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The impact of vaccine access difficulties on HPV vaccine intention and uptake among female university students in China

Weiyi Wang[1,2*]

Abstract

Background Ensuring vaccine access is a prerequisite for promoting human papilloma virus (HPV) vaccination. Although HPV vaccination efforts in China have primarily focused on young females, little research has examined the difficulties they face in accessing the HPV vaccine and its impact on vaccine uptake and intention. This study analyzed the overall perception of access difficulties to HPV vaccines, as well as three specific vaccine access difficulties, and examined their influencing factors among female university students in China. We also examined the associations between overall and specific vaccine access difficulties and HPV vaccination intention and uptake.

Methods A cross-sectional study was conducted among female university students from eight universities or colleges in Zhejiang Province, China, from December 2020 to January 2021. Logistic regressions were used to identify factors associated with both overall and specific perceptions of vaccine access difficulties. A multivariable logistic regression model and a multiple linear regression model were used to explore factors influencing HPV vaccine uptake and vaccine intention by controlling for potential confounding factors, respectively.

Results A total of 3176 female university students were included in this study. The proportion of female students perceiving overall difficulty in obtaining HPV vaccine, as well as difficulties in accessing the desired type of HPV vaccine, HPV vaccination centers, and HPV vaccination information, were 60.6%, 57.7%, 60.7%, and 54.0%, respectively. Perceived overall difficulty in obtaining HPV vaccine, as well as difficulties in accessing the desired type of HPV vaccine, HPV vaccination centers, and HPV vaccination information were associated with HPV vaccine uptake and intention.

Conclusions Chinese female university students generally perceived various difficulties in accessing HPV vaccine. It is crucial to improve access to HPV vaccine, optimize the layout and service quality of HPV vaccination centers, and enhance the dissemination and transparency of HPV vaccine information. More efforts are needed to provide a strong guarantee for HPV vaccination uptake among female university students.

Keywords HPV vaccination, Vaccine access difficulty, Vaccine uptake, Vaccine intention, Female university students, China

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Background

Promoting human papilloma virus (HPV) vaccination is of paramount importance in reducing sexually transmitted diseases and accelerating the elimination of cervical cancer as a significant public health problem [1]. It is viewed as one of the most promising measures for cervical cancer prevention and control [2]. Despite the recent global expansion of HPV vaccination programs, the coverage of HPV vaccination is far from satisfactory and exhibits significant disparities [3–5]. HPV vaccine access is a key factor that could contribute to these disparities [6].

Vaccine access usually refers to the ability of individuals or groups to obtain and utilize vaccines, involving various aspects such as vaccine supply, distribution, and vaccination services [7]. Globally, significant differences in HPV vaccine access arise from variations in economic development level, medical resource allocation, sociocultural background, and public health policy [8–10]. These differences lead to varying emphases among countries on key factors in determining HPV vaccine administration [5, 11, 12]. In low- and middle-income countries, promoting HPV vaccine uptake focuses mainly on ensuring its accessibility and affordability for fair distribution of resources [13, 14], as well as increasing health awareness [15, 16]. In contrast, in high-income countries with sufficient coverage of resources and services, the emphasis shifts toward factors such as vaccine safety [17, 18], effectiveness [19, 20], side effects [21, 22], and public confidence [23, 24]. Therefore, recognizing and understanding these distinct key factors is crucial for the successful implementation of HPV vaccination programs worldwide.

China was a decade behind most developed countries in promoting HPV vaccination [25]. Since the HPV vaccine has not been included in the national immunization program (NIP), vaccine coverage in China remains low [26, 27]. There are three types of HPV vaccines available in China: bivalent, quadrivalent, and nine-valent, all of which are recommended for women aged 9 to 45 [28]. The nine-valent HPV vaccine has received widespread public attention since its market approval due to its relatively comprehensive preventive effect [29]. However, constrained by production and supply limitations, demand for the nine-valent HPV vaccine in China exceeds the available supply [30], sparking extensive public discussions on difficulties in accessing vaccines. Meanwhile, certain content on social media tends to exaggerate the preventive effects of the nine-valent HPV vaccine [31]. The misleading information has to some extent led to vaccine hesitancy toward other well-supplied types of HPV vaccines [32], thereby amplifying anxiety and uncertainty about access to HPV vaccines.

The difficulty in accessing vaccines is a significant aspect of vaccination barriers [33], and identifying these barriers is essential for designing successful HPV vaccine immunization programs. Previous research has primarily focused on individual concerns regarding the attributes of the HPV vaccine, such as price [34], side effects [22], and efficacy [20], with limited attention given to access-related barriers. Differing from the barriers presented by the HPV vaccine itself, difficulties in accessing HPV vaccines often center on the barriers individuals face when seeking and obtaining vaccination services. These may include inadequate vaccine supply [30], distant vaccination locations [35], and limited access to vaccination information [36].

Currently, few studies have discussed the impact of vaccine access difficulties on HPV vaccine intention and uptake among young females, especially university students who are in sexually active ages and at higher risk of HPV infection. Studies have shown that new HPV infections are most prevalent among individuals aged 18–26 [37], with the first peak occurring in women aged 21–24 in China [38], which aligns with the typical age range of university students. An increasing number of female students in China are becoming sexually active during their university years [39], necessitating early preventive measures. Furthermore, since university students are generally well-educated, they tend to be more independent in their decision-making than younger individuals [40]. They are less likely to be influenced by parents or external factors [41] and are also eligible for the HPV vaccine in China [28].

With its large population, China bears a heavy burden of cervical cancer [42]. In 2022, approximately 150,700 new cases and 55,700 deaths were reported, making cervical cancer the fifth most common cancer among Chinese women [43, 44]. It also has the highest incidence and mortality among female genital cancers [43], and ranks among the top three cancers in both incidence and mortality for women aged 15 to 39 in China [45]. The HPV vaccination program in China is still in its infancy, with the phenomenon of HPV vaccine hesitancy [32] coexisting alongside a vaccination spree [46]. In such a social context, understanding the current difficulties female university students face in accessing HPV vaccines and analyzing how these difficulties impact their intention and uptake of vaccination is of great significance.

Therefore, the purpose of this study was twofold: (1) to investigate the perception of access difficulties to HPV vaccines among Chinese female university students and analyze the potential influencing factors; and (2) to examine the associations between vaccine access difficulties and HPV vaccination intention and uptake. To gain a more comprehensive understanding of the factors influencing HPV vaccination among female

university students in China, this study integrated the Protection Motivation Theory (PMT) [47] and the Theory of Planned Behavior (TPB) [48], which are often used to explain individual differences in vaccination practices [49, 50].

Methods

Study design and setting

Between December 2020 and January 2021, a cross-sectional study was conducted among female university students in Zhejiang Province, China. With 109 higher education institutions and over 1.2 million students, Zhejiang Province is a prominent hub for higher education and ranks fourth in gross domestic product (GDP) among Chinese provinces. It has a relatively sound healthcare system and places significant emphasis on the comprehensive prevention and treatment of cervical cancer, actively responding to the implementation of the national HPV vaccination policies, thereby providing a strong foundation for this study. Geographically, Zhejiang Province is divided into five regions: north, south, east, west, and central. We purposely selected one to two cities from each region and one multi-disciplinary university from each selected city. Eight universities in seven cities were selected as the survey sites.

Participants and procedures

The target population for this study was female university students, who are considered ideal respondents for assessing the HPV vaccine uptake in mainland China. Researchers obtained approval from university administrators before commencing the study. Dormitories were randomly selected from each university, and all female students were invited to participate in the survey during their rest periods, covering various majors and grades. Five research assistants were recruited and trained at each site to collect data. Participants voluntarily completed a self-administered questionnaire using the online platform Sojump after giving informed consent. Detailed instructions for completing the study, along with a printed quick-response code for the electronic questionnaire, were provided by the research assistants. Confidentiality and anonymity were ensured for all participants, and no monetary compensation or gifts were provided. Ethical approval was provided by the Zhejiang University School of Public Health Research Ethics Committee (ZGL202006-08).

Measures

HPV vaccine uptake and intention

HPV vaccine uptake and intention were assessed with two items. Vaccine uptake was assessed by asking all participants about their receipt of any vaccine doses (0 = no, 1 = yes). Those who reported not receiving any doses of HPV vaccines were asked a single question to assess their vaccine intention: "Do you intend to receive the HPV vaccine in the future?" with responses ranging from 1 (very unlikely) to 5 (very likely) on a Likert scale.

Vaccine access difficulties

Participants reported their perceived HPV vaccine access difficulties on four items. First, participants were asked a question to assess their overall perception of difficulties in accessing HPV vaccines: "Overall, I find it difficult to obtain HPV vaccines." Then, three items were used to assess participants' specific perceptions of difficulties in obtaining HPV vaccines. These items encompass the difficulties in obtaining the desired type of HPV vaccine, accessing HPV vaccination centers, and obtaining information about HPV vaccination. All items were rated on a 5-point scale (1 = strongly disagree; 5 = strongly agree).

Perception of HPV infection and vaccination

Based on the PMT-TPB integrated model, the survey assessed a range of independent variables related to participants' perceptions of HPV infection and vaccination that may impact female university students' vaccine uptake. These factors include perceived severity and susceptibility to HPV infection and cervical cancer, response efficacy, self-efficacy, response costs, subjective norms, and social norms. Thereinto, subjective norms, which encompass parental, peer, and healthcare professional norms, were evaluated by multiplying participants' perceptions of advice from these important individuals regarding HPV vaccination by the influence of that advice on their decision to vaccinate [51]. Social norms were assessed by asking participants how many people around them intend to get, plan on getting, or have already received the HPV vaccine. All items were assessed using a 5-point Likert scale (ranging from 1 to 5), and the score for each dimension was calculated by averaging the total scores of all items within that dimension. Higher scores indicate stronger perception or agreement toward that dimension.

HPV and HPV vaccine knowledge

HPV and HPV vaccine knowledge was measured using a 15-item scale derived and adopted from existing research [28, 52, 53] and the World Health Organization (WHO) website [54]. The content mainly includes HPV transmission routes, susceptible groups, potential diseases, vaccination timing, protective efficacy, misconceptions, and other relevant topics. Each item was assigned 1 point for correct answers and 0 points for incorrect or unknown answers. The total score ranged from 0 to 15 points, with higher scores indicating greater HPV and HPV vaccine knowledge.

Socio-demographics

Participants provided basic demographic information including age, ethnicity, education level, major, parental and maternal education level, monthly household income (RMB), and residence. They were also asked about their sexual experience, history of HPV infection, and family history of cervical cancer.

Table 1 Sample characteristics ($n = 3176$)

Variable	*N* (%) [a]
Age (years), Mean (SD)	20.70 (2.23)
Ethnicity	
Ethnic minorities	123 (3.9)
Han nationality	3053 (96.1)
Education level	
Junior college student	163 (5.1)
Undergraduate	2301 (72.4)
Postgraduate and above	712 (22.4)
Major	
Non-medicine	2460 (77.5)
Medicine	716 (22.5)
Paternal education level	
Primary school and below	365 (11.5)
Junior high school	1225 (38.6)
High school/technical secondary school	878 (27.6)
Junior college/university and above	708 (22.3)
Maternal education level	
Primary school and below	657 (20.7)
Junior high school	1254 (39.5)
High school/technical secondary school	774 (24.4)
Junior college/university and above	491 (15.5)
Monthly household income (RMB)	
≤¥ 5000 ($698)	675 (21.3)
¥ 5001-10,000 ($698–1397)	1170 (36.8)
¥ 10,001-20000 ($1397–2793)	889 (28.0)
>¥ 20,000 ($2793)	442 (13.9)
Residence	
Urban	1535 (48.3)
Rural	1641 (51.7)
HPV and HPV vaccine knowledge	
Low	1680 (52.9)
High	1496 (47.1)
Sexual experience	
No/Refuse to answer	2712 (85.4)
Yes	464 (14.6)
History of HPV infection	
No/Not sure	3157 (99.4)
Yes	19 (0.6)
Family history of cervical cancer	
No/Not sure	3138 (98.8)
Yes	38 (1.2)

[a] Data are noted as N (%) unless otherwise stated

Statistical analysis

Descriptive analyses were reported as frequencies and percentages (%) or means and standard deviations (SDs). HPV and HPV vaccine knowledge was classified as either "low" (score ≤ 11) or "high" (score > 11) based on the median knowledge score. For the analysis of vaccine access difficulties, responses were dichotomized into "yes" (strongly agree, agree) and "no" (uncertain, disagree, strongly disagree). Logistic regressions were then used to identify factors associated with both overall and specific perceptions of vaccine access difficulties. Multivariable logistic regression models were used to explore factors influencing HPV vaccine uptake by controlling for potential confounding factors. Model 1 incorporated overall perceptions of vaccine access difficulties, while Model 2 included three specific types of vaccine access difficulties.

Since vaccination intentions are relatively subjective, HPV vaccine intention was treated as a continuous outcome variable in multiple linear regression models to examine its extent among female university students, based on findings from our pre-survey qualitative interviews and the PMT-TPB integrated theoretical framework. All assumptions for linear regression models were examined graphically and analytically (linearity, normality, independence, and homoscedasticity) and were fulfilled. Education level was excluded due to its high collinearity with age. We also conducted two sensitivity analyses to ensure the robustness of data analysis and understand the impact of any differences on the results. First, we conducted an ordinal logistic regression analysis. However, the Brant parallel line test indicated that the proportional odds assumption was violated ($p < 0.001$). Second, we converted HPV vaccine intention into a binary categorical variable and conducted multivariable logistic regressions to verify the results from treating HPV vaccine intention as a continuous variable.

Results

A total of 3176 female university students aged 17 to 30 years were included in this study (Table 1). The sample consisted predominantly of undergraduates (72.4%) and postgraduates (22.4%). Nearly one-quarter (22.5%) of participants majored in medicine and roughly half (51.7%) came from rural areas. Most participants (64.8%) reported a monthly household income of 5001 to 20,000 RMB (equivalent to $698 to $2793). Approximately 15% reported having sexual experience, while 1.2% reported a family history of cervical cancer.

Regarding knowledge about HPV infection and the HPV vaccine, only 8.9% ($n = 281$) of respondents answered all 15 questions correctly, whereas 78.9% ($n = 2505$) correctly answered more than half of the 15 questions. Overall, less than half (47.1%) of the

respondents who scored above the median knowledge score (Med = 11) were considered to have a high level of knowledge. Please see Supplementary Table 1 for the complete set of questions.

Out of 3176 participants, 394 (12.4%) reported receiving at least one dose of the HPV vaccine at the end of the survey (Table 2). Among 2782 (87.6%) unvaccinated respondents, 1937 (69.6%) reported that they were likely or very likely to get the HPV vaccine in the future. In terms of HPV vaccine access difficulties, 1924 (60.6%) perceived an overall difficulty, 1831 (57.7%) reported difficulties in obtaining their desired type of HPV vaccine, 1928 (60.7%) encountered obstacles in accessing vaccination centers, and 1716 (54.0%) experienced difficulties in obtaining vaccination information. Table 2 displays the means and standard deviations (SDs) for participants' perceptions of HPV infection and vaccination. Female university students reported high levels of perceived severity, perceived susceptibility, response efficacy, and self-efficacy. They also reported moderate levels of subjective norms and social norms.

Table 2 HPV vaccine uptake, intention, vaccine access difficulties, and perception of HPV infection and vaccination ($n = 3176$)

Variable	*N* (%)
HPV vaccine uptake and intention	
Receipt of any doses of the HPV vaccine	
No	2782 (87.6)
Yes	394 (12.4)
Intend to receive the HPV vaccine [a] ($n = 2782$)	
Very unlikely	14 (0.5)
Unlikely	60 (2.2)
Uncertain	771 (27.7)
Likely	1187 (42.7)
Very likely	750 (27.0)
Vaccine access difficulties	
Difficulty in obtaining HPV vaccine	
No	1252 (39.4)
Yes	1924 (60.6)
Difficulty in obtaining the desired type of HPV vaccine	
No	1345 (42.3)
Yes	1831 (57.7)
Difficulty in accessing HPV vaccination centers	
No	1248 (39.3)
Yes	1928 (60.7)
Difficulty in obtaining information about HPV vaccination	
No	1460 (46.0)
Yes	1716 (54.0)
Variable	Mean (SD) [a]
Perception of HPV infection and vaccination[a]	
Perceived severity	4.35 (0.64)
Perceived susceptibility	3.77 (0.83)
Response efficacy	4.23 (0.62)
Self-efficacy	4.08 (0.67)
Response costs	3.36 (0.71)
Parent norm	15.07 (5.88)
Peer norm	14.18 (5.56)
Healthcare professional norm	15.36 (5.29)
Social norms	2.62 (1.05)

[a] Scores on continuous study variables ranged from one to five, with higher values indicating more endorsement

SD = standard deviation

Table 3 shows the results of the factors associated with female university students' overall and specific perceptions of difficulties in accessing HPV vaccines. Older age and a high level of HPV and HPV vaccine knowledge were associated with perceived overall difficulty in obtaining the HPV vaccine (aOR = 1.05, 95% CI 1.01–1.09; aOR = 1.25, 95% CI 1.07–1.45), as well as perceived difficulty in obtaining the desired type of HPV vaccine (aOR = 1.10, 95% CI 1.06–1.14; aOR = 1.34, 95% CI 1.15–1.56) and accessing vaccination centers (aOR = 1.08, 95% CI 1.04–1.12; aOR = 1.25, 95% CI 1.07–1.46). By contrast, having a history of HPV infection was associated with lower odds of perceiving overall difficulty in obtaining the HPV vaccine (aOR = 0.33, 95% CI 0.13–0.86) and three specific vaccine access difficulties (aOR = 0.28, 95% CI 0.10–0.74; aOR = 0.39, 95% CI 0.15–0.99; aOR = 0.37, 95% CI 0.14–0.99, respectively). Female students whose mothers had college/university or higher education were less likely to perceive overall difficulty in obtaining the HPV vaccine (aOR = 0.53, 95% CI 0.39–0.73), as well as difficulty in obtaining the desired type of HPV vaccine (aOR = 0.54, 95% CI 0.39–0.74), accessing vaccination centers (aOR = 0.54, 95% CI 0.39–0.74), and obtaining vaccination information (aOR = 0.58, 95% CI 0.43–0.80), compared to those whose mothers had primary school education or below. Similarly, higher monthly household income was associated with lower perceived overall difficulty in obtaining the HPV vaccine (aOR = 0.76, 95% CI 0.58–0.99 for more than ¥ 20,000 compared to ¥ 5,000 or less).

The factors associated with HPV vaccine uptake among female university students were identified in the multivariable logistic regression model (Table 4). After adjusting for potential confounding factors, Model 1 shows that participants who perceived an overall difficulty in obtaining HPV vaccine were 0.14 times (95% CI 0.10–0.19) less likely to have received the HPV vaccine. Those who reported greater perceived susceptibility (aOR = 1.23, 95% CI 1.03–1.46), self-efficacy (aOR = 2.57, 95% CI 1.82–3.62), parent norm (aOR = 1.15, 95% CI 1.11–1.18), and social norms (aOR = 1.57, 95% CI 1.37–1.81), as well as lower response costs (aOR = 0.48, 95% CI 0.39–0.58), were more likely to be already vaccinated. Older age (aOR = 1.32, 95% CI 1.24–1.40) and a high level of HPV and HPV vaccine knowledge (aOR = 1.89, 95% CI 1.41–2.55) were associated with female students' HPV vaccine

Table 3 Factors associated with vaccine access difficulties ($n = 3176$) [a]

Variables	Difficulty in obtaining HPV vaccine	Difficulty in obtaining the desired type of HPV vaccine	Difficulty in accessing HPV vaccination centers	Difficulty in obtaining information about HPV vaccination
	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
Age (mean, SD)	**1.05 (1.01–1.09) ****	**1.10 (1.06–1.14) *****	**1.08 (1.04–1.12) *****	1.00 (0.97–1.04)
Ethnicity				
Ethnic minorities	Ref.	Ref.	Ref.	Ref.
Han nationality	0.93 (0.64–1.36)	1.01 (0.70–1.46)	0.77 (0.52–1.13)	0.83 (0.58–1.21)
Major				
Non-medicine	Ref.	Ref.	Ref.	Ref.
Medicine	1.04 (0.87–1.25)	0.98 (0.82–1.17)	1.02 (0.85–1.22)	0.87 (0.73–1.04)
Paternal education level				
Primary school and below	Ref.	Ref.	Ref.	Ref.
Junior high school	1.05 (0.81–1.36)	1.13 (0.88–1.45)	1.05 (0.82–1.36)	1.15 (0.90–1.47)
High school/technical secondary school	1.01 (0.76–1.34)	1.14 (0.86–1.51)	1.02 (0.77–1.35)	1.01 (0.77–1.32)
Junior college/university and above	1.00 (0.73–1.38)	1.17 (0.85–1.60)	1.09 (0.79–1.50)	1.10 (0.80–1.50)
Maternal education level				
Primary school and below	Ref.	Ref.	Ref.	Ref.
Junior high school	0.82 (0.67–1.02)	**0.79 (0.64–0.97) ***	**0.75 (0.61–0.93) ****	0.87 (0.71–1.06)
High school/technical secondary school	**0.67 (0.52–0.86) ****	**0.70 (0.55–0.90) ****	**0.75 (0.58–0.97) ***	0.84 (0.65–1.07)
Junior college/university and above	**0.53 (0.39–0.73) *****	**0.54 (0.39–0.74) *****	**0.54 (0.39–0.74) *****	**0.58 (0.43–0.80) ****
Monthly household income (RMB)				
≤¥ 5,000 ($698)	Ref.	Ref.	Ref.	Ref.
¥ 5,001–10,000 ($698–1397)	1.08 (0.88–1.33)	1.09 (0.91–1.39)	1.02 (0.85–1.26)	1.02 (0.84–1.24)
¥ 10,001-20000 ($1397–2793)	0.86 (0.69–1.07)	1.05 (0.85–1.31)	1.01 (0.81–1.25)	0.92 (0.74–1.14)
>¥ 20,000 ($2793)	**0.76 (0.58–0.99) ***	0.93 (0.72–1.22)	0.84 (0.64–1.10)	0.84 (0.64–1.09)
Residence				
Urban	Ref.	Ref.	Ref.	Ref.
Rural	1.07 (0.9–1.26)	1.12 (0.95–1.32)	1.02 (0.86–1.20)	1.05 (0.90–1.24)
HPV and HPV vaccine knowledge				
Low	Ref.	Ref.	Ref.	Ref.
High	**1.25 (1.07–1.45) ****	**1.34 (1.15–1.56) *****	**1.25 (1.07–1.46) ****	1.04 (0.89–1.20)
Sexual experience				
No/Refuse to answer	Ref.	Ref.	Ref.	Ref.
Yes	1.12 (0.9–1.39)	1.13 (0.91–1.40)	1.16 (0.93–1.45)	1.08 (0.87–1.33)
History of HPV infection				
No/Not sure	Ref.	Ref.	Ref.	Ref.
Yes	**0.33 (0.13–0.86) ***	**0.28 (0.10–0.74) ***	**0.39 (0.15–0.99) ***	**0.37 (0.14–0.99) ***
Family history of cervical cancer				
No/Not sure	Ref.	Ref.	Ref.	Ref.
Yes	0.76 (0.39–1.45)	0.78 (0.40–1.50)	0.85 (0.44–1.65)	0.73 (0.38–1.38)

[a] Boldface indicates statistical significance (*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$)

OR = odds ratio; CI = confidence interval; Ref = reference category

uptake. In model 2, three specific vaccine access difficulties were associated with HPV vaccine uptake. Female university students who reported difficulties in obtaining their desired type of HPV vaccine, accessing HPV vaccination centers, and obtaining information about HPV vaccination were 0.53 times (95% CI 0.36–0.78), 0.47 times (95% CI 0.32–0.71), and 0.54 times (95% CI 0.37–0.79) less likely to have been vaccinated, respectively.

Among unvaccinated participants, the results of the multiple linear regression model for HPV vaccine intention are presented in Table 5. In Model 1, older age ($\beta = 0.04$, $p = 0.018$) and a high level of HPV and HPV vaccine knowledge ($\beta = 0.05$, $p = 0.001$) were significantly associated with greater HPV vaccination intentions. Perceived susceptibility ($\beta = 0.07$, $p < 0.001$), self-efficacy ($\beta = 0.38$, $p < 0.001$), parent norm ($\beta = 0.08$, $p < 0.001$), peer norm ($\beta = 0.05$, $p = 0.007$), healthcare professional norm

Table 4 Multivariable logistic regression analysis of HPV vaccine uptake among female university students ($n = 3176$) [a]

Variables	Model 1		Model 2	
	OR (95%CI)	*p*	OR (95%CI)	*p*
Age (mean, SD)	1.32 (1.24–1.40)	**< 0.001**	1.32 (1.24–1.40)	**< 0.001**
Ethnicity				
Ethnic minorities	Ref.		Ref.	
Han nationality	1.13 (0.49–2.56)	0.779	1.07 (0.47–2.44)	0.865
Major				
Non-medicine	Ref.		Ref.	
Medicine	0.84 (0.60–1.18)	0.313	0.79 (0.56–1.10)	0.154
Paternal education level				
Primary school and below	Ref.		Ref.	
Junior high school	0.65 (0.38–1.13)	0.127	0.69 (0.40–1.19)	0.184
High school/technical secondary school	0.74 (0.41–1.32)	0.302	0.78 (0.44–1.39)	0.401
Junior college/university and above	1.11 (0.59–2.07)	0.746	1.18 (0.63–2.18)	0.607
Maternal education level				
Primary school and below	Ref.		Ref.	
Junior high school	1.10 (0.68–1.77)	0.709	1.03 (0.65–1.65)	0.893
High school/technical secondary school	1.59 (0.94–2.69)	0.087	1.65 (0.99–2.77)	0.056
Junior college/university and above	1.32 (0.72–2.41)	0.374	1.32 (0.73–2.38)	0.354
Monthly household income (RMB)				
≤¥ 5,000 ($698)	Ref.		Ref.	
¥ 5,001–10,000 ($698–1397)	1.19 (0.75–1.90)	0.466	1.29 (0.81–2.05)	0.281
¥ 10,001-20000 ($1397–2793)	1.22 (0.75–1.97)	0.425	1.32 (0.82–2.12)	0.253
>¥ 20,000 ($2793)	1.47 (0.86–2.50)	0.158	1.56 (0.92–2.64)	0.101
Residence				
Urban	Ref.		Ref.	
Rural	0.76 (0.55–1.05)	0.094	0.76 (0.55–1.05)	0.096
HPV and HPV vaccine knowledge				
Low	Ref.		Ref.	
High	1.89 (1.41–2.55)	**< 0.001**	1.94 (1.45–2.61)	**< 0.001**
Sexual experience				
No/Refuse to answer	Ref.		Ref.	
Yes	0.78 (0.53–1.15)	0.205	0.83 (0.57–1.21)	0.332
History of HPV infection				
No/Not sure	Ref.		Ref.	
Yes	2.41 (0.61–9.46)	0.208	2.12 (0.55–8.23)	0.277
Family history of cervical cancer				
No/Not sure	Ref.		Ref.	
Yes	1.50 (0.53–4.29)	0.449	1.41 (0.49–4.08)	0.529
Perceived severity	0.81 (0.64–1.03)	0.081	0.80 (0.63–1.01)	0.056
Perceived susceptibility	1.23 (1.03–1.46)	**0.022**	1.18 (0.99–1.40)	0.071
Response efficacy	0.54 (0.40–1.04)	0.056	0.54 (0.40–1.03)	0.055
Self-efficacy	2.57 (1.82–3.62)	**< 0.001**	2.82 (2.01–3.96)	**< 0.001**
Response costs	0.48 (0.39–0.58)	**< 0.001**	0.53 (0.44–0.65)	**< 0.001**
Parent norm	1.15 (1.11–1.18)	**< 0.001**	1.14 (1.11–1.18)	**< 0.001**
Peer norm	0.98 (0.95–1.01)	0.180	0.98 (0.95–1.01)	0.181
Healthcare professional norm	0.97 (0.94–1.01)	0.097	0.97 (0.94–1.01)	0.111
Social norms	1.57 (1.37–1.81)	**< 0.001**	1.53 (1.33–1.75)	**< 0.001**
Difficulty in obtaining HPV vaccine				
No	Ref.		-	
Yes	0.14 (0.10–0.19)	**< 0.001**	-	
Difficulty in obtaining the desired type of HPV vaccine				
No	-	-	Ref.	
Yes	-	-	0.53 (0.36–0.78)	**0.001**

Table 4 (continued)

Variables	Model 1		Model 2	
	OR (95%CI)	*p*	OR (95%CI)	*p*
Difficulty in accessing HPV vaccination centers				
No	-	-	Ref.	
Yes	-	-	0.47 (0.32–0.71)	**< 0.001**
Difficulty in obtaining information about HPV vaccination				
No	-	-	Ref.	
Yes	-	-	0.54 (0.37–0.79)	**0.001**

[a] Boldface indicates statistical significance

OR = odds ratio; CI = confidence interval; Ref = reference category

(β = 0.11, $p < 0.001$), and social norms (β = 0.14, $p < 0.001$) were positively associated with vaccination intentions, while response costs (β = -0.10, $p < 0.001$) were negatively related to vaccination intentions. Participants who perceived an overall difficulty in obtaining HPV vaccine (β = 0.10, $p < 0.001$) had greater vaccination intentions to receive HPV vaccination in the future. Further, Model 2 shows that perceived difficulty in obtaining the desired type of HPV vaccine (β = 0.06, $p = 0.007$) was positively associated with HPV vaccination intentions.

Discussion

Ensuring vaccine access is a prerequisite for promoting HPV vaccination in China. We investigated the perception of access difficulties to HPV vaccines among Chinese female university students and analyzed the potential influencing factors, and examined the impact of vaccine access difficulties on HPV vaccine intention and uptake. Our main findings indicate that over 60.0% of female students perceived an overall difficulty in obtaining HPV vaccine, which reduced their likelihood of vaccination uptake. Meanwhile, over half of female students reported difficulties in obtaining their desired type of HPV vaccine (57.7%), accessing vaccination centers (60.7%), and obtaining vaccination information (54.0%), respectively. These specific vaccine access difficulties were associated with a lower likelihood of HPV vaccine uptake, highlighting the importance of increasing accessibility of HPV vaccines among female university students.

Our research has confirmed that Chinese female university students generally face difficulties in accessing the HPV vaccine, with 60.6% of them expressing an overall vaccine access difficulty. The heavy dependence on imported HPV vaccines, particularly the nine-valent vaccine in mainland China [55], has resulted in persistent supply shortages in the market [56], making it difficult for female students to access the HPV vaccine. Specifically, more than half of the participants in our study find it difficult to receive their desired type of HPV vaccine. This aligns with the high demand for the nine-valent vaccine exceeding the available supply in mainland China [30]. Although China has domestic bivalent HPV vaccines as substitutes for imported ones [57], female university students still prefer imported vaccines [58]. Expediting domestic nine-valent HPV vaccine development and approval processes, along with bolstering confidence in domestic vaccines, are crucial for future HPV vaccination efforts in China. Secondly, difficulty in accessing HPV vaccination centers was also a common concern among female students, with nearly two-thirds of respondents reporting this situation. This may be related to the uneven distribution and insufficient number of HPV vaccination centers, as well as the imperfect vaccine reservation system [59]. Furthermore, we were somewhat surprised that a significant percentage (54.4%) of respondents experienced difficulties in obtaining information about HPV vaccination. Despite extensive efforts to promote HPV vaccination, many female students still feel puzzled and confused about how to obtain sufficient and accurate information about HPV vaccination. This may suggest that promoting HPV vaccination requires consideration of a variety of information dissemination methods to ensure the timeliness, accuracy, and completeness of information.

We found that several sociodemographic and health and risk factor variables were associated with difficulties in accessing HPV vaccine. Age is a key factor affecting vaccine access difficulties. In mainland China, age-specific limits on HPV vaccines may heighten female university students' urgency for vaccination as they age, potentially increasing difficulties in obtaining the vaccines. Fortunately, in August 2022, the China National Medical Products Administration approved the nine-valent HPV vaccine to expand its application age for females from 16 to 26 to 9–45 [60], thus easing access difficulties to some extent among female university students. Higher levels of maternal education were associated with lower odds of perceptions of vaccine access difficulties. Similar findings have been reported in previous studies indicating that female college students with higher maternal education levels were more likely to receive the HPV vaccine [61]. Additionally, having a high level of HPV and HPV vaccine knowledge was associated with vaccine access difficulties, whereas having a history

Table 5 Multiple linear regression analysis on HPV vaccine intention among female university students ($n=2782$) [a]

Variables	Model 1 [b]			Model 2 [c]		
	β	95CI	*p*	β	95CI	*p*
Age	0.04	0.01, 0.03	**0.018**	0.03	0.01, 0.03	**0.036**
Ethnicity						
Ethnic minorities (Ref.)						
Han nationality	-0.01	-0.12, 0.11	0.920	0.01	-0.12, 0.12	0.981
Major						
Non-medicine (Ref.)						
Medicine	-0.01	-0.07, 0.04	0.565	-0.01	-0.07, 0.04	0.616
Paternal education level						
Primary school and below (Ref.)						
Junior high school	-0.02	-0.10, 0.05	0.513	-0.02	-0.11, 0.05	0.501
High school/technical secondary school	-0.01	-0.10, 0.08	0.863	0.01	-0.09, 0.08	0.871
Junior college/university and above	-0.01	-0.12, 0.08	0.729	-0.01	-0.12, 0.08	0.663
Maternal education level						
Primary school and below (Ref.)						
Junior high school	-0.01	-0.07, 0.06	0.966	0.01	-0.06,0 0.07	0.919
High school/technical secondary school	0.03	-0.03, 0.13	0.217	0.02	-0.03, 0.13	0.248
Junior college/university and above	0.04	-0.01, 0.20	0.069	0.04	0.01, 0.20	0.056
Monthly household income (RMB)						
≤¥ 5,000 ($698) (Ref.)						
¥ 5,001–10,000 ($698–1397)	0.02	-0.03, 0.09	0.361	0.01	-0.04, 0.09	0.467
¥ 10,001-20000 ($1397–2793)	0.02	-0.04, 0.10	0.349	0.02	-0.04, 0.10	0.422
>¥ 20,000 ($2793)	0.01	-0.07, 0.11	0.659	0.01	-0.08, 0.10	0.766
Residence						
Urban (Ref.)						
Rural	0.01	-0.04, 0.06	0.693	0.01	-0.04, 0.07	0.643
HPV and HPV vaccine knowledge						
Low (Ref.)						
High	0.05	0.04, 0.14	**0.001**	0.05	0.04, 0.14	**0.001**
Sexual experience						
No/Refuse to answer (Ref.)						
Yes	0.01	-0.05, 0.10	0.476	0.01	-0.05, 0.10	0.481
History of HPV infection						
No/Not sure (Ref.)						
Yes	0.01	-0.25, 0.42	0.621	0.01	-0.24, 0.43	0.574
Family history of cervical cancer						
No/Not sure (Ref.)						
Yes	-0.02	-0.37, 0.06	0.151	-0.02	-0.37, 0.06	0.157
Perceived severity	-0.02	-0.06, 0.02	0.303	-0.02	-0.06, 0.02	0.301
Perceived susceptibility	0.07	0.04, 0.10	**< 0.001**	0.07	0.04, 0.10	**< 0.001**
Response efficacy	0.03	-0.02, 0.09	0.215	0.02	-0.02, 0.08	0.243
Self-efficacy	0.38	0.42, 0.52	**< 0.001**	0.37	0.41, 0.52	**< 0.001**
Response costs	-0.10	-0.16, -0.09	**< 0.001**	-0.11	-0.18, -0.10	**< 0.001**
Parent norm	0.08	0.01, 0.02	**< 0.001**	0.08	0.01, 0.02	**< 0.001**
Peer norm	0.05	0.01, 0.02	**0.007**	0.05	0.00, 0.01	**0.006**
Healthcare professional norm	0.11	0.01, 0.03	**< 0.001**	0.11	0.01, 0.03	**< 0.001**
Social norms	0.14	0.09, 0.14	**< 0.001**	0.14	0.09, 0.14	**< 0.001**
Difficulty in obtaining HPV vaccine						
No (Ref.)						
Yes	0.10	0.13, 0.23	**< 0.001**	-	-	-
Difficulty in obtaining the desired type of HPV vaccine						
No (Ref.)	-	-	-			
Yes	-	-	-	0.06	0.03, 0.17	**0.007**

Table 5 (continued)

Variables	Model 1 [b]			Model 2 [c]		
	β	95CI	*p*	β	95CI	*p*
Difficulty in accessing HPV vaccination centers						
No (Ref.)	-	-	-			
Yes	-	-	-	0.04	-0.01, 0.15	0.060
Difficulty in obtaining information about HPV vaccination						
No (Ref.)	-	-	-			
Yes	-	-	-	0.03	-0.02, 0.11	0.178

[a] All assumptions for linear regression models were examined (linearity, normality, independence, and homoscedasticity) and were fulfilled

[b] Model 1: Durbin-Watson = 1.699, $R^2 = 0.46$, Adjusted $R^2 = 0.45$; F = 85.52, $p < 0.001$; All VIF values were < 4 and Tolerance values were > 0.2

[c] Model 2: Durbin-Watson = 1.703, $R^2 = 0.48$, Adjusted $R^2 = 0.45$; F = 80.04, $p < 0.001$. All VIF values were < 4 and Tolerance values were > 0.2

Boldface indicates statistical significance

CI = confidence interval; Ref = reference category

of HPV infection was associated with lower odds of vaccine access difficulties. Female university students with a high level of knowledge may be more sensitive to vaccine access difficulties due to their understanding of its importance and their urgent demand for vaccination. By contrast, female students with prior HPV infections may have already experienced its health issues and psychological burden, leading them to have a more positive attitude toward obtaining and receiving the HPV vaccine. We also found that higher monthly household income was associated with lower perceived overall difficulty in obtaining the HPV vaccine, suggesting that price remains a key concern for female university students in HPV vaccination.

The availability of resources and opportunities determines health behaviors to a certain extent [48]. Our results showed that participants who perceived an overall difficulty in obtaining HPV vaccine, as well as perceived difficulty in obtaining desired type of HPV vaccine, accessing HPV vaccination centers, and obtaining information about HPV vaccination, were less likely to have received the HPV vaccine, respectively. This suggests that access to vaccines is an important factor in female university students' HPV vaccine uptake. The availability of specific vaccine types, geographical disparities in vaccination center distribution, as well as the clarity and accessibility of information, all exert a crucial influence on female students' decisions regarding HPV vaccination. These findings provide important evidence highlighting the need for public health interventions to reduce barriers to HPV vaccine access. Through optimizing resource allocation [62] and enhancing the dissemination and transparency of detailed vaccination information [63], we hope to ultimately improve HPV vaccine coverage. Our findings also showed that perceived overall difficulty in obtaining HPV vaccine and perceived difficulty in obtaining the desired type of HPV vaccine were significantly associated with greater HPV vaccination intentions among those unvaccinated female students. One possible explanation is that scarce market resources intensify public demand for HPV vaccines, and female students with a strong willingness to vaccinate may be more sensitive to difficulties in obtaining vaccines.

Our study also confirms the roles of the PMT-TPB integrated model in predicting HPV vaccine uptake and intention. The results showed that greater perceived susceptibility, self-efficacy, parent norm, and social norms, as well as lower response costs were associated with a higher likelihood of HPV vaccine uptake among vaccinated participants, whereas greater perceived susceptibility, self-efficacy, parent norm, peer norm, healthcare professional norm, and social norms, as well as lower response costs were associated with greater vaccination intentions among unvaccinated female university students. These findings are consistent with previous research indicating that self-efficacy is an important driver for HPV vaccination [11, 64], and social norms play a crucial role in HPV vaccination uptake and intention [65].

Although the HPV vaccination rate reported in this study is very limited, the intention to vaccinate among unvaccinated female university students is relatively high. This positive trend suggests a significant pool of potential participants for HPV vaccination. However, it is worth noting that intentions do not always translate into actual behavior [66]. The potential gap between intentions and actual behavior should be considered [67]. The vaccine access difficulty in our study may provide a new perspective for exploring possible reasons for the gap between HPV vaccine intention and uptake. Even with good intentions, female university students may not be able to adhere to vaccination due to inadequate HPV vaccine accessibility. According to the China Statistical Yearbook, there are over 149 million females in China aged between 9 and 45 [68], highlighting a substantial potential market demand for HPV vaccine uptake. In order to translate the high intention for HPV vaccination into actual

vaccination uptake, addressing the difficulties in accessing HPV vaccines is crucial.

While our results highlight the impact of vaccine access difficulties on HPV vaccine intention and uptake, we acknowledge several limitations. First, our cross-sectional study cannot establish causality. We did not track the process from HPV vaccine intention to uptake, nor did we determine if access difficulties were key factors influencing this relationship. However, our findings offer valuable insights for future research and implementation. Further longitudinal studies could expand the identification of variables influencing HPV vaccination uptake. Second, participants were female university and college students, potentially limiting the generalizability of our findings. Third, the study was conducted only in Zhejiang Province, so the results may not be generalizable to other regions or nationally. However, this potential bias may be minimized since university students come from all over the country and HPV vaccination in China is not restricted geographically. Future studies should be conducted on a broader population across different regions to validate the findings. Fourth, difficulties in access HPV vaccine are likely to be multifaceted. While we have examined three major aspects of difficulties in accessing HPV vaccine, more aspects need to be considered. Finally, all data were self-reported and inevitably influenced by recall bias and social desirability bias. These biases were minimized through strict quality control and large sample sizes.

Conclusions

The improvement of vaccine access is a key consideration for promoting HPV vaccination efforts. Our findings indicated that Chinese female university students generally perceived various difficulties in accessing HPV vaccine. The overall perception of difficulty in obtaining the HPV vaccine, as well as difficulties in obtaining the desired type of HPV vaccine, accessing HPV vaccination centers, and obtaining information about HPV vaccination, all significantly influence HPV vaccine uptake and intention among female university students. These results provide a new perspective for future research into potential factors underlying the intention-behavior gap in HPV vaccination. Successful public health efforts should comprehensively improve access to HPV vaccines, optimize the layout and service quality of vaccination centers, enhance the dissemination and transparency of HPV vaccine information, and provide a strong guarantee for HPV vaccination uptake among female university students.

Abbreviations

HPV Human papilloma virus
NIP National immunization program
PMT Protection Motivation Theory
TPB Theory of Planned Behavior
GDP Gross domestic product

Supplementary Information

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Supplementary Material 1

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Author contributions

W. W. conceptualized and designed the study; W. W. collected and analyzed the data; W. W. drafted and reviewed the manuscript, and provided final approval.

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Data availability

The datasets generated and/or analyzed during the current study are not publicly available due to promised data protection reasons. However, materials and instruments are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

The study received ethical clearance from the Zhejiang University School of Public Health Research Ethics Committee (ZGL202006-08). Each participant received a thorough briefing on the study's goals, confidentiality, and voluntary nature, and provided informed consent.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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