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Influences of HPV disease perceptions, vaccine accessibility, and information exposure on social media on HPV vaccination uptake among 11,678 mothers with daughters aged 9–17 years in China: a cross-sectional study

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Abstract

Background Mothers play a crucial role in influencing their daughters' HPV vaccination decisions. Addressing barriers to receiving HPV vaccination among mothers of girls may achieve two goals in one strike: increasing vaccination coverage among both mothers and their daughters. This study aims to examine the HPV vaccination uptake and its determinants among mothers of girls in China at both the individual and interpersonal levels.

Methods From July to October 2023, a cross-sectional online study was conducted to investigate HPV vaccine refusal for daughters aged 9–17 years among 11,678 mothers in Shenzhen, China. A randomized selection method was employed, targeting 11 primary schools and 13 secondary schools in Shenzhen. The research team invited mothers of girls to participate in an anonymous online survey. Multilevel logistic regression models (level 1: schools; level 2: individual participants) were employed to analyze the data.

Results Among 11,678 mothers, 41.1% self-reported receiving at least one dose of HPV vaccination. Through multilevel logistic regression analysis, eight items measuring illness representations of HPV, which refers to how people think about HPV, were associated with higher HPV vaccination uptake (AOR: 1.02–1.14). These items included identity (identifying symptoms of HPV), timeline (whether HPV is acute/chronic), negative consequences, personal and treatment control (whether HPV is under volitional control), concern, negative emotions, and coherence (overall understanding of HPV). In addition, participants refusing HPV vaccines for the index daughters (AOR: 0.82, 95%CI: 0.76, 0.89) had lower vaccine uptake. Perceived more difficulties in accessing the 9-valent vaccines (AOR: 1.06, 95%CI: 1.04, 1.08)

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and more satisfaction with vaccine-related promotional materials (AOR: 1.50, 95%CI: 1.46, 1.54) at the individual level were associated with higher vaccine uptake. At the interpersonal factors, higher frequency of exposure to testimonials given by others about HPV vaccination on social media (AOR: 1.19, 95%CI: 1.14, 1.25) and thoughtful consideration of the veracity of the information (AOR: 1.11, 95%CI: 1.07, 1.16) were correlated with higher HPV vaccination uptake.

Conclusions These findings offer essential implications for modifying HPV disease perceptions, addressing difficulties in accessing the 9-valent HPV vaccines, and enhancing health communication needs to improve HPV vaccine uptake among mothers of girls.

Keywords HPV vaccine uptake, Mothers of girls, Illness representation, Satisfaction with health promotion materials, Social media influence, Socioecological model, China

Background

Cancers caused by human papillomavirus (HPV) are serious health threats for women. Globally, about 625,600 women are diagnosed with HPV-related cancers annually [1]. Both the incidence and mortality rate of HPV-related cancers are high and increasing continuously among Chinese women [2–4]. HPV vaccination is highly effective in preventing HPV-related cancers without safety concerns [5, 6]. Receiving HPV vaccination prior to the onset of sexual behaviors was considered the most efficacious [7–9]. The main scheme of the HPV vaccination program in China started to roll out in 2016. The main scheme first provided bivalent HPV vaccines to females aged 9–45 years (in August 2016) [10], and then expanded to supply quadrivalent and the 9-valent vaccines to the same age group of females in May 2017 [10] and August 2022 [11]. Although the basic health insurance in China covers 80% of the cost of bivalent (¥1080 or US$148 for the whole course) and quadrivalent vaccines (¥2496 or US$343 for the whole course), it cannot cover the 9-valent vaccines (¥3993 or US$547 for the whole course). A pilot scheme under the national program started in 2022 in some Chinese cities including Shenzhen, the study site, providing free bivalent vaccines to girls aged 13–15 years. However, girls who wish to receive quadrivalent or the 9-valent vaccines have to follow the arrangement of the main scheme. Currently in China, HPV vaccination is not available for males. In China, the mean age at sexual debut for girls ranges from 19.3 to 23.1 years [12, 13]. The coverage of at least one dose of HPV vaccination in different age groups of females was 4.6% (9–17 years), 23.4% (18–26 years), 22.0% (27–35 years), 20.2% (36–44 years), and 3.2% (45–50 years), respectively [14].

Mothers have an important influence on their daughters' HPV vaccination uptake. In China, mothers are the main decision-makers for their children's vaccination [15]. Previous studies highlighted the important roles of mothers in communicating with their daughters about vaccination, reproductive health, and sexual behaviors [16, 17]. In the literature, mothers who were hesitant to receive HPV vaccination were unlikely to vaccinate their daughters against HPV [18–22]. In China, most mothers with daughters aged 9–17 years are within the recommended age limit (45 years) for HPV vaccination. Addressing barriers to receiving HPV vaccination among this group of mothers may achieve two goals in one strike (i.e., increasing vaccination coverage among both mothers and their daughters).

Determinants to receive an HPV vaccination among women in general and girls under 18 years in China were well studied. However, very few studies examined the facilitators and barriers to receiving an HPV vaccination among the group of mothers with daughters aged 9–17 years. Our literature identified three relevant studies, which showed that the HPV vaccination uptake rate was between 2.6 and 18.6% among Chinese mothers having daughters [23–25]. A limited number of determinants were considered by these studies, such as background characteristics (i.e., the level of education and income, history of HPV infection), daughter's age, and perceptions regarding HPV vaccination (i.e., concerns about protection and costs, availability issues, family recommendations, and perceived self-efficacy) [23–25].

This study examined the determinants of HPV vaccination uptake among mothers at both the individual and interpersonal levels under the socioecological model [26], a commonly used framework to understand facilitators and barriers of vaccination uptake [27–31]. At the individual level, this study considered illness representations using the Brief Illness Perception Questionnaire (B-IPQ) and satisfaction with governmental health promotion materials. Illness representations refer to how individuals think about a disease or health condition [32], which has been increasingly used to explain various health behaviors and outcomes [33–35]. The Common-sense Model of Self-regulation suggests that individuals would construct schematic representations of an illness based on available information [32]. A health threat (i.e., HPV infection) would activate cognitive representation to regular the objective threat and the emotional representation to regulate emotions [36]. Both types of illness representations would guide the coping strategies for the health threat. Illness representations have been applied to understand determinants of various types of vaccination (i.e., coronavirus disease 2019 (COVID-19), pneumococcal, and

mpox vaccination) [33–35]. Health authorities in China have been promoting HPV vaccination through different mass media channels. It is crucial to assess the level of satisfaction among mothers regarding these health promotion materials, as they may not comprehensively address mothers' concerns or provide adequate information to facilitate the decision-making process for vaccination [3, 37]. Previous studies showed that people who were more satisfied with the government-produced vaccination materials had a higher uptake rate of COVID-19 vaccination [38, 39]. As compared to bivalent and quadrivalent HPV vaccines, the 9-valent HPV vaccines offer more comprehensive protection against HPV [40]. Previous studies suggested that Chinese women preferred to receive the 9-valent HPV vaccines over other types of vaccines [41, 42]. However, local news reported some issues related to the accessibility of the 9-valent HPV vaccines. Since the supply of 9-valent HPV vaccines could not meet its demands, most Chinese cities set limited quotas for receiving such vaccine [3]. Moreover, the procedures to register for the 9-valent vaccines were considered complicated [43]. The cost of the 9-valent vaccines may be another issue, as it is high and cannot be covered by basic health insurance in China (¥3993 or US$547 for three doses) [44]. Thus, the accessibility of the 9-valent HPV vaccines could potentially influence a mother's decision to receive HPV vaccination.

At the interpersonal level, social media platforms are crucial and indispensable health-related information sources. In the context of HPV vaccination, Chinese mothers heavily rely on social media to gather information about vaccination [45]. Exposure to negative or anti-vaccine content on social media was associated with lower uptake of HPV vaccination [45]. In contrast, exposure to information supporting vaccination uptake could reduce vaccine hesitancy [46]. In addition, misinformation related to vaccination is widespread on social media, which may aggravate vaccine hesitancy [47, 48]. Thoughtful consideration of the veracity of the information on social media could help mitigate the negative impact of misinformation [49, 50]. Previous studies showed a significant positive correlation between thoughtful consideration and vaccination uptake [50, 51]. Therefore, this study also investigated the associations between these interpersonal-level factors and HPV vaccination uptake among mothers with daughters aged 9–17 years.

To our knowledge, there was a dearth of studies investigating the influences of HPV disease perceptions, accessibility of the 9-valent vaccines, satisfaction with governmental promotional materials, or social media information exposure on the HPV vaccination uptake among Chinese mothers having daughters. To address the knowledge gaps, this study investigated HPV vaccination uptake among mothers with daughters aged 9–17 years in Shenzhen, China. We also examined potential determinants of vaccination uptake at the individual level (HPV vaccine refusal for daughters, illness representation of HPV, satisfaction with governmental health promotional materials, and accessibility of the 9-valent HPV vaccines) and interpersonal level (information exposure on social media and thoughtful consideration of veracity of information). We hypothesized that mothers' establishing specific perceptions about HPV influenced subsequent vaccination behavior and that satisfaction with governmental health promotional materials, accessibility of the 9-valent vaccines, and information exposure on social media would significantly impact their HPV vaccination uptake.

Methods

Study design

A cross-sectional online survey was conducted to investigate HPV vaccine refusal for daughters aged 9–17 years among mothers in Shenzhen, China, between July and October 2023 [52]. This study is a secondary analysis among mothers aged 52 years or below. We did not include mothers aged over 52 years (45 years in 2016), as they were unlikely to benefit from the main scheme of the national HPV vaccination program (started in 2016 for women aged 9–45 years).

Participants and data collection

The inclusion criteria for the original study were as follows: (1) mothers aged 18 or above, (2) able to read simplified Chinese, (3) having a daughter aged between 9 and 17 years at the time of the survey, (4) the daughter was attending a primary or secondary school in Shenzhen, and (5) having a smartphone with internet access.

Our research team randomly selected 3% of the primary and secondary schools from the updated school list in Shenzhen (11 out of 343 primary schools and 13 out of 475 secondary schools) using Excel's "select random cells" function. All these schools agreed to participate. These schools have established WeChat groups for parents and teachers to communicate school notices. Teachers in the selected schools posted the study information and a QR code to access the questionnaire in the WeChat groups, inviting mothers of female students to participate. The teachers also sent reminders twice during the study period in the WeChat groups. Participants were asked to keep the survey link private from people outside the WeChat groups. Before starting the online survey, participants were informed that participation was voluntary and their personal information would be kept confidential. Electronic informed consent was obtained. The research team developed an online questionnaire

using Questionnaire Star, a widely used survey platform in China. The questionnaire consisted of 90 items, with about 15 items per page for six pages, which took about 15 min to complete. The online survey platform checked for completeness before submission, allowing participants to review and change their responses. No incentives were given to participants. The data, protected by a password, was stored on the survey platform server, with only the corresponding author accessing the database. During the study period, 11,728 mothers completed the survey (response rate: 83.8%). We excluded 50 participants aged over 52 years and performed analysis among the remaining 11,678 participants. Ethics approval was obtained from the Shenzhen Longhua District Maternity and Child Healthcare Hospital (ref: 2022122201).

Sample size planning

Sample size planning of the original survey was explained in a published paper [52]. This secondary analysis included 11,678 participants. Such sample size allowed us to detect the smallest odds ratio of 1.12 between mothers with and without the facilitating conditions, with a power of 0.80 and an alpha of 0.05 and assuming the HPV vaccination uptake rate in the reference group (with a facilitating condition of HPV vaccination) to be 10–50% (PASS 11.0, NCSS LLC).

Measurements

Development of the questionnaire

The study questionnaire was designed by a panel of experts, including epidemiologists, clinicians, and CDC employees. To ensure its clarity and readability, the questionnaire underwent a pilot test with ten mothers. All participants in the pilot study found the questionnaire easy to understand. Using their feedback, the panel made final adjustments to the questionnaire. These ten mothers were not involved in the actual survey.

Covariates: background characteristics

The questionnaire gathers sociodemographic information about mothers, including age, education level, relationship status, employment status, and monthly household income. Information about their self-reported history of HPV-related diseases and the age of their daughters was also collected.

Dependent variable: HPV vaccination uptake among mothers

Mothers provided information on the number of HPV vaccine doses they received. Additional details on the type and location of vaccination were collected for those who had received at least one dose.

Independent variables at the individual level

In case the participant has more than one daughter aged 9–17 years, she referred to the one whose birthday is closest to the survey date when answering the questions. Participants were first asked whether their index daughters had received any HPV vaccination. For mothers whose index daughters had not received any HPV vaccination, they were asked about their likelihood of having the index daughters received HPV vaccination in the next year (response categories: 1 = very unlikely, 2 = unlikely, 3 = neutral, 4 = likely, and 5 = very likely). Vaccine refusal was defined as "very unlikely," "unlikely," or "neutral." The same definition was used in numerous studies [52, 53].

Participants' illness representations of HPV were assessed using the B-IPQ [54]. This reliable and valid approach was commonly used in previous studies to evaluate illness representations of individuals at risk for a particular disease [54, 55]. In this study, the B-IPQ scale was modified by replacing "illness" with "HPV" [54]. The open-ended question about the cause of illness was not included, consistent with previous research [54]. The remaining eight B-IPQ items assessed scores ranging from 0 to 10. These items include (1) consequences ("If you contracted HPV, how much does HPV infection affect your life?"), (2) timeline ("If you contracted HPV, how long do you think your illness will continue?"), (3) personal control ("If you contracted HPV, how much control do you feel you can deal with the illness?"), (4) treatment control ("If you contracted HPV, how much do you think existing treatment can help your illness?"), (5) identity ("If you contracted HPV, how much do you experience symptoms from the illness?"), (6) concern ("If you contracted HPV, how concerned are you about your illness?"), (7) coherence ("If you contracted HPV, how well do you feel you understand HPV?"), and (8) emotions ("If you contacted HPV, how much does your illness affect you emotionally?") [36]. Higher scores on consequence, timeline, identity, concern, and emotion items indicated more negative perceptions of the illness, while higher scores on personal control, treatment control, and coherence indicated more positive perceptions.

We modified the scale validated in the Chinese population to measure satisfaction with government-produced HPV vaccination health promotional materials (i.e., advertisements, posters, and others) [56]. The Cronbach's alpha for this scale was 0.91. Participants were asked whether the information presented by the health promotional materials was helpful for them to understand the policy and arrangement of HPV vaccination, address

concerns related to HPV vaccination, and facilitate their decision to receive an HPV vaccination (response categories: 1 = disagree, 2 = neutral, 3 = agree). Higher scores on the scale indicated higher satisfaction with the health promotional materials.

Four items measured perceived accessibility of the 9-valent HPV vaccines; they were (1) "It's difficult to obtain a quota to receive the 9-valent vaccines online," (2) "Making an appointment to receive the 9-valent vaccine is complicated," (3) "There is an insufficient supply of the 9-valent vaccines," and (4) "The cost is expensive for the 9-valent vaccines" (response categories: 1 = disagree, 2 = neutral, 3 = agree). The Difficulties to Access the 9-valent Vaccine Scale was constructed by summing up individual item scores, with higher scores indicating lower accessibility of the 9-valent vaccines. The Cronbach's alpha for this scale was 0.82.

Independent variables at the interpersonal level

We adapted validated questions to assess the frequency of exposure to information related to HPV vaccination on common social media platforms in China (i.e., WeChat moments, Weibo, TikTok, Red) in the past month [57]. These questions included exposure to testimonials from others, dissemination of negative information pertaining to HPV vaccines, and dissemination of negative information related to other vaccine incidents in China. Another validated measurement was used to measure thoughtful consideration about the veracity of information specific to HPV vaccines [49]. The response categories to the questions above were 1 = almost none, 2 = seldom, 3 = sometimes, and 4 = always.

Statistical analysis

Descriptive statistics were presented. The mean and standard deviation (SD) of the items and scales measuring satisfaction with health promotional materials, accessibility of the 9-valent vaccines, illness representation, and influence of social media related to HPV or HPV vaccinations were also calculated. The dependent variable was the uptake of at least one dose of the HPV vaccine among mothers. Multilevel logistic regression models (level 1: schools; level 2: individual participants) were employed to investigate the factors related to the dependent variable. Random intercept models were utilized to accommodate the variance in the regression model's intercept across schools, addressing the issue of intra-correlated nested data. This approach is frequently used in previous studies employing similar sampling methods [58, 59]. A univariate two-level logistic regression model was used to evaluate the significance of the relationship between each background characteristic and the dependent variable. Background characteristics that showed significance at $P < 0.05$ in the univariate analysis were then included and adjusted in the multivariate two-level logistic regression model. Crude odds ratio (OR), adjusted odds ratios (AOR), and their 95% confidence intervals (CI) were reported. Multicollinearities were assessed through the variance inflation factor (VIF); variables exceeding a VIF value of 5 were adjusted or eliminated if theoretically redundant. Hosmer and Lemeshow goodness-of-fit test was used to assess model fits of logistic regression models. The insignificant Hosmer and Lemeshow goodness-of-fit test ($P > 0.05$) indicates that the model's estimates fit the data at an acceptable level [60, 61]. The analyses were performed using SPSS (version 29.0; IBM, Armonk, NY, USA). A significance level of $P < 0.05$ was used.

Results

Background characteristics

About half of the participants were aged between 36 and 40 years (41.6%), had received tertiary education (48.2%), and were without a full-time job (58.3%). The majority of them were married (95.9%), had a monthly household income of more than ¥5000 (USD 685) (83.4%), and did not have a history of HPV infection (95.9%) or HPV-related diseases (97.8%). Over half of them had a daughter who was 9–12 years old (61.1%) (Table 1).

HPV vaccination uptake

Among all participants, 41.1% (n = 4800) self-reported receiving at least one dose of HPV vaccination, and 64.9% of vaccinated participants (3115/4800) completed the whole course of vaccination. Among vaccinated participants, 53.0% received a quadrivalent vaccine (Gardasil 4) (2547/4800), 18.1% received the 9-valent vaccines (Gardasil 9) (868/4800), 15.2% received a bivalent vaccine (729/4800), and 13.7% were uncertain about the type of vaccine they received (656/4800). The most common venues to receive HPV vaccination were public hospitals and community health centers in Shenzhen (3935/4800, 82.0%) (Table 2).

HPV vaccine refusal for daughters

Among the mothers, 18.2% reported that their 9–17 years old daughters had taken up HPV vaccines. Among participants whose 9–17 years old daughters were unvaccinated against HPV, 46.7% intended to have such daughters received HPV vaccination in the next 12 months. The proportion of mothers who had HPV vaccine refusal for their 9–17 years old daughters was 43.3% (Table 2).

Other factors at individual and interpersonal levels

The mean scores and SD of the items related to illness representations of HPV were presented in Table 2.

Table 1 Background characteristics of the participants (n = 11,678)

	n	%
Age group, years		
18–35	3175	27.2
36–40	4863	41.6
41–52	3640	31.2
Education level		
Junior high or below	3304	28.3
Senior high or equivalent	2741	23.5
College and above	5633	48.2
Relationship status		
Married	11,194	95.9
Currently single	484	4.1
Employment status		
Full time	4872	41.7
Without full-time job	6806	58.3
Monthly household income, ¥ (US$)		
<5000 (685)	1944	16.6
5000–9999 (685–1369)	3551	30.4
10,000–15,000 (1369–2054)	1902	16.3
>15,000 (2054)	3110	26.6
Refuse to disclose	1171	10.0
Self-reported history of HPV infection		
No	11,199	95.9
Yes	479	4.1
Self-reported history of HPV-related diseases (i.e., genital warts, cervical/anus/vagina cancers, and precancerous lesions)		
No	11,420	97.8
Yes	258	2.2
Age of the index daughter, years		
9–12	7132	61.1
13–17	4546	38.9

More than half of the participants found it challenging to obtain the 9-valent vaccines (Gardasil 9) quota (60.5%) and considered the cost of these vaccines to be expensive (64.8%). Less than half of the participants were satisfied with government-produced promotional materials for HPV vaccination (39.1–42.8%).

Regarding the interpersonal-level variables, less than 30% of participants were sometimes/always exposed to testimonials given by others about HPV vaccination (29.2%), negative information (27.8%), and other vaccine incidents related to HPV vaccination (25.8%) on common social media platforms. About 16.3% of the participants always considered the veracity of HPV vaccine-specific information (Table 2).

Factors associated with HPV vaccination uptake

In the univariate analysis, mothers who were older, currently single, with an older daughter, and without full-time jobs were less likely to take up HPV vaccination. Higher education, higher income, and a history of HPV infection or disease were correlated with higher HPV vaccination uptake (Table 3).

After adjusting for significant background characteristics, HPV vaccines refusal for their index daughters was correlated with lower HPV vaccination uptake among mothers (AOR: 0.82, 95%CI: 0.76, 0.89). Participants who perceived more negative effects of HPV on their lives (consequences) (AOR: 1.02, 95%CI: 1.00, 1.03), longer duration of HPV infection (timeline) (AOR: 1.02, 95%CI: 1.00, 1.03), HPV infection can be controlled by themselves (personal control) (AOR: 1.05, 95%CI: 1.04, 1.06) and medical treatment (treatment control) (AOR: 1.04, 95%CI: 1.02, 1.05), severe symptoms if contracted HPV (identity) (AOR: 1.05, 95%CI: 1.03, 1.07), more concerns (concern) (AOR: 1.14, 95%CI: 1.12, 1.15) and better understanding of HPV (coherence) (AOR: 1.13, 95%CI: 1.11, 1.15), and negative emotional responses to HPV (emotions) (AOR: 1.06, 95%CI: 1.05, 1.07) had higher HPV vaccination uptake. More satisfaction with the government's health promotional materials (AOR: 1.50, 95%CI: 1.46, 1.54) and perceived more difficulties (AOR: 1.06, 95%CI: 1.04, 1.08) in accessing the 9-valent HPV vaccines were also associated with higher HPV vaccination uptake. At the interpersonal level, a higher frequency of exposure to testimonials given by others about HPV vaccination (AOR: 1.19, 95%CI: 1.14, 1.25) was associated with higher vaccine uptake. Thoughtful consideration of the veracity of the information specific to HPV vaccines was also associated with higher vaccine uptake (AOR: 1.11, 95%CI: 1.07, 1.16) (Table 4). The VIF values for each variable in all logistic models were consistently below 5, ranging between 1.00 and 1.21, indicating that no adjustments were necessary for the variables. The aforementioned logistic regression models had acceptable fits (Hosmer and Lemeshow test ranged from 0.07 to 0.94).

Discussion

To our knowledge, this is one of the first studies to investigate the influence of HPV disease perceptions, accessibility of the 9-valent vaccines, satisfaction with governmental health promotional materials, and social media information exposure on HPV vaccination uptake among mothers having daughters. This study included the novel application of the Common-sense Model of Self-regulation to examine HPV disease perceptions, which extended the application of this theory and could inform public health messaging that is theoretically

Table 2 HPV vaccine uptake, individual level and interpersonal level factors related to HPV and/or HPV vaccines ($n = 11,678$)

	n	%
HPV vaccine uptake		
Uptake of at least one dose of HPV vaccine		
No	6878	58.9
Yes	4800	41.1
Number doses of HPV vaccination completed by the participants (among 4800 participants who had received at least one dose of HPV vaccine)		
One dose of domestic bivalent vaccines	40	0.8
Two doses of domestic bivalent vaccines	506	10.5
One dose of imported bivalent vaccines	11	0.2
Two doses of imported bivalent vaccines	146	3.1
One dose of quadrivalent vaccine (Gardasil 4)	75	1.6
Two doses of quadrivalent vaccine (Gardasil 4)	346	7.2
Three doses of quadrivalent vaccine (Gardasil 4)	2098	43.7
One dose of 9-valent vaccine (Gardasil 9)	203	4.2
Two doses of 9-valent vaccine (Gardasil 9)	294	6.1
Three doses 9-valent vaccine (Gardasil 9)	365	7.6
Uncertain	716	15.0
Type of HPV vaccination received by the participants (among 4800 participants who had received at least one dose of HPV vaccine)		
Domestic bivalent vaccines	567	11.8
Imported bivalent vaccines	162	3.4
Quadrivalent vaccine (Gardasil 4)	2547	53.0
9-valent vaccine (Gardasil 9)	868	18.1
Uncertain	656	13.7
Venues of HPV vaccination uptake among the participants (among 4800 participants who had received at least one dose of HPV vaccine)		
Public hospitals or community health centers in Shenzhen	3935	82.0
Private hospitals in Shenzhen	437	9.1
Other provinces or cities	156	3.3
Hong Kong, Macao, or other countries	425	8.9
Individual level factors		
HPV vaccine refusal for index daughters		
The index daughters have received HPV vaccines		
No	9482	81.8
Yes	2196	18.2
Likelihood of having the index daughter take up HPV vaccines in the next 12 months (among mothers whose index daughters have never received any HPV vaccines, $n = 9482$)		
Very unlikely/unlikely/neutral	5055	53.3
Likely/very likely	4427	46.7
HPV vaccine refusal for their daughters		
No	6623	56.7
Yes	5055	43.3
Domains of the Brief Illness Perception Questionnaire (B-IPQ), mean (SD)		
Consequences[a]	7.2	3.2
Timeline[b]	6.9	3.0
Personal control[c]	5.5	3.1
Treatment control[d]	6.2	2.8
Identity[e]	7.9	2.6
Concern[f]	7.7	2.7
Coherence[g]	4.8	2.7
Emotions[h]	7.0	2.9
Satisfaction with HPV vaccine health promotional materials (i.e., advertisement, poster, and others) produced by the government, yes		
Helpful for you to understand the policy and arrangement of HPV vaccination	5000	42.8
Can address your concerns related to HPV vaccination	4570	39.1
vHelpful for you to make decision on whether to receive HPV vaccines	4938	42.3
Satisfaction with Health Promotional Materials Scale[i], mean (SD)	7.1	1.6

Table 2 (continued)

	n	%
Difficulties to access the 9-valent HPV vaccines, agree		
It's difficult to obtain a quota to receive the 9-valent vaccines (Gardasil 9) online	7067	60.5
Making an appointment to receive the 9-valent vaccines (Gardasil 9) is complicated	5331	45.6
There is an insufficient supply of the 9-valent vaccines (Gardasil 9)	6427	55.0
The cost is expensive for the 9-valent vaccines (Gardasil 9)	7566	64.8
Difficulties to Access the 9-valent Vaccine Scale[j], mean (SD)	9.9	2.1
Interpersonal level factors		
Frequency of exposure to the following information on social media platforms (i.e., WeChat moments, Weibo, TikTok, Red) in the past month		
Testimonials given by others about HPV vaccination		
Almost none	3975	34.0
Seldom	4293	36.8
Sometimes	2704	23.2
Always	706	6.0
Item score, mean (SD)[k]	2.0	0.9
Negative information about HPV vaccines (i.e., concerns about efficacies and supplies, side effects of the vaccines)		
Almost none	3650	31.3
Seldom	4778	40.9
Sometimes	2726	23.3
Always	524	4.5
Item score, mean (SD)[l]	2.0	0.9
Negative information about other vaccine incidents in China (i.e., selling problematic vaccines and severe side effects)		
Almost none	3971	34.0
Seldom	4699	40.2
Sometimes	2461	21.1
Always	547	4.7
Item score, mean (SD)[m]	2.0	0.9
Thoughtful consideration about veracity of information specific to HPV vaccines in the past month		
Almost none	2551	21.8
Seldom	3226	27.6
Sometimes	4008	34.3
Always	1893	16.3
Item score, mean (SD)[n]	2.5	1.0

[a] Consequences, item score: 0–10, a higher score indicated perceived severer consequences of HPV infection

[b] Timeline, item score: 0–10, a higher score indicated perceived HPV infection would last longer

[c] Personal control, item score: 0–10, a higher score indicated the perception that one had stronger ability to control the HPV infection

[d] Treatment control, item score: 0–10, a higher score indicated the perception that the treatment had stronger ability to control the HPV infection

[e] Identity, item score: 0–10, a higher score indicated perceived more symptoms of HPV infection

[f] Concern, item score: 0–10, a higher score indicated one had more concern about HPV infection

[g] Coherence, item score: 0–10, a higher score indicated one had more understanding about HPV infection

[h] Emotion, item score: 0–10, a higher score indicated one had more negative emotions caused by HPV infection

[i] Satisfaction with Health Promotional Materials Scale, 3 items, scale score: 3–9, a higher score indicated more satisfaction with health promotional materials; Cronbach's alpha: 0.91; one factor was identified by exploratory factor analysis, explaining for 84.6% of total variance

[j] Difficulties to Access 9-valent Vaccine Scale, 4 items, scale score: 4–12, a higher score indicated lower accessibility of the 9-valent vaccines; Cronbach's alpha: 0.82; one factor was identified by exploratory factor analysis, explaining for 52.7% of total variance

[k] Testimonials given by others about HPV vaccination, item score: 1–4, a higher score indicated a higher frequency of exposure to testimonials given by others about HPV vaccination

[l] Negative information about HPV vaccines, item score: 1–4, a higher score indicated a higher frequency of exposure to negative information about HPV vaccines

[m] Negative information about other vaccine incidents in China, item score: 1–4, a higher score indicated a higher frequency of exposure to negative information about other vaccine incidents in China

[n] Thoughtful consideration about the veracity of information specific to HPV vaccines in the past month, item score: 1–4, a higher score indicated a higher frequency of thoughtful consideration of the veracity of the information specific to HPV vaccines

Table 3 Associations between background characteristics and HPV vaccine uptake among mothers

	OR (95%CI)	*P* values
Age group, years		
18–35	Reference	
36–40	0.94 (0.85, 1.03)	0.15
41–52	0.56 (0.50, 0.62)	<0.001
Education level		
Junior high or below	Reference	
Senior high or equivalent	1.18 (1.06, 1.31)	<0.001
College and above	1.80 (1.06, 1.31)	0.003
Relationship status		
Married	Reference	
Currently single	0.74 (0.61, 0.90)	0.002
Employment status		
Full time	Reference	
Without full-time job	0.85 (0.79, 0.91)	<0.001
Monthly household income, ¥ (US$)		
<5000 (685)	Reference	
5000–9999 (685–1369)	1.28 (1.13, 1.43)	<0.001
10,000–15,000 (1369–2054)	1.48 (1.29, 1.69)	<0.001
>15,000 (2054)	1.82 (1.61, 2.05)	<0.001
Refuse to disclose	1.25 (1.08, 1.46)	0.004
Self-reported history of HPV infection		
No	Reference	
Yes	2.00 (1.66, 2.41)	<0.001
Self-reported history of HPV-related diseases (i.e., genital warts, cervical/anus/vagina cancers, and precancerous lesions)		
No	Reference	
Yes	1.63 (1.27, 2.08)	<0.001
Age of the index daughter, years		
9–12	Reference	
13–17	0.84 (0.78, 0.91)	<0.001

OR Crude odds ratios obtained from two-level logistic regression models (level 1: schools, level 2: individual participants), *CI* Confidence interval

anchored. This study also examined the associations between social media information exposure, satisfaction with governmental health promotion materials, and HPV vaccine uptake, which has not been extensively studied among mothers in China. Other strengths of this study included the large sample size (n = 11,678) and high response rate (83.8%).

In the study, 41.1% of the mothers received at least one dose of HPV vaccination and 64.9% of vaccinated mothers completed the whole course. The HPV vaccination uptake rate was higher than previous studies targeting the same population conducted from 2020 to 2022 (2.6 to 18.6%) [23–25], which suggested an increase in HPV vaccination coverage in this group. However, the HPV vaccination uptake rate was still lower than that of mothers having daughters in the USA (49.0 to 83.0%) [62–64]. A modeling study suggested that HPV vaccination coverage should reach at least 95% among females in China in order to effectively reduce HPV infection at the population level [65]. There is a strong need and large room to improve HPV vaccination coverage among females in China.

In line with the findings of previous studies, mothers who were older and single reported lower HPV vaccination uptake [50, 51, 66]. Since the rollout of the HPV vaccination program started late in China (2016), older mothers might perceive HPV vaccination as less effective for them [67, 68]. In China, single mothers often have a heavy burden in raising their children, constrained by tight financial resources [69, 70]. Lack of time and low income might become barriers for single mothers to receive HPV vaccination. In contrast, better socioeconomic status (higher education, higher income, and full-time employment) was associated with higher HPV vaccine uptake in this study. Such findings were similar

Table 4 Associations of individual level and interpersonal level factors with HPV vaccine uptake among mothers

	AOR (95%CI)	*P* values
Individual level factors		
HPV vaccine refusal for the index daughters	0.82 (0.76, 0.89)	<0.001
Domains of the Brief Illness Perception Questionnaire (B-IPQ), mean (SD)		
Consequences	1.02 (1.00, 1.03)	0.01
Timeline	1.02 (1.00, 1.03)	0.01
Personal control	1.05 (1.04, 1.06)	<0.001
Treatment control	1.04 (1.02, 1.05)	<0.001
Identity	1.05 (1.03, 1.07)	<0.001
Concern	1.14 (1.12, 1.15)	<0.001
Coherence	1.13 (1.11, 1.15)	<0.001
Emotions	1.06 (1.05, 1.07)	<0.001
Satisfaction with Health Promotional Materials Scale	1.50 (1.46, 1.54)	<0.001
Difficulties to Access the 9-valent Vaccine Scale	1.06 (1.04, 1.08)	<0.001
Interpersonal level factors		
Frequency of exposure to the following information on social media platforms (i.e., WeChat moments, Weibo, TikTok, Red) in the past month		
Testimonials given by others about HPV vaccination	1.19 (1.14, 1.25)	<0.001
Negative information about HPV vaccines (i.e., concerns about efficacies and supplies, side effects of the vaccines)	1.02 (0.98, 1.07)	0.38
Negative information about other vaccine incidents in China (i.e., selling problematic vaccines and severe side effects)	1.00 (0.96, 1.05)	0.93
Thoughtful consideration about veracity of information specific to HPV vaccines in the past month	1.11 (1.07, 1.16)	<0.001

AOR Adjusted odds ratios, odds ratios obtained from two-level logistic regression models (level 1: schools, level 2: individual participants) after adjusting for significant background characteristics listed in Table 3, *CI* Confidence interval

to previous studies [71, 72]. To address the disparities, future HPV vaccination programs should pay more attention to single mothers and those with lower socioeconomic status. Furthermore, mothers who reported a history of HPV infection and HPV-related diseases had higher vaccine uptake. It is possible that these mothers perceive a greater threat from HPV and, therefore, have a greater motivation to get vaccinated [41].

Promoting HPV vaccination among mothers who have daughters might increase vaccine coverage among both mothers and their daughters, as higher HPV vaccination uptake among mothers was correlated with lower vaccine refusal for their daughters in this study. Our findings provided some practical implications to inform such health promotion. Our findings highlighted that HPV disease perceptions could be incorporated into health communication messages to encourage vaccination uptake. Mothers who perceived more negative effects of HPV on their lives (consequences), longer duration of HPV infection (timeline), and more severe symptoms if contracted HPV (identity) were more likely to receive HPV vaccination. Health communication messages may anchor these perceptions by highlighting the effectiveness of HPV vaccination in preventing severe and long-term consequences of HPV infection. Perceived higher personal control and treatment control of HPV were also correlated with higher HPV vaccination uptake. Similar associations have been observed in the context of seasonal influenza vaccination and hepatitis C virus testing [55, 73]. Beliefs in personal and treatment control may be linked to the perceived efficacy of HPV, a facilitator of vaccination uptake [41, 74]. Participants who better understood HPV (coherence) were more likely to be vaccinated. This is consistent with previous studies among females that found better knowledge of HPV was a facilitator of HPV vaccination uptake [75]. HPV infection elicited negative emotions and concerns among mothers. Similar to previous studies, such negative emotions and concerns were associated with higher HPV vaccination uptake [55, 73]. To promote HPV vaccination, it may be beneficial to encourage the adoption of positive coping strategies that aim to alleviate the negative emotions and concerns associated with HPV among mothers. It is plausible to encourage mothers experiencing high levels of negative emotions and concerns to receive HPV vaccination, transforming their negative emotions into prevention behaviors.

It is necessary to improve current HPV vaccination promotional materials, as less than half of the mothers found such materials to help address their concerns and facilitate their vaccination decisions. Higher satisfaction with these health promotional materials was associated with higher HPV vaccination uptake. Currently, most health promotional materials are developed by academics or healthcare professionals [76]. These materials are standardized

without considering the needs of end-users from their perspectives [77]. To address this issue, utilizing a co-creation approach, which involves collaboration between academics, end-users, and other stakeholders, may help improve these materials and lead to behavioral change [78, 79]. This approach has shown promise in addressing complex issues and promoting behavioral change [78].

About half of the mothers perceived some difficulties in accessing the 9-valent HPV vaccines, including inadequate supply, limited quota, complicated procedures to register, and high costs. It was interesting to find that perceived more difficulties in accessing such vaccines was associated with higher HPV vaccination uptake. One possible explanation was that women would have first-hand experience of such difficulties when they were trying to get the 9-valent vaccines. In contrast, those who did not have an interest in receiving the HPV vaccination might be less aware of these issues. The 9-valent vaccines developed and manufactured by China have entered clinical trials with positive results [80]. The supply issues might be tackled after the domestic 9-valent vaccines enter the market. The Chinese government should also consider simplifying the procedures for registering the 9-valent vaccines and expanding the basic health insurance to cover such vaccines to remove other difficulties related to vaccine access.

Our study showed that HPV vaccination might not be a hot topic on social media, as only one-third of the participants were sometimes/always exposed to information related to HPV vaccination in the past month through such channels. In line with previous studies [45, 81], higher exposure to information related to HPV vaccination on social media was associated with higher HPV vaccination uptake, highlighting the potential of using social media for vaccination promotion. Health authorities should consider utilizing their official social media platforms to disseminate health promotion messages related to HPV vaccination, as Chinese mothers tend to perceive these accounts as credible sources of information [49]. Furthermore, our findings highlighted the role of thoughtful consideration of the veracity of information specific to HPV vaccination in improving vaccine uptake, which aligns with previous studies [49–51]. Thoughtful consideration may mitigate the negative impacts of misinformation on the acceptance to receive HPV vaccination. Only 16.3% of the participants always thought carefully about the veracity of information specific to HPV vaccination, and there is room for improvement. Health authorities should proactively identify misinformation related to HPV vaccination and provide timely clarification. Empowering the women with adequate skills to critically evaluate the veracity of information may also be helpful.

This study has several limitations. First, it is ideal to measure illness representations of main diseases caused by HPV (i.e., genital warts, cervical cancers, and other HPV-related cancers) at the same time. However, we were not able to do so due to the limited length of the questionnaire. We followed the approach used by previous studies and focused on B-IPQ of HPV [82]. Second, we did not include a group of mothers without daughters in this study and were not able to ascertain whether the level of vaccination uptake and associated factors were the same between mothers with and without daughters. Third, all participants were recruited from Shenzhen, and the findings cannot be generalized to other Chinese cities. Shenzhen is one of the most developed cities in China, and it has better access to and supply of HPV vaccines. The HPV vaccination uptake rate among females in Shenzhen is expected to be higher than that of less developed cities. Fourth, due to limited resources, we were unable to verify the HPV vaccination status through medical records or laboratory testing. However, mothers were able to provide detailed information about their vaccination. Mothers might over-report HPV vaccination uptake due to social desirability [83]. Fifth, the scale measuring difficulties in accessing the 9-valent vaccines was self-constructed in the absence of validated measurement. Cronbach's alpha on this scale was acceptable. However, this scale was not validated by an independent study. Furthermore, the survey was anonymous, and we were unable to collect information from mothers who refused to answer the questionnaire online. Selection bias existed. Last but not least, this study was cross-sectional and cannot establish causality.

Conclusions

In sum, the current HPV vaccination uptake rate among mothers having daughters in Shenzhen, China, was suboptimal. More efforts to promote HPV vaccination uptake are needed, especially for single mothers and those with low socioeconomic status. Modifying HPV disease perceptions, improving governmental health promotion materials, and addressing difficulties in accessing the 9-valent HPV vaccines might be useful in increasing HPV vaccination uptake. Health authorities may consider using social media as one communication channel to encourage HPV vaccination uptake.

Abbreviations

HPV	Human papillomavirus
B-IPQ	Brief Illness Perception Questionnaire
COVID-19	Coronavirus disease 2019
SD	Standard deviation
OR	Crude odds ratio
AOR	Adjusted odds ratios
CI	Confidence interval
VIF	Variance inflation factor

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Authors' contributions
Conceptualization: Z.L., S.C., L.S., Y.L., Z.W.; methodology: Z.L., S.C., L.S., Y.L., H.C., Z.H., Z.C., Y.F., X.L., Z.W.; data curation: Z.L., L.S., Y.L., H.C., Z.H., J.C., B.L., C.W.; project administration: Z.L., L.S., Y.L., H.C., Z.H., J.C., B.L., C.W.; writing-original draft preparation: S.C., Z.L., L.S., Y.L., Z.C., Y.F., X.L., Z.W.; writing-review and editing: S.C., Z.C., Y.F., X.L., J.C., B.L., C.W, and Z.W. All authors read and approved the final manuscript.

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Availability of data and materials
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
Prospective participants were informed that the survey was anonymous, their information will be kept strictly confidential, and they had the right to refuse to participate or withdraw from the study at any time. Refusal and withdrawal would not affect their access to any services. Electronic informed consent was obtained. Ethics approval was obtained from the Shenzhen Longhua District Maternity and Child Healthcare Hospital (ref: 2022122201).

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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