



# Preference for human papillomavirus vaccine type and vaccination strategy among parents of school-age girls in Guangdong province, China

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## ABSTRACT

In China, the human papillomavirus (HPV) vaccination coverage among age-eligible girls is rather low, and parent's attitude often plays a determinant role in their girls' HPV vaccination. To accelerate HPV vaccination coverage, several cities and Guangdong province in China offered different HPV vaccine types with different reimbursement methods. In April 2022, we conducted a province-wide survey to investigate parents of children aged 9–15 in Guangdong province, and analyzed factors associated with their preference for HPV vaccine type and vaccination strategy. Of the 4,967 surveyed respondents, 2,610 (58.1%) have not yet vaccinated their children. Among these parents, 67.9% preferred to vaccinate their children with the nine-valent vaccine, while only 8.1% preferred the quadrivalent vaccine and 7.4% preferred the bivalent vaccine. More parents preferred fixed subsidies with free choices of HPV vaccine type over the domestic bivalent vaccine provided by the government (58.1% vs. 39.3%). The multinomial logistic regression showed that parents' relationship with children, educational level, household income, and vaccination status were significantly associated with parents' preference for HPV vaccine type. Parent's relationship with children, workplace, household income, vaccination status, and age of children, were significantly associated with parents' preference for HPV vaccination strategy. Our findings suggest that policymakers may consider adjusting the current vaccination strategy by offering more vaccination choices. More health education on HPV vaccine and vaccination should also be provided to parents of age-eligible girls. Future research should examine which HPV vaccination strategy is more effective in promoting HPV vaccine uptakes in China.

## 1. Introduction

Cervical cancer has become the fourth leading cause of cancer among women. In 2020, worldwide, there were 604,127 more new cases of cervical cancer, which caused 341,831 new deaths (Sung et al., 2021). More than 95 % of cervical cancer is attributed to sexually transmitted human papillomavirus (HPV) (World Health Organization, 2022a). Getting an HPV vaccine is effective in preventing up to 90 % of HPV-attributable cancers (US Centers for Disease Control and Prevention, 2022). The World Health Organization (WHO) recommends that the HPV vaccine should be involved as part of routine vaccinations in all

countries, along with routine cervical cancer screening and other preventive measures, and that girls aged 9–14 should be the primary target population for HPV vaccination (World Health Organization, 2017). Since 2006, when the first HPV vaccine became available, over 100 countries have approved one or more types of HPV vaccines, with 74 countries offering free HPV vaccination via the national immunization program for teenage girls (World Health Organization, 2022b).

With the promotion of HPV vaccination, many countries have reached a high coverage rate. For example, in the United States, in 2020, 75 % of adolescents have received HPV vaccination (Pingali et al., 2021). In Australia, in 2021, 80 % of girls have completed HPV

**Abbreviations:** HPV, Human Papillomavirus; WHO, World Health Organization; GDP, Gross Domestic Product; OR, Odds Ratio; RRR, Relative Risk Ratio; CI, Confidence Interval.

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vaccination by the age of 15 (Brynley et al., 2022). In the United Kingdom, almost 77 % of girls aged 12–13 completed HPV vaccination coverage for at least one dose (Department of Health & Social Care, 2020). In comparison, in China, the HPV vaccination coverage remained rather low, despite all types of HPV vaccines (including domestic and imported bivalent and quadrivalent and imported nine-valent vaccines) being made available to females aged 9–45. By 2021, only 20 million out of 382 million Chinese females aged 9 to 45 received HPV vaccination (Yuan et al., 2022). For girls aged 9–15, by 2020, the vaccination rate was less than 1% (Center for Social Media Research School of New Media, 2020).

Since HPV vaccination has not yet been included in the national immunization program in China, getting an HPV vaccine is completely self-pay for age-eligible females. This creates many access barriers, such as the tight supply of the HPV vaccine (especially the nine-valent vaccine), and economic burden – for many Chinese families receiving a complete dose of HPV vaccination is expensive (especially the nine-valent vaccine) – for Chinese age-eligible girls to get HPV vaccination. To improve HPV vaccination coverage among teenage girls, some cities in China implemented a local HPV vaccination program with different reimbursement methods (Li et al., 2023). Some cities offer domestic bivalent HPV vaccine for girls aged 13–14 free of charge, while some others offer fixed subsidy to girls aged 13–14 if they choose to be vaccinated from designated vaccine types (i.e., domestic bivalent HPV vaccine, imported bivalent vaccine, or imported quadrivalent vaccine). The free vaccination program can help eliminate the economic barrier, allowing every age-eligible girl to get access to the designated HPV vaccine, while the subsidy strategy alleviates the economic burden but keeps free choices for the type of vaccines. Yet, currently, it is still unclear which vaccination strategy is more effective in encouraging age-eligible girls to get HPV vaccination, especially for girls aged 13–14.

In Chinese families, parental attitudes often play a determinant role in their children's HPV vaccination (Wang et al., 2015; Xie et al., 2021). A prior study investigated parental perceptions of HPV vaccination with a sample of 925 in central China in 2017 and found that parents with higher knowledge of HPV were more likely to vaccinate their children against HPV (Zhou et al., 2019). In another survey that assessed parents' willingness to vaccinate their 9–18-year-old daughters in China, parents with enough confidence in the HPV vaccine were willing to vaccinate their daughters even if it is self-paid (Zhang et al., 2023). In a study on the preference for the HPV vaccine of their daughters among 3,586 Chinese mothers, more than 40% of mothers tended to vaccinate their daughter with the nine-valent HPV vaccine (Lin et al., 2021). Therefore, parents' preference towards which vaccination strategy could influence vaccination status of age-eligible girls (especially girls aged 13–14 who are direct beneficiaries of those local vaccination programs), but evidence in this regard is lacking.

In September 2022, Guangdong province became the first to offer province-wide free domestic bivalent HPV vaccines for girls aged 13–14. In April 2022 before the policy was implemented, we conducted a province-wide survey to investigate parents of children aged 9–15 in Guangdong province, and analyzed factors associated with their preference for the type of HPV vaccines and vaccination strategy to vaccinate their children. In particular, we compared preference for HPV vaccine type and vaccination strategy among parents of children aged 9–12, parents of children aged 13–14, and parents of children aged 15, to reflect the differential impact of the direct beneficiaries of the free vaccination program (13–14 years old) and indirect beneficiaries (9–12 and 15 years old). The findings provided important implications for policymakers to consider adjusting the HPV vaccination promotion strategy and also lay an important foundation for future research to examine the impact of the policy on parents' attitudes toward vaccinating their children.

## 2. Methods

### 2.1. Study design, setting, and participant

This study used a cross-sectional survey design. We conducted an online survey targeting parents of children aged 9–15 in Guangdong province, China between April 21 to 29, 2022. Guangdong province is located in the south of China, close to Hong Kong and with a long coastline. Guangdong province has a total of 126 million population, and children under 14 account for about 19 % of the total population, a little higher than the national average (18 %).

The questionnaire was self-designed by researchers based on previous literature and expert consultation, which included information on parents' socio-demographic characteristics, reasons for vaccinating and not vaccinating their children, preference for HPV vaccine type and vaccination strategy, and other related information. Before the questionnaire was made available to all participants, a pilot study was conducted among a small sample of parents (n = 32) to ensure that the questionnaire was easily understood and completed.

The final survey was distributed online via the official public account of the Shenzhen Health Commission registered in WeChat, the most commonly used instant messaging and social media application among Chinese residents. The public account has more than 13 million followers, with followers mostly being residents of Guangdong province. Parents of children aged between 9 and 15 were encouraged to participate in the survey and filled out the questionnaire via the mini-application "Wen Juan Xing", a widely used online survey platform embedded in WeChat. Informed consent was sent through the same survey link. All participants must fill out the informed consent to agree to continue the survey.

### 2.2. Outcome of interest

The main outcomes of interest were parents' preference for HPV vaccine type and vaccination strategy to vaccinate their children. The survey asked parents the type of HPV vaccines they prefer to vaccinate their children, with response options of "bivalent", "quadrivalent", "nine-valent", and "no preference". A categorical variable was created to indicate parents' preference for each type of HPV vaccine, with 0 indicating "no preference", 1 indicating "bivalent", 2 indicating "quadrivalent", and 3 indicating "nine-valent". The survey also asked parents if they prefer domestic bivalent HPV vaccine free of charge fixed subsidy but free choices of vaccine type, or no preference. We created a categorical variable to indicate parents' preference for each vaccination strategy, with 0 indicating "no preference", 1 indicating "preference for free domestic vaccine", and 2 indicating "preference for subsidy".

### 2.3. Other variables

The key explanatory variable was the children's age. We categorized children's age into three groups (9–12, 13–14, versus 15 years old) to reflect the direct beneficiaries of the free vaccination program (13–14 years old) and indirect beneficiaries (9–12 and 15 years old).

Parents' socio-demographic characteristics included the relationship with children (father versus mother), age (35 and below, 36–40, 41–45, versus 46 and above), educational level (primary school and below, junior or senior high school, undergraduate and above), marital status (married versus others), work industry (public sectors or institutions, business industry, production-manufacturing industry, versus others), annual household income (in Chinese Yuan, less than 100,000, 100,000–200,000, 200,001–400,000, more than 400,000), and HPV vaccination status (the survey asked "whether you or your spouse vaccinated against HPV").

## 2.4. Statistical analysis

We first rated reasons for parents to vaccinate and not vaccinate their children in all samples and by different children's age groups. We then limited our sample to parents who have not yet vaccinated their children. We reported percentages of parents' preference for each type of HPV vaccine and vaccination strategy and conducted Pearson Chi-square tests to compare percentage differences among parents of girls aged 9–12, parents of girls aged 13–14, and parents of girls aged 15. We then conducted a multinomial logistic regression to test parents' preference for HPV vaccine and a multivariable logistic regression to test parents' preference for HPV vaccination strategy, all by children's age group, controlling for parents' socio-demographic characteristics mentioned above. In the model for parents' preference for HPV vaccine type, the dependent variable was a categorical variable indicating parents' preference for each type of HPV vaccine (i.e., bivalent, quadrivalent, and nine-valent), with the base outcome being the bivalent vaccine; parents who have no preference for HPV vaccine type were excluded from the analysis. In the model for parents' preference for HPV vaccination strategy, the dependent variable was the dummy variable indicating parents preferring free domestic bivalent HPV vaccine over fixed subsidy with free choices of vaccine type; parents who have no preference for HPV vaccination strategy were excluded from the analysis. The independent variables of both models included children's age group and parents' socio-demographic characteristics. Odds ratios (ORs) or relative risk ratios (RRRs) and their corresponding 95 % confidence intervals (CIs) were reported.  $P < 0.05$  with two-tail tests was considered statistically significant. All analyses were performed using Stata version 17.0 (StataCorp Inc., Chicago, USA).

## 2.5. Ethical approval

This study was approved by the Institutional Review Board of the Shenzhen Center for Disease Prevention and Control (2020055A). The participants provided their informed consent to participate in this study.

## 3. Results

A total of 5,281 participants completed the survey. We excluded participants who were residing outside Guangdong province ( $N = 136$ ), relatives of children ( $N = 176$ ), and parents of children aged below 9 or above 15 ( $N = 2$ ). The final sample consists of 4,967 parents (including 1,837 fathers and 3,130 mothers) with children aged 9–15 residing in Guangdong province.

### 3.1. Characteristics of study participants

Table 1 shows the characteristics of the study sample. The majority (83.0 %) of sample parents were aged 40 and below, 36.9 % had a junior or senior high school diploma, more than half (52.8 %) had an undergraduate or above degree, 93.8 % were married, 32.6 % were public sector or institution workers, 28.4 % worked in the business industry, 22.4 % worked in production-manufacturing industry, 63.3 % had an annual household income below 200,000 Chinese Yuan, and 59.8 % reported their spouse or themselves have received HPV vaccination. Of all 4,967 respondents, 803 (16.2 %) have children aged 13–14 and 417 (8.4 %) have children aged 15.

### 3.2. Reasons for parents to vaccinate and not vaccinate their children by children's age group

Table 2 presents reasons for parents to vaccinate and not vaccinate their children by children's age group. Among 2,375 parents who have vaccinated their children, the top three reasons to vaccinate their children were a family history of cervical disease (39.1 %), recommended by family members (37.5 %), and recommended by doctors (29.2 %). In the

**Table 1**

Socio-demographic characteristics of study participants in Guangdong province, China, 2022.

	Frequency (%)
<b>Total</b>	4,967(100.0)
<b>Parents' Characteristics</b>	
<b>Relationship with children</b>	
Father	1,837(37.0)
Mother	3,130(63.0)
<b>Age</b>	
35 and below	2,515(50.6)
36–40	1,610(32.4)
41–45	636(12.8)
46 and above	206(4.2)
<b>Educational level</b>	
Primary school and below	512(10.3)
Junior or senior high school	1,834(36.9)
Undergraduate and above	2,621(52.8)
<b>Marital status</b>	
Married	4,660(93.8)
Others	307(6.2)
<b>Workplace</b>	
Public sectors or institutions	1,618(32.6)
Business Industry	1,411(28.4)
Production-manufacturing industry	1,115(22.4)
Others	823(16.6)
<b>Annual household income (in Chinese Yuan)</b>	
Less than 100,000	1,349(27.2)
100,000–200,000	1,792(36.1)
200,001–400,000	1,243(25.0)
More than 400,000	583(11.7)
<b>HPV vaccination status</b>	
Vaccinated	2,971(59.8)
Not vaccinated	1,996(40.2)
<b>Children's Information</b>	
<b>Age</b>	
9–12	3,747(75.4)
13–14	803(16.2)
15	417(8.4)

Note: Study participants were 4,967 parents of girls aged 9–15 residing in Guangdong province, China.

children's age subgroup, the main reasons for parents to vaccinate their children are consistent with the overall, the majority of parents of children aged 15 reported that they vaccinate their children as recommended by family members (44.3 %). Among 2,610 parents who have not yet vaccinated their children, the top three reasons to not vaccinate their children were children's age not qualified for vaccination (52.1 %), shortage of HPV vaccine supply (48.7 %), and too expensive to get a HPV vaccine (25.5 %). Children's age was the most rated reason among parents of children aged 9–12 (55.2 %), vaccine supply shortage was the most rated reason among parents of children aged 13–14 (55.4 %) and 15 (52.9 %).

### 3.3. Parents' preference for HPV vaccine type and vaccination strategy by children's age group

Table 3 presents parents' preference for HPV vaccine type and vaccination strategies among parents who have not yet vaccinated their children by children's age group. Of the 2,610 responding parents who have not yet vaccinated their children, the majority of responding parents reported that they preferred the nine-valent vaccine for their daughters (1,772, 67.9 %), followed by quadrivalent vaccine (210, 8.0 %), and the least choice was the bivalent vaccine (193, 7.4 %). In terms of HPV vaccination strategy, 1,025 (39.3 %) parents preferred free domestic bivalent HPV vaccine provided over fixed subsidy but with free choices of vaccine type (1,516, 58.1 %). We found that parents of children aged 13–14 (5.2 %) were the least to prefer bivalent vaccine to vaccinate their children as compared to parents of children aged 9–12 (8.1 %) and parents of children aged 15 (6.2 %). In contrast, more parents of children aged 13–14 (41.3 %) prefer free domestic bivalent

**Table 2**

Reasons for parents of children aged 9–15 in Guangdong province, China to vaccinate and not vaccinate their children with human papillomavirus by children's age group, 2022.

	Total	Children's Age		
		9–12	13–14	15
	<b>Frequency (%)</b>			
<b>Parents who have vaccinated their children</b>	<b>2,357 (47.5)</b>	1866 (79.2)	299 (12.7)	192 (8.2)
<b>Reasons for parents to vaccinate their children</b>				
Family history of cervical disease	921 (39.1)	727 (39.0)	138 (46.2)	56 (29.2)
Recommended by family members	884 (37.5)	683 (36.6)	116 (38.8)	85 (44.3)
Recommended by doctors	688 (29.2)	532 (28.5)	105 (35.1)	51 (26.6)
HPV vaccination being recognized by peers	399 (16.9)	304 (16.3)	68 (22.7)	27 (14.1)
To prevent them from human papillomavirus infection	296 (12.6)	226 (12.1)	42 (14.0)	28 (14.6)
<b>Parents who have not vaccinated their children</b>	<b>2,610 (52.5)</b>	1881 (72.1)	504 (19.3)	225 (8.6)
<b>Reasons for parents to not vaccinate their children</b>				
Children's age not qualified for vaccination	1,359 (52.1)	1,038 (55.2)	224 (44.4)	97 (43.1)
Shortage of HPV vaccine supply	1,270 (48.7)	872 (46.4)	279 (55.4)	119 (52.9)
HPV vaccine is too expensive	666 (25.5)	454 (24.1)	146 (29.0)	66 (29.3)
Concern about the safety of the vaccine	475 (18.2)	349 (18.6)	90 (17.9)	36 (16.0)
Concern about the effectiveness of the vaccine	356 (13.6)	261 (13.9)	69 (13.7)	26 (11.6)
Children not willing to be vaccinated	224(8.6)	154 (8.2)	44(8.7)	26 (11.6)
Children's health condition not able to be vaccinated	190(7.3)	153 (8.1)	26(5.2)	11(4.9)

Note: The question asked reasons for parents to vaccinated and not vaccinate were multiple choices in the survey.

**Table 3**

Descriptive analysis of preference for HPV vaccine type and vaccination strategy to vaccinate their children among parents of children aged 9–15 in Guangdong province, China, 2022.

	Total	Children's Age			P-value
		9–12	13–14	15	
	<b>Frequency (%)</b>				
<b>Parents' preference for HPV vaccine type</b>					0.001
Bivalent	193 (7.4)	153 (8.1)	26(5.2)	14(6.2)	
Quadrivalent	210 (8.1)	158 (8.4)	38(7.5)	14(6.2)	
Nine-valent	1,772 (67.9)	1,291 (68.6)	337 (66.9)	144 (64.0)	
No preference	435 (16.7)	279 (14.8)	103 (20.4)	53 (23.6)	
<b>HPV vaccination strategy</b>					0.032
Free domestic bivalent vaccine	1,025 (39.3)	749 (39.8)	208 (41.3)	68 (30.2)	
Fixed subsidy with free choices of vaccine type	1,516 (58.1)	1,078 (57.3)	287 (56.9)	151 (67.1)	
No preference	69(2.6)	54(2.9)	9(1.8)	6(2.7)	

Note: The analysis was limited in parents who have not vaccinated their children. P-values were from Pearson Chi-square tests.

vaccine than parents of children aged 9–12 (39.8 %) and parents of children aged 15 (30.2 %).

**3.4. Factors associated with parents' preference for HPV vaccine type and vaccination strategy to vaccinate their children**

Table 4 and 5 present the results from the logistic regression of

**Table 4**

Multinomial logistic regression analysis of preference for the HPV vaccine type to vaccinate their children among parents of children aged 9–15 in Guangdong province, China, 2022.

	Prefer quadrivalent to bivalent		Prefer nine-valent to bivalent	
	RRR (95 % CI)	P-value	RRR (95 % CI)	P-value
<b>Relationship with children</b>				
Father	1.00		1.00	
Mother	1.23 (0.80,1.90)	0.336	2.46 (1.76,3.45)	<0.001
<b>Age</b>				
35 and below	1.00		1.00	
36–40	0.75 (0.47,1.19)	0.223	1.08 (0.76,1.52)	0.681
41–45	1.70 (0.82,3.54)	0.157	2.41 (1.32,4.43)	0.004
46 and above	0.81 (0.24,2.73)	0.729	2.06 (0.78,5.42)	0.144
<b>Age of children</b>				
15	1.00		1.00	
9–12	1.17 (0.51,2.68)	0.708	1.08 (0.58,2.02)	0.806
13–14	1.52 (0.61,3.77)	0.372	1.37 (0.68,2.76)	0.385
<b>Educational level</b>				
Primary school and below	1.00		1.00	
Junior or senior high school	0.44 (0.22,0.86)	0.016	1.08 (0.60,1.95)	0.786
Undergraduate and above	0.71 (0.36,1.41)	0.331	3.24 (1.79,5.87)	<0.001
<b>Marital status</b>				
Others	1.00		1.00	
Married	0.52 (0.24,1.11)	0.092	1.10 (0.56,2.16)	0.791
<b>Workplace</b>				
Public sectors or institutions	1.00		1.00	
Business Industry	0.76 (0.45,1.28)	0.305	0.83 (0.55,1.24)	0.357
Production-manufacturing industry	1.02 (0.56,1.86)	0.944	1.02 (0.62,1.66)	0.951
Others	0.56 (0.28,1.12)	0.103	1.40 (0.84,2.32)	0.198
<b>Annual Household income (in Chinese Yuan)</b>				
Less than 100,000	1.00		1.00	
100,000–200,000	0.88 (0.53,1.46)	0.625	0.85 (0.57,1.26)	0.412
200,001–400,000	0.60 (0.34,1.06)	0.078	0.64 (0.41,0.98)	0.041
More than 400,000	0.71 (0.26,1.90)	0.491	1.67 (0.78,3.56)	0.186
<b>HPV vaccination status</b>				
Not vaccinated	1.00		1.00	
Vaccinated	0.37 (0.24,0.57)	<0.001	0.70 (0.51,0.96)	0.026
Observation	2,175			

Note: The analysis was limited in parents who have not vaccinated their children. The dependent variable was a categorical variable indicating parents' preference for each type of HPV vaccine (i.e., bivalent, quadrivalent, and nine-valent), with the base outcome being the bivalent vaccine; parents who have no preference for HPV vaccine type were excluded from the analysis.

**Table 5**

Multivariable logistic regression analysis of preference for the HPV vaccination strategy to vaccinate their children among parents of children aged 9–15 in Guangdong province, China, 2022.

	Prefer free domestic bivalent vaccine to fixed subsidy with free choices of vaccine type	
	OR (95 %CI)	P-value
<b>Relationship with children</b>		
Father	1.00	
Mother	0.82(0.67,1.00)	0.050
<b>Age</b>		
35 and below	1.00	
36–40	1.02(0.84,1.24)	0.862
41–45	0.96(0.74,1.24)	0.734
46 and above	1.08(0.73,1.60)	0.705
<b>Age of children</b>		
15	1.00	
9–12	1.73(1.25,2.40)	0.001
13–14	1.59(1.12,2.26)	0.009
<b>Educational level</b>		
Primary school and below	1.00	
Junior or senior high school	1.40(0.94,2.08)	0.094
Undergraduate and above	0.84(0.57,1.24)	0.393
<b>Marital status</b>		
Others	1.00	
Married	1.06(0.75,1.49)	0.742
<b>Workplace</b>		
Public sectors or institutions	1.00	
Business industry	0.78(0.63,0.98)	0.031
Production-manufacturing industry	0.73(0.56,0.95)	0.019
Others	0.86(0.68,1.09)	0.215
<b>Annual household income (in Chinese Yuan)</b>		
Less than 100,000	1.00	
100,000–200,000	0.72(0.59,0.88)	0.002
200,001–400,000	0.42(0.32,0.53)	<0.001
More than 400,000	0.37(0.27,0.51)	<0.001
<b>HPV vaccination status</b>		
Not vaccinated	1.00	
Vaccinated	0.73(0.61,0.87)	<0.001
Observations	2,541	

Note: The analysis was limited in parents who have not vaccinated their children. The dependent variable was the dummy variable indicating parents preferring free domestic bivalent HPV vaccine over fixed subsidy with free choices of vaccine type; parents who have no preference for HPV vaccination strategy were excluded from the analysis.

parents' preference for HPV vaccine type and vaccination strategy among parents who have not yet vaccinated their children. After controlling for parents' characteristics, we did not find significant difference in parents' preference for HPV vaccine type by children's age. The multinomial logistic regression shows that mothers were 2.46 (95 % CI, 1.76–3.45,  $P < 0.001$ ) times more likely than fathers to prefer the nine-valent vaccine to the bivalent vaccine. Parents with junior or senior high school diploma were 0.44 (95 % CI, 0.22–0.86,  $P = 0.016$ ) times less likely than parents with only primary school or below education level prefer the quadrivalent to bivalent, and parents with undergraduate or higher educational level were 3.24 (95 % CI, 1.79–5.87,  $P < 0.001$ ) times more likely than parents with only primary school or below education level prefer the nine-valent to bivalent.

The multivariable logistic regression shows that mothers were 0.82 (95 % CI, 0.67–1.00,  $P = 0.050$ ) times less likely than fathers to prefer domestic HPV vaccine over subsidy with free choices of vaccine type. Parents of children aged 13–14 and parents of children aged 9–12 were more likely than parents of girls aged 15 to prefer free domestic HPV vaccine over subsidy with free choices of vaccine type (parents of children aged 13–14: OR = 1.59, 95 % CI, 1.12–2.26,  $P = 0.009$ ; parents of children aged 9–12: OR = 1.73, 95 % CI, 1.25–2.40,  $P = 0.001$ ). Compared with parents working in public sectors or institutions, parents working in business industry or production-manufacturing industry

were less likely to prefer free domestic HPV vaccine over subsidy with free choices of vaccine type (parents working in business industry: OR = 0.78, 95 % CI, 0.63–0.98,  $P = 0.031$ ; parents working in production-manufacturing industry: OR = 0.73, 95 % CI: 0.56–0.95,  $P = 0.019$ ). Parents with higher household income were less likely to prefer free domestic HPV vaccine over subsidy with free choices of vaccine type. (Compared with parents' household income less than 100,000 Chinese Yuan, parents' household income between 100,000 to 200,000 Chinese Yuan: OR = 0.72, 95 % CI, 0.59–0.88,  $P = 0.002$ ; parents' household income between 200,001 to 400,000 Chinese Yuan: OR = 0.42, 95 % CI, 0.32–0.53,  $P < 0.001$ ; parents' household income more than 400,000 Chinese Yuan: OR = 0.37, 95 % CI, 0.27–0.51,  $P < 0.001$ ). Parents who were vaccinated against HPV were 0.73 (95 % CI, 0.61–0.87,  $P < 0.001$ ) times less likely than parents who were not vaccinated to prefer free domestic HPV vaccine over subsidy with free choices of vaccine type.

#### 4. Discussion

To promote the elimination of cervical cancer and improve HPV vaccination coverage among age-eligible girls, many cities in China are experimenting with HPV vaccination programs for girls aged 13–14, either providing free domestic bivalent vaccines or providing subsidies with free choices of vaccine type. The currently implemented policy in Guangdong province is to offer free domestic HPV vaccination for girls aged 13–14. Our study investigated preference for HPV vaccine type and vaccination strategy among Chinese parents of girls aged 9–15 to vaccinate their daughters.

Our findings indicated that the majority of parents of children aged 9–15 prefer the nine-valent vaccine, while only a few parents prefer the quadrivalent vaccine or the bivalent vaccine to vaccinate their daughters. This finding is consistent with a prior study that also examined parent's preference for the type of HPV vaccine to vaccinate their daughters (Lin et al., 2021). Our study also indicated that overall, parents of children aged 9–15 were more likely to prefer fixed subsidy with free choices of vaccine type over free domestic bivalent vaccine to vaccinate their daughters, and in particular, parents of children aged 13–14 and parents of children aged 9–12 were more likely than parents of children aged 15 to prefer free domestic HPV vaccine over subsidy with free choices of vaccine type.

Our findings call for policy attention that this free vaccination policy implemented in Guangdong province may not be the most efficient in encouraging parents to vaccinate their children, especially among parents of children in higher ages and not yet been vaccinated with HPV, as these parents in our survey were less likely to prefer free domestic bivalent vaccination approach. Future research is warranted to evaluate the effect of the current vaccination policy on improving the HPV vaccination rate among age-eligible girls. If indeed the policy was less effective, policymakers may need to reconsider if they should adjust the vaccination policy to allow self-selection of HPV vaccine type with subsidies instead of directly offering free but designated HPV vaccine.

However, it should be noted that Guangdong province ranked number 1 for the level of Gross Domestic Product (GDP) among all other provinces in 2021, which may contribute to part of the reasons that parents prefer self-selecting the type of HPV vaccines with subsidies rather than the free domestic bivalent vaccine. These parents may concern more about the availability of the vaccine type they prefer than its vaccination costs. Future research is warranted to survey parents in other areas of China with different GDP levels to understand parents' preferences roundly.

The reasons that parents do not prefer domestic HPV vaccine could be due to their limited knowledge level of various HPV vaccine types. Because the nine-valent vaccine is much more expensive than the domestic bivalent vaccine, it may convey a stereotype among parents that the more expensive the better. In countries like the United States, the nine-valent vaccine has already become the only available type of HPV vaccines on the market, and vaccinations are covered in most health

insurance plans. However, in developing countries and countries that have not yet included HPV vaccination in the national vaccination program, the domestic bivalent vaccine is still considered the most cost-effective among other types of HPV vaccine for school-age girls that the government could afford to provide for free (Zhou et al., 2022; Zou et al., 2020). There were numerous studies indicating that the domestic bivalent vaccine has similar effects to the imported bivalent vaccine (Qiao et al., 2020; Zhu et al., 2017).

We proposed several strategies to further promoting HPV vaccination among age-eligible girls. First, improving the knowledge about the effectiveness and safety of different types of HPV vaccine among parents of girls aged 9–15 and who have not yet been vaccinated with HPV through health education activities may help facilitate parents' attitude towards vaccinating their girls. Studies have indicated parents' attitudes towards the HPV vaccine were associated with knowledge level (Sitar-esmi et al., 2020; Smolarczyk et al., 2022). Second, since vaccination is offered through community health centers in China, family doctors in community health centers could play a role in encouraging parents to vaccinate their children with the domestic vaccine (Poon et al., 2021; Riedesel et al., 2005). When parents accompany their children in doctor visits or complete annual physical checks, family doctors can offer vaccination recommendations and prescribe vaccination for children who would like to be vaccinated with HPV. Third, schools can also take the lead in advocating and encouraging their students to vaccinate with HPV. The local center for disease prevention and control can offer helps to organize campus vaccination activity and coordinate doctors and nurses to provide vaccination services on campus.

This study has several limitations. First, this study may suffer from selection bias. Since the survey was conducted online and distributed via a smartphone application, only parents who had a smartphone and happened to reach the survey and those who are interested in the topic and willing to answer the questionnaire would participate in the survey. Second, because our study sample was residents of Guangdong province, which has a relatively higher GDP level compared to the national average, our results may be generalized to other areas with similar or higher income levels but may not be generalized to areas with lower income levels. Third, the survey did not ask parents about their children's gender, and thus we cannot identify if parents had girls or boys or both in our analysis. However, it is expected that parents of girls will be more motivated to answer the survey given the fact that the HPV vaccination in China is only available to female.

#### CRedit authorship contribution statement

**Pei Xie:** Formal analysis, Writing – original draft. **Jie Zhao:** Investigation, Writing – original draft. **Xiaoheng Li:** Writing – review & editing. **Xuan Zou:** Writing – review & editing. **Gang Liu:** Conceptualization, Investigation, Data curation. **Xinxin Han:** Conceptualization, Methodology, Writing – review & editing, Supervision, Project administration.

#### Declaration of Competing Interest

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

#### Data availability

Data will be made available on request.

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