 0.70. EFA of the nine barrier items was conducted among the 275 unvaccinated students with complete item responses, using a polychoric correlation matrix, principal axis factoring, and oblimin rotation. The Kaiser–Meyer–Olkin measure of sampling adequacy was 0.71, and Bartlett's test of sphericity was significant ($\chi^2 = 705.90$, df = 36, $p < 0.001$), confirming that the data were suitable for factor analysis. In parallel analysis (5,000 permutations of the item responses), the first two empirical eigenvalues (2.71 and 1.73) exceeded the corresponding 95th-percentile random-data eigenvalues (1.37 and 1.25), whereas the third eigenvalue (1.18) exceeded its threshold (1.16) only marginally; in the three-factor solution, the item "belief that vaccination is unnecessary without sexual experience" loaded 0.89 on a single-item third factor, with all other loadings on this factor below 0.25, and was therefore not substantively interpretable. A two-factor structure was retained as the most interpretable solution. Factor 1 (Perceived necessity and social norm barriers) had strong loadings from family or partner opposition (0.87), the belief that men do not

need vaccination (0.84), perceived age inappropriateness (0.69), and the belief that vaccination is unnecessary with a regular partner (0.51). Factor 2 (Structural and practical access barriers) had strong loadings from appointment difficulty (0.74), cost (0.72), safety concerns (0.53), and insufficient vaccine information (0.42). In the retained two-factor solution, the item "belief that vaccination is unnecessary without sexual experience" showed low loadings on Factors 1 and 2 (0.11 and 0.05, respectively), indicating that it did not clearly belong to either dimension and providing additional empirical support for its exclusion from the primary barrier index. The two factors were moderately correlated (r = 0.23). As a descriptive approximation based on the squared pattern loadings divided by the number of items, the two factors accounted for 41.7% of the total item variance (Factor 1: 24.6%; Factor 2: 17.1%); because the factors are correlated under oblimin rotation, these values should not be interpreted as a strict variance decomposition. The factor loadings are summarized in Table S1, and the mean scores and internal consistency of the two dimensions are reported in Table S3. The two-factor structure confirmed that the barrier items did not form a unidimensional construct, supporting the interpretation of the barrier index as an exploratory composite rather than a validated scale; this structure requires confirmation in independent samples.

3.3. Perceived barriers among unvaccinated students

Among the 264 unvaccinated students, the most highly rated barriers included insufficient vaccine information or not knowing where to get vaccinated, concern about vaccine safety or side effects, difficulty making appointments or long waiting times, and high cost or unaffordability. These barriers mainly reflected practical access constraints and vaccine confidence concerns.

In unadjusted comparisons, the overall eight-item exploratory barrier index did not differ significantly between students with and without definite short-term intention. However, students without definite short-term intention reported higher scores for insufficient vaccine information, safety concerns, and the belief that vaccination was unnecessary without sexual experience. Detailed barrier ratings by intention status are presented in Table 2.

3.4. Multivariable multinomial logistic regression

Results of the multivariable multinomial logistic regression are shown in Table 3. Compared with students with no definite short-term intention, those intending to vaccinate within six months were more likely to report being sexually active with a regular partner (adjusted odds ratio [aOR] = 4.14, 95% confidence interval [CI]: 2.20–7.79) or sexually active without a regular partner (aOR = 3.06, 95% CI: 1.12–8.35). Senior undergraduate or postgraduate students also had higher odds of intending to vaccinate within six months (aOR = 1.83, 95% CI: 1.01–3.31). Female sex and medical major were not independently associated with short-term vaccination intention.

Vaccinated students, compared with those with no definite short-term intention, were more likely to be female (aOR = 4.17, 95% CI: 2.41–7.19), medical students (aOR = 3.58, 95% CI: 2.15–5.95), sexually active with a regular partner (aOR = 3.14, 95% CI: 1.76–5.60), sexually active without a regular partner (aOR = 2.69, 95% CI: 1.08–6.65), and senior undergraduates or postgraduates (aOR = 2.07, 95% CI: 1.23–3.47). The HPV knowledge index was not independently associated with either short-term intention or vaccination status. The McFadden pseudo-R^2 of the multinomial model was 0.13.

3.5. Binary logistic regression among unvaccinated students

Among 264 unvaccinated students, 89 (33.7%) reported definite intention to vaccinate within six months. Results of the multivariable binary logistic regression are shown in Table 4. Definite short-term intention was associated with reporting sexual activity with a regular partner (aOR = 4.92, 95% CI: 2.51–9.64), sexual activity without a regular partner (aOR = 3.34, 95% CI: 1.17–9.55), and senior undergraduate/postgraduate status (aOR = 1.88, 95% CI: 1.02–3.48). The McFadden pseudo-R^2 of the binary model was 0.12.

The eight-item exploratory barrier index showed an inverse but non-significant association with definite short-term intention (aOR = 0.63, 95% CI: 0.39–1.03, p = 0.064).

3.6. Sensitivity analyses

Sensitivity analyses are summarized in Table 5. Ordinal logistic regression using the original four-stage outcome showed generally consistent association directions. However, the proportional odds assumption was violated according to the Brant test (overall test: χ^2 = 28.34, df = 12, p = 0.005). The violation was primarily driven by sexual status and grade level, whose effects differed significantly across outcome thresholds; in addition, the very small no-intention category (n = 11) produced unstable threshold-specific coefficient estimates, further supporting the use of the merged three-category outcome.

Model diagnostics were mixed. All variance inflation factors were below 1.35, indicating no relevant multicollinearity. Hausman–McFadden tests produced negative statistics (omitting the vaccinated category:

Table 2. Perceived barriers to human papillomavirus vaccination among unvaccinated students by short-term vaccination intention

Barrier item/index	Overall (*n* = 264)	No definite short-term intention (*n* = 175)	Intending within six months (*n* = 89)	*p*-value
Eight-item exploratory barrier index	2.78 ± 0.63	2.78 ± 0.59	2.77 ± 0.70	0.770
Original nine-item barrier index	2.77 ± 0.59	2.81 ± 0.54	2.70 ± 0.67	0.111
Insufficient vaccine information or not knowing where to get vaccinated	3.72 ± 1.00	3.88 ± 0.92	3.40 ± 1.07	<0.001
Concern about vaccine safety or side effects	3.66 ± 1.13	3.75 ± 1.14	3.47 ± 1.09	0.030
Difficulty making appointments or long waiting time	3.44 ± 1.12	3.46 ± 1.08	3.39 ± 1.21	0.788
High cost or unaffordability	3.27 ± 1.20	3.26 ± 1.21	3.27 ± 1.18	>0.900
Belief that vaccination is unnecessary without sexual experience	2.76 ± 1.37	3.09 ± 1.36	2.10 ± 1.13	<0.001
Belief that age is not appropriate	2.26 ± 1.09	2.23 ± 1.09	2.30 ± 1.08	0.632
Belief that vaccination is unnecessary with a regular partner	2.23 ± 1.22	2.17 ± 1.24	2.36 ± 1.17	0.134
Opposition from family or partner	1.89 ± 1.01	1.83 ± 0.92	1.99 ± 1.17	0.631
Belief that men do not need HPV vaccination	1.76 ± 1.08	1.65 ± 0.98	1.98 ± 1.22	0.034

Notes: Values are mean ± standard deviation. Items were assessed using a five-point Likert scale, with higher scores indicating stronger perceived barriers. The eight-item exploratory barrier index was used in the primary analysis. The item "belief that vaccination is unnecessary without sexual experience" was excluded from the primary eight-item index because it had the lowest corrected item-total correlation and reduced internal consistency. The original nine-item index is shown descriptively and was examined in sensitivity analysis. *P*-values were calculated using Wilcoxon rank-sum tests. Item-level comparisons were exploratory, and no adjustment for multiple comparisons was applied.

Table 3. Multivariable multinomial logistic regression for human papillomavirus vaccination readiness and uptake

Predictor	Intending within six months aOR (95% confidence interval)	*p*-value	Vaccinated aOR (95% confidence interval)	*p*-value
Female vs. male	0.98 (0.55–1.74)	0.949	4.17 (2.41–7.19)	<0.001
Medical vs. non-medical major	1.64 (0.90–2.98)	0.105	3.58 (2.15–5.95)	<0.001
Sexually active with a regular partner vs. no sexual experience	4.14 (2.20–7.79)	<0.001	3.14 (1.76–5.60)	<0.001
Sexually active without a regular partner vs no sexual experience	3.06 (1.12–8.35)	0.029	2.69 (1.08–6.65)	0.033
HPV knowledge score (0–13)	1.09 (0.98–1.21)	0.109	1.06 (0.97–1.16)	0.204
Senior undergraduate/postgraduate vs. junior undergraduate	1.83 (1.01–3.31)	0.046	2.07 (1.23–3.47)	0.006
Monthly expense 2,001–3,000 RMB vs ≤2,000 RMB	0.56 (0.31–1.01)	0.052	0.93 (0.56–1.56)	0.786
Monthly expense >3,000 RMB vs. ≤2,000 RMB	0.66 (0.22–2.01)	0.468	2.19 (0.90–5.38)	0.086

Notes: The reference outcome was no definite short-term vaccination intention. Values are adjusted odds ratios (aORs) mutually adjusted for all variables shown in the table. Reference categories were male, non-medical major, no sexual experience, junior undergraduate, and monthly living expenses ≤2,000 RMB. The human papillomavirus (HPV) knowledge score was based on 13 items applicable to all respondents (range 0–13).

Table 4. Multivariable binary logistic regression for definite intention to vaccinate within six months among unvaccinated students

Predictor	aOR	95% confidence interval	*p*-value
Female vs. male	0.99	0.55–1.78	0.980
Medical vs. non-medical major	1.49	0.81–2.74	0.204
Sexually active with a regular partner vs. no sexual experience	4.92	2.51–9.64	<0.001
Sexually active without a regular partner vs. no sexual experience	3.34	1.17–9.55	0.024
Human papillomavirus knowledge score (0–13)	1.09	0.97–1.22	0.147
Senior undergraduate/postgraduate vs junior undergraduate	1.88	1.02–3.48	0.044
Monthly expense 2,001–3,000 RMB vs. ≤2,000 RMB	0.67	0.37–1.23	0.197
Monthly expense >3,000 RMB vs. ≤2,000 RMB	0.68	0.22–2.15	0.511
Eight-item exploratory barrier index	0.63	0.39–1.03	0.064

Notes: The outcome was coded as 1 = definite intention to vaccinate within six months and 0 = no definite intention. Values are adjusted odds ratios (aORs) mutually adjusted for all variables shown in the table. Reference categories were male, non-medical major, no sexual experience, junior undergraduate, and monthly living expenses ≤2,000 RMB. The HPV knowledge score was based on 13 items applicable to all respondents (range 0–13). The eight-item exploratory barrier index was used as the primary barrier variable.

Table 5. Summary of sensitivity analyses

Sensitivity analysis	Purpose	Main finding	Interpretation
Ordinal logistic regression using the original four-stage readiness outcome	To assess whether findings were consistent when preserving the original Transtheoretical Model-informed outcome	Directions of association were consistent with the primary multinomial logistic regression model	Used only as sensitivity analysis because the proportional odds assumption was violated
Proportional odds assumption assessment	To evaluate whether ordinal logistic regression was appropriate	Brant test indicated violation of the proportional odds assumption	Supported multinomial logistic regression as the primary model
Original nine-item exploratory barrier index	To assess sensitivity of the barrier finding to item composition	The original nine-item index was inversely associated with definite short-term vaccination intention among unvaccinated students (aOR = 0.54, 95% CI: 0.32–0.89, $p = 0.017$)	Interpreted cautiously because the nine-item index had lower internal consistency than the eight-item primary barrier index
Sex-stratified multinomial logistic regression	To assess whether the primary associations were consistent among male and female students	Sexual experience remained associated with both outcomes among male and female students; among male students, monthly living expenses >3,000 RMB were additionally associated with vaccination status (aOR = 10.83, 95% CI: 2.56–45.92, $p = 0.001$)	This supported the robustness of the main findings; however, the expense association among male students should be interpreted cautiously given the small cell size. The complete sex-stratified results are provided in Table S2
Model diagnostics (VIF and IIA assessment)	To assess multicollinearity and the independence of irrelevant alternatives assumption of the multinomial model	All variance inflation factors were below 1.35. Hausman–McFadden tests produced negative statistics (omitting the vaccinated category: $\chi^2 = -4.31$, df = 9; omitting the intending category: $\chi^2 = -1.17$, df = 9), which arise from non-positive-definite covariance-difference matrices	Multicollinearity was not a concern; the IIA test results were inconclusive, and the multinomial model was retained on conceptual grounds

Notes: The primary barrier analysis used the eight-item exploratory barrier index. The original nine-item index included the item "belief that vaccination is unnecessary without sexual experience," which was excluded from the primary index because it had the lowest corrected item-total correlation and reduced internal consistency.
Abbreviations: aOR: Adjusted odds ratio; CI: Confidence interval; IIA: Independence of irrelevant alternatives; VIF: Variance inflation factor.

$\chi^2 = -4.31$, df = 9; omitting the intending category: $\chi^2 = -1.17$, df = 9); because negative statistics arise from non-positive-definite covariance-difference matrices, these tests were considered inconclusive rather than as evidence supporting the IIA assumption. The multinomial model was retained because it directly represented the nominal three-category outcome; however, the IIA assumption could not be formally verified. The sex-stratified analyses were exploratory and based on reduced subsample sizes. In these analyses, sexual experience remained associated with short-term intention and vaccination status among both male and female students, and medical major remained associated with vaccination status in both sexes. Among male students, monthly living expenses above 3,000 RMB were additionally associated with vaccination status (aOR = 10.83, 95% CI: 2.56–45.92, $p = 0.001$), an association not observed among female students; given the small number of male students in this expense stratum (14 of 175), this estimate should be interpreted cautiously. The complete sex-stratified results are provided in Table S2.

When the original nine-item barrier index replaced the 8-item version, it was inversely associated with definite short-term vaccination intention among unvaccinated students (aOR = 0.54, 95% CI: 0.32–0.89, $p = 0.017$). This finding suggests that the association between perceived barriers and short-term intention was sensitive to item composition.

In post hoc factor-level analyses among unvaccinated students, the structural and practical access barriers dimension (Factor 2 mean score) was inversely associated with definite short-term intention (aOR = 0.58, 95% CI: 0.40–0.83, $p = 0.003$), whereas the perceived necessity and social norm barriers dimension (Factor 1 mean score) was not (aOR = 1.13, 95% CI: 0.78–1.64, $p = 0.530$); both models were adjusted for the same covariates as the primary binary model (Table S4). These factor-level analyses were post hoc and exploratory.

4. Discussion

4.1. Principal findings

This cross-sectional study examined HPV vaccination readiness, uptake, and perceived barriers among university students in the Pearl River Delta region. Overall, 38.5% of students had received HPV vaccination, 20.7% intended to vaccinate within six months, and 40.8% had no definite short-term plan. More than one-third of participants had initiated HPV vaccination, although 40.8% still had no definite short-term plan.

Several findings are noteworthy. Sexual experience was consistently associated with both short-term vaccination intention and vaccination status. Female sex and medical background were strongly associated with vaccination status, but neither was independently associated with short-term intention among unvaccinated students. This pattern may indicate that these factors were associated with a higher likelihood of having initiated vaccination, rather than with current willingness among those who remained unvaccinated. General HPV knowledge was not independently associated with either outcome after adjustment. Among unvaccinated students, the highest-rated barriers were practical and structural, including insufficient actionable information, safety concerns, appointment difficulty, and cost.

4.2. Comparison with previous studies

The vaccinated proportion in this study was higher than that reported in many earlier studies of Chinese university students, where uptake was often low despite moderate or high willingness.[11] This relatively higher uptake may reflect the economic development of the Pearl River Delta region, improved vaccine availability, increased public awareness, and the growing availability of domestically produced HPV vaccines.[9,20] Direct comparison with earlier studies should be made cautiously because vaccination definitions and study periods differed across studies.

Nevertheless, the finding that many students remained unvaccinated is consistent with previous evidence showing persistent gaps between awareness, willingness, and actual vaccination behavior.[11] A systematic review of HPV vaccination barriers and facilitators among young people identified cost, access, safety concerns, and insufficient recommendation as major barriers.[15] Similarly, practical access barriers and safety concerns were among the highest-rated barriers in this study.

The strong association between female sex and vaccination status is also consistent with previous research. HPV vaccination has historically been framed primarily as cervical cancer prevention, and many public health messages, clinical recommendations, and media campaigns have focused on women.[11] This gendered framing may partly explain why female students were more likely to have been vaccinated. However, female sex was not associated with short-term intention among unvaccinated students, suggesting no independent association between sex and short-term intention was detected among unvaccinated students at the time of this cross-sectional survey. This pattern is consistent with growing recognition that HPV also affects men, causing genital warts and HPV-related anogenital and oropharyngeal cancers.[2] One item-level comparison ("belief that men do not need HPV vaccination") differed significantly between intention

groups (**Table 2**), but the direction was unexpected and mean scores were low in both groups; because item-level comparisons were exploratory and unadjusted for multiple comparisons, no substantive interpretation is offered. HPV vaccination promotion should use gender-inclusive messaging that explicitly communicates HPV risks for men and the personal benefits of vaccination for all eligible individuals, rather than framing HPV vaccination solely as a women's health issue.

Medical major was strongly associated with vaccination status, consistent with previous findings that medical students or students with health-related education may have better access to vaccine information and greater familiarity with disease prevention.[11] However, medical major was not independently associated with definite short-term intention among unvaccinated students. This may suggest that medical background is associated with having received at least one HPV vaccine dose, whereas practical barriers, perceived risk, affordability, or appointment access may be more relevant for students who remained unvaccinated at the time of the survey.

4.3. Transtheoretical Model-informed interpretation of vaccination readiness

The Transtheoretical Model has been widely used to conceptualize health behavior change as movement through stages such as precontemplation, contemplation, preparation, action, and maintenance.[16,17] In this study, a Transtheoretical Model-informed classification helped distinguish students with no definite short-term intention, those intending to vaccinate within six months, and those already vaccinated.

This staged classification is useful because unvaccinated students are not a homogeneous group. Students without a definite short-term plan may benefit from interventions focused on perceived relevance, risk communication, vaccine confidence, and misconception correction. In contrast, students who already intend to vaccinate may need more practical support, such as information on vaccine types, appointment procedures, vaccination sites, cost, and dose schedules.

At the same time, the Transtheoretical Model should be interpreted cautiously in HPV vaccination research. Unlike repeated behaviors such as smoking cessation or physical activity, HPV vaccination is an episodic preventive behavior involving a limited number of doses. Therefore, this study used the Transtheoretical Model as an organizing framework rather than as evidence of longitudinal behavioral progression. Longitudinal studies are needed to examine whether students move from uncertainty to intention and then to vaccination over time.

4.4. Sexual experience, perceived susceptibility, and partner influence

Sexual experience was one of the most consistent correlates of both vaccination intention and vaccination status. Students who were sexually active, either with or without a regular partner, had higher odds of intending to vaccinate and of being vaccinated compared with students without sexual experience.

One possible explanation is that students with sexual experience may perceive themselves as more susceptible to HPV infection, which may be associated with preventive behavior. However, because this study is cross-sectional, the temporal ordering of sexual experience and vaccination cannot be determined, and the observed associations may reflect confounding by health-seeking behavior, personality traits, or unmeasured factors. This explanation is consistent with health behavior theories and previous research showing that perceived risk can influence vaccination decisions.[15] However, this association should not be interpreted solely as evidence of individual risk perception. In university settings, romantic relationships and sexual partnerships may also increase exposure to HPV-related information through partners, peers, or conversations about sexual health. Partner encouragement, peer vaccination norms, and shared appointment information may all influence vaccination behavior.

Reverse causation is also possible. Some students may have sought vaccination before or during the formation of romantic relationships, and students who are more proactive about health management may be more likely both to seek vaccination and to communicate openly about sexual health. Because this study was cross-sectional, the temporal relationship between sexual experience and vaccination cannot be established.

The public health implication is important. HPV vaccination is most beneficial before exposure to HPV, ideally before sexual debut.[8] If many students become aware of vaccination only after sexual initiation, this may represent a gap in timely prevention; however, this interpretation is based on cross-sectional data and cannot confirm the temporal sequence of events. Campus communication should therefore emphasize that HPV vaccination is preventive rather than reactive and that it is recommended before, but not only before, sexual activity.

4.5. Sex differences and the need for gender-inclusive communication

Female sex was strongly associated with vaccination status but not with short-term intention among unvaccinated students. This pattern suggests that the observed sex difference in vaccine uptake may partly reflect

accumulated historical differences in vaccine messaging, recommendations, and service availability rather than a persistent sex difference in current willingness.

This finding is consistent with the historical positioning of HPV vaccination as cervical cancer prevention.[5,6] Although cervical cancer prevention remains a central goal, HPV also causes substantial disease burden in men, including genital warts and HPV-related anogenital and oropharyngeal cancers.[2] The World Health Organization position paper on HPV vaccines recognizes vaccination of boys and men as an option where feasible and affordable, although girls remain the primary target population.[8]

Human papillomavirus vaccination promotion in university settings should therefore be gender-inclusive. Male students should be informed that HPV vaccination is relevant to their own health as well as partner protection. Messages that frame HPV vaccination solely as a women's health issue may unintentionally reduce perceived relevance among male students and reinforce the misconception that men do not need HPV vaccination.

4.6. Human papillomavirus knowledge and the intention–behavior gap

The HPV knowledge index was not independently associated with short-term vaccination intention or vaccination status after adjustment. This finding does not necessarily mean that knowledge is unimportant. Rather, it may indicate that the 13-item HPV knowledge score used in this study primarily captured general factual knowledge about HPV rather than practical vaccine literacy—i.e., actionable knowledge such as where to get vaccinated, which vaccine to choose, cost, appointment procedures, and dose schedules. The null finding could also reflect possible limitations in the content and discriminatory capacity of the knowledge measure. Future studies should distinguish general HPV knowledge from actionable vaccine literacy and use validated measures of the latter.

Previous studies in China have often reported that HPV awareness and vaccine knowledge are associated with willingness or acceptance.[10,11] However, willingness does not always translate into uptake, particularly when vaccination requires payment, appointment navigation, and multiple doses.[15,18] These findings support the idea that practical vaccine literacy may matter more than general disease knowledge. A student may know that HPV causes cervical cancer and that vaccines are effective, yet remain unvaccinated because they do not know where to get vaccinated, which vaccine to choose, whether the vaccine is safe, how to make an appointment, how much it costs, or whether they are still eligible.

4.7. Practical and structural barriers to vaccination

The highest-rated barriers in this study were insufficient vaccine information, safety concerns, difficulty making an appointment, and cost. These findings are consistent with previous research identifying access barriers, affordability, safety concerns, and insufficient recommendation as major obstacles to HPV vaccination.[10,11,15]

The prominence of these barriers suggests that students may need practical support rather than general educational campaigns alone. These priorities were based primarily on descriptive item ratings rather than robust independent associations with intention. Campus health promotion should provide clear, actionable information on where HPV vaccines are available, how to make appointments, which vaccine types are available, who is eligible, expected cost, dose schedules, common side effects, and what to do if adverse symptoms occur. Universities and local health authorities could consider campus-based vaccination sessions, group appointments, direct links to community vaccination clinics, or student-friendly scheduling.

Cost remains another important concern. Although domestically produced HPV vaccines may potentially improve affordability and access in China,[9,20] this inference is based on background evidence rather than the present data: this study did not collect data on whether students were aware of domestic versus imported vaccine options or actual price points. This limits the practical utility of the cost finding, as students' cost perceptions may be based on inaccurate price information. Future research should examine whether students perceive domestic vaccines as affordable, accessible, safe, and acceptable alternatives, and should collect data on actual vaccine price awareness.

4.8. Interpretation of the exploratory barrier index

The barrier-related findings require cautious interpretation. The original nine-item barrier index showed only moderate internal consistency, and the items captured heterogeneous domains. Removing the item "belief that vaccination is unnecessary without sexual experience" improved internal consistency, supporting the use of the eight-item index in the primary analysis. However, the eight-item index did not differ significantly between intention groups in unadjusted comparisons and showed only a non-significant inverse association in adjusted regression. In contrast, the original nine-item index was significantly associated with short-term intention in sensitivity analysis, suggesting that the barrier association was sensitive to item composition. The two-factor structure identified in the EFA further suggests that future studies could model structural and practical access barriers and perceived necessity and social norm barriers as separate predictors rather than combining them

into a single composite score.

Conceptually, the removed item remains important. The belief that vaccination is unnecessary without sexual experience is directly relevant to HPV prevention because vaccination is ideally administered before sexual debut.[8] Psychometrically, however, it may represent a distinct perceived necessity construct rather than the same dimension as practical access barriers. Additionally, the item "belief that men do not need HPV vaccination" had low endorsement (mean ≈ 1.89) and may not be a relevant barrier in this population; it could be dropped in future work. Future studies should develop multidimensional HPV vaccination barrier scales that separately assess structural access, safety confidence, financial burden, perceived susceptibility, perceived necessity, gender norms, and social influence.

4.9. External validity and generalizability

Because this study used convenience and snowball sampling in the Pearl River Delta region, the findings should be interpreted primarily as evidence from an economically developed, highly educated university population. The Pearl River Delta has relatively high economic development, dense university resources, and comparatively better access to health information and vaccination services than many other regions in China. The findings may not be directly generalizable to students in less developed regions, vocational colleges, junior colleges, rural areas, or non-student young adults. In addition, the number of participating universities and the city-level distribution of respondents were not recorded; the sample was recruited through selected university networks rather than from a census of universities in the region, and the findings should therefore not be interpreted as representative of all university students in the Pearl River Delta. Intervention implications should therefore be applied most directly to similar university settings and adapted cautiously for other contexts.

4.10. Policy and practice implications

Several practical strategies may help improve HPV vaccination uptake among university students. Campus health promotion should provide actionable vaccination guidance, not just general HPV education. Communication should be gender-inclusive and should present HPV vaccination as relevant to all eligible students. Safety concerns should be addressed transparently, with communication materials explaining expected side effects, safety monitoring, contraindications, and when to seek medical advice.

Cost reduction may also be important. Wider availability of domestic HPV vaccines may improve affordability and access, although this was not directly assessed in the present study; future research should assess students' perceptions of domestic versus imported vaccines.

4.11. Strengths

This study has several strengths. First, it used a staged vaccination readiness outcome rather than a simple binary classification, allowing differentiation between students without a definite short-term plan, those intending to vaccinate within six months, and those already vaccinated. Second, it included both male and female students, supporting gender-inclusive interpretation. Third, it separately examined short-term intention among unvaccinated students, which is important for identifying intervention targets. Fourth, it assessed the internal consistency and sensitivity of the barrier index, reducing the risk of overinterpreting an unstable composite measure. Finally, the study followed the Strengthening the Reporting of Observational Studies in Epidemiology reporting guideline and conducted multiple sensitivity analyses to assess the robustness of the findings.

4.12. Limitations

Several limitations should be noted. First, the cross-sectional design precludes causal inference. Associations, particularly those between sexual experience and vaccination outcomes, may reflect reverse causation. Second, convenience and snowball sampling through a single online distribution channel (WeChat) may have introduced selection bias, and findings from the Pearl River Delta may not generalize to other regions or non-student populations. Third, self-reported data, including vaccination status and sexual status, are susceptible to recall and social desirability bias. Social desirability bias may differentially affect vaccinated and unvaccinated groups: vaccinated students may be more comfortable reporting sexual activity, while unvaccinated students may underreport sexual experience due to perceived stigma, potentially biasing the observed associations.

Fourth, this study lacked data on several potential confounders, including parental education, household income, urban–rural background, and physician or peer recommendations. Monthly living expenses were used as a proxy for individual financial resources, but this measure may not fully capture family socioeconomic status or ability to pay for vaccination. Fifth, the barrier index was exploratory. Although the eight-item version showed improved internal consistency, it should not be treated as a validated scale. The EFA-confirmed two-factor structure further indicates that a composite total score may not adequately represent the distinct barrier

dimensions. Future studies should develop and validate multidimensional barrier measures for HPV vaccination among Chinese university students and model barrier factors separately. Sixth, the study did not collect data on whether students were aware of domestic versus imported vaccine options or actual price points, limiting the practical utility of the cost-related findings. Seventh, because school level showed sparse cells and potential separation, it was excluded from the primary multinomial model; residual confounding related to institutional characteristics may remain. Eighth, age was not collected; grade level was used as a proxy for age and academic stage, but residual confounding by age cannot be excluded. Finally, HPV knowledge was measured with a general knowledge index, and the five sex-specific items could not be included in the primary score; knowledge subdomains (e.g., transmission, disease outcomes, practical vaccine literacy) were not modeled separately. In addition, the primary vaccination outcome captured initiation (self-reported receipt of at least one dose) rather than series completion; among the 59 vaccinated students who had not completed all scheduled doses, some may still have been within the normal vaccination schedule, and no first-dose dates were collected to distinguish these scenarios. The number of participating universities and cities was also not recorded. The two-factor barrier structure identified in the EFA requires confirmation in independent samples. The revised eight-item barrier index was derived and evaluated in the same sample, so its apparent psychometric improvement may be sample-specific. The questionnaire was not formally pilot-tested, and the self-developed knowledge and barrier measures lacked external criterion validation; no prespecified completion-time threshold was applied. The IIA assumption could not be formally verified because the Hausman–McFadden tests were inconclusive; multinomial model estimates should therefore be interpreted with this limitation in mind. Merging the no-intention and uncertain/considering categories into the reference outcome was a data-driven decision based on the observed category distribution, and the factor-level barrier analyses were post hoc; both should be considered exploratory.

5. Conclusion

In this convenience sample of university students from the Pearl River Delta, short-term HPV vaccination intention was associated with sexual experience and grade level, whereas self-reported receipt of at least one vaccine dose was additionally associated with female sex and medical major. General HPV knowledge was not independently associated with either outcome. Practical barriers were frequently endorsed, but the association between the exploratory barrier index and short-term intention was not robust to item composition. These cross-sectional findings should not be interpreted causally or generalized beyond similar university settings.

In similar economically developed university settings, HPV vaccination promotion may need to move beyond general knowledge dissemination and provide practical vaccination guidance, gender-inclusive communication, safety reassurance, improved appointment accessibility, and measures to improve affordability.

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Conflict of interest

The authors declare they have no competing interests.

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Ethics approval and consent to participate

Ethical approval was obtained from the Medical Ethics Committee of Zhongshan School of Medicine, Sun Yat-sen University before data collection (approval number: Zhongshan Medical Ethics Review No. 085 [2026], approved on March 26, 2026). All participants provided electronic informed consent before completing the questionnaire. The survey was anonymous, and no personally identifiable information was collected.

Consent for publication

Not applicable.

Availability of data

The data used in this study are not publicly available because they contain sensitive health-related and behavioral information from university students. De-identified data may be made available from the corresponding author

upon reasonable request and with appropriate ethical approval.

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