



A nationwide post-marketing survey of knowledge, attitudes and recommendations towards human papillomavirus vaccines among healthcare providers in China

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ABSTRACT

Since licensure of human papillomavirus (HPV) vaccine in mainland China, little research has been conducted about healthcare providers' (HCPs) understanding and recommendation of HPV vaccine. A multi-stage convenience sample of Chinese HCPs ($N = 5270$) were surveyed, involving obstetrician-gynecologists, HCPs from Division of Expanded Program on Immunization (DEPI), Community Health Center (CHC) and other non-HPV closely related professions. Binary logistic regression was conducted to explore factors associated with knowledge and recommendation behaviors. Overall, HCPs showed basic HPV/HPV vaccine knowledge with median (interquartile range) score at 9.5 (7.5–11.6) out of 16 and relatively high recommendation behavior (74.8%). Identified knowledge gaps among HCPs included risk factors of HPV infection, best time to vaccinate, prophylactic functions of HPV vaccine and especially classification of low-risk and high-risk types. Profession-specific analysis in individual knowledge item showed HCPs from CHC were suboptimal on HPV while obstetrician-gynecologists were less competent on HPV vaccine knowledge. Obstetrician-gynecologists also recommended vaccination less frequently than HCPs from DEPI and CHC. Besides being key predictors of recommendation practice (2.74, 95% CI: 2.34–3.21), knowledge shared independent determinants with recommendation behavior on age and ethnicity and additionally associated with education and title by itself. Findings highlight overall and profession-specific gaps on HPV and HPV vaccine knowledge and recommendation practice. Future education and training efforts should be profession-niche-targeting and focus much on HCPs with lower title or education background and from minorities.

1. Introduction

Human papillomavirus (HPV) is one of the most common sexually transmitted infections worldwide, with a few low risk types causing

benign warts and high risk types responsible for cancers of the cervix, vulva, vagina, penis, anus and oropharynx (Stone, 1995; Bansal et al., 2016). In 2018, 690,000 HPV attributable cancer cases were estimated, accounting for approximately 3.8% of the total new cancer cases

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globally (de Martel et al., 2020). China contributes to about 18.7% of the global burden of cervical cancer and the incidence and death have more than tripled from 2005 to 2015 (de Martel et al., 2020; Lu et al., 2020). The burden of other HPV-attributable anogenital cancers have also increased to varying degrees (Lu et al., 2020).

HPV vaccine is a promising step towards lowering the corresponding disease burden and have been marketed globally since 2006. The real-world effectiveness of HPV vaccines has been documented in countries with HPV National Immunization Program (NIP) (Drolet et al., 2019). However, HPV vaccines were only available in mainland China until July 2016. Due to the late approval and unavailability in the NIP, the current HPV vaccine uptake in China is far from optimistic. Reported awareness and knowledge towards HPV or HPV vaccines are also lower than those in developed countries (López et al., 2020; Taebi et al., 2019; Zhang et al., 2016).

Recommendations from healthcare providers (HCPs) are major facilitators of both HPV vaccine uptake among general population and parental intention to vaccinate their children (Loke et al., 2017; Reiter et al., 2013a; Johnson et al., 2017; Kisaakye et al., 2018; Dorell et al., 2011; Perkins et al., 2013; Reiter et al., 2013b). Meanwhile, HPV-related knowledge is a crucial determinant of HCP's confidence and willingness for HPV vaccine recommendation (Malo et al., 2014; Rosen et al., 2016; Hopkins et al., 2009). However, relatively little research on HCPs' knowledge, attitudes and recommendation towards HPV vaccine has been carried out in mainland China since HPV licensure and all published studies were mainly conducted in medical students and majority of them were regional-based studies targeting several regions in China, without a nationally representative study (Chen et al., 2020; Liu et al., 2020a).

In current healthcare practice in China, HCPs from department of obstetrics and gynecology (obstetrician-gynecologist) in hospitals, HCPs from Division of Expanded Program on Immunization (DEPI) affiliated to Chinese Center for Disease Control and Prevention (CDC) and HCPs from Community Health Center (CHC) are three major professions routinely situated to public HPV vaccine recommendation or inoculation. Consequently, it is essential to assess whether these HCP professions are adequately equipped with the knowledge and status of their recommendation practice of HPV vaccines. Previous study also demonstrated role of HCPs from other professions in discussing HPV and HPV vaccine queries during patients' clinic visits (Dodd et al., 2017).

Therefore, we conducted a nationwide post-marketing survey aiming to describe the current status of the overall and profession-specific knowledge, attitudes and recommendation on HPV and HPV vaccines among HCPs in mainland China. Secondly, the potential factors associated with knowledge and recommendation behaviors were also assessed.

2. Materials and methods

2.1. Study design and settings

This is a national level cross-sectional survey conducted by multi-stage convenience sampling for HCPs from seven geographical regions (east, central, north, northeast, northwest, south and southwest) of mainland China. At least 3 provinces were selected from each geographical region and at least 2 representative cities were included in each selected province for participant recruitment. The study was approved by the Institutional Review Board of the National Cancer Center/Cancer Hospital, Chinese Academy of Medical Sciences and Peking Union Medical College. Anonymous informed consents were obtained from all respondents. A target sample size of 4000 was pre-determined based on the ability to estimate an HPV awareness rate of $50\% \pm 1.5\%$ with 95% precision.

2.2. Questionnaire

The questionnaire was developed by a research team consisting of epidemiologists, HCPs from DEPI and gynecologists based on information from previous studies conducted by the research team (Wang et al., 2014; Wang et al., 2015). The draft questionnaire was then tested on two HCPs, one obstetrician-gynecologist and one HCP from DEPI. They were first asked to complete the questionnaire alone. After finishing the survey, they were interviewed on their understanding of each question and any difficulties met when completing the survey. Questionnaires were finalized after adjusting the contents and wording based on the feedback from these interviewees. The questionnaire included 55 questions covering 5 domains: (i) Socio-demographic characteristics, (ii) Awareness of HPV and HPV vaccine, (iii) Knowledge of HPV and HPV vaccine, (iv) Willingness and behavior of recommending HPV vaccination, (v) The opinions on the appropriate population for HPV vaccination. The contents evaluating HPV knowledge covered diseases attributable to HPV, HPV transmission routes, risk factors of HPV infection and classification of high risk and low risk types. The contents regarding HPV vaccine knowledge included meaning of "valent", necessity of cervical screening after vaccination, best time to get vaccinated and function of HPV vaccine. According to expert panel review, one point was assigned to every single-option question and three points were assigned to every multiple-option question. For multiple-option questions, the score assigned to each correct option was three divided by the number of correct options in this question. Total knowledge score was calculated by summing the score of correct responses on HPV and HPV vaccines to give a maximum score of 16. Opinions on HPV vaccines included perceived appropriate gender, population characteristics and education stage for HPV vaccination as well as the knowledge information source.

2.3. Data collection

The survey was administered between April 2019 and October 2019. Data were collected and managed using Research Electronic Data Capture (REDCap), an electronic data capture tool hosted at Cancer Hospital, Chinese Academy of Medical Sciences & Peking Union Medical College (Harris et al., 2009; Harris et al., 2019). REDCap is a secure, web-based software platform designed to support data capture for research studies, providing 1) an intuitive interface for validated data capture; 2) audit trails for tracking data manipulation and export procedures; 3) automated export procedures for seamless data downloads to common statistical packages; and 4) procedures for data integration and interoperability with external sources. The Quick Response (QR) code was generated through REDCap and distributed by sub-investigators from seven geographical regions to eligible respondents via convenience sampling. Through scanning the QR code, respondents were guided to finish the electronic questionnaire. Before accessing the questionnaire, they were required to provide informed consent by clicking on the agreement button after reviewing the informed consent form (ICF). Questionnaires filled out were directly sent to the backstage data center of REDCap.

2.4. Data analysis

Sociodemographic characteristics of the responded HCPs were described. HCPs were divided into four groups according to professions: HCPs from DEPI; HCPs from CHC; obstetrician-gynecologist, and other HCPs. "Obstetrician-gynecologist" included healthcare providers working in department of Obstetrics and Gynecology or Women's Health and Family Planning. "Other HCPs" included healthcare providers from non-immunization division of CDC, non-obstetrician-gynecologist clinicians, nurses and researchers in hospitals. Areas were recoded into Eastern, Central, and Western China according to geospatial locations of provinces.

Overall and profession-specific awareness of HPV and HPV vaccine,

knowledge on each individual item as well as the willingness and behavior of recommending HPV vaccination were presented with frequency and percentage. The knowledge score of HPV and HPV vaccine was summarized with median and interquartile range (IQR). Difference on awareness, knowledge and recommendation across the four HCP profession groups were compared using Chi-square tests on dichotomous responses and Kruskal-Wallis tests on knowledge score as knowledge score was not normally distributed. When describing HCPs' opinions on the appropriate population to receive HPV vaccination, HCPs were dichotomized into two categories: (1) HCPs related to HPV/HPV vaccine (including Obstetrician-gynecologist, HCPs from DEPI or CHC) and (2) other HCPs.

Binary logistic regression was conducted to explore factors (including area, age group, sex, ethnicity, education, profession, title) associated with HPV and HPV vaccine knowledge score (HPV and HPV vaccine knowledge score \leq median; HPV and HPV vaccine knowledge score $>$ median) among respondents who heard of both HPV and HPV vaccine, and factors related to recommendation behavior of HPV vaccination (yes; no) among respondents who have heard of HPV vaccine. Besides above stated demographic variables, HPV and HPV vaccine knowledge score was also included in the multivariate logistic regression model for recommendation behavior of HPV vaccination. Adjusted OR (aOR) and corresponding 95% CI were presented. Analyses were performed using R software, version 3.5.2.

3. Results

3.1. Demographics

Among 6260 records returned, 990 were excluded including 309 without informed consent, 641 created but not submitted, 4 with missing values on province, HPV awareness or professions, and 36 with contradictory information during logical check. A total of 5270 were included in the final analysis. Table 1 showed the sample characteristics. The majority of the respondents were no more than 40 years old (62.9%,

Table 1
Sociodemographic characteristics (N = 5270).

Characteristic	Respondents (n)	Respondents (%)
Geographic area		
Eastern	2792	53.0
Central	1671	31.7
Western	807	15.3
Age (years) ^a		
<40	3316	62.9
\geq 40	1895	36.0
Sex		
Male	832	15.8
Female	4438	84.2
Ethnicity		
Han	4255	80.7
Minority	1015	19.3
Highest education		
High school and below	250	4.7
Professional degree	1579	30.0
Bachelor	2736	51.9
Master and above	705	13.4
Profession		
HCPs from DEPI	545	10.3
HCPs from CHC	464	8.8
Obstetrician-gynecologist	1582	30.0
Other HCPs	2679	50.8
Title ^b		
Junior	2556	48.5
Middle	1729	32.8
Associate senior/senior	984	18.7

HCPs: Healthcare Providers; DEPI: Division of Expanded Program on Immunization; CHC: Community Health Center.

^a 59 missing values in HCP age.

^b One missing value in HCP title.

$n = 3316$), female (84.2%, $n = 4438$) and had an education degree higher than high school (95.3%, $n = 5020$). Around half of the respondents were from Eastern China (53.0%, $n = 2792$) and from professions working closely with HPV and HPV vaccination (49.2%, $n = 2591$).

3.2. Awareness

Table 2 showed HPV and HPV vaccine awareness by HCP profession groups. Overall, majority of respondents had heard of HPV (94.6%, $n = 4988$) and HPV vaccine (83.9%, $n = 4422$). Both HPV and HPV vaccine awareness differed by professions. Generally, HCPs from DEPI showed higher awareness of HPV (98.7%) and HPV vaccine (96.9%) compared with the rest of three professions.

3.3. Knowledge

The knowledge score of HPV and HPV vaccine by profession groups was shown in Table 2. Out of a maximum knowledge score of 16, the overall median (IQR) knowledge score was 9.5 (7.5–11.6) and varied across professions. The obstetrician-gynecologist (median:10.8) and HCPs from DEPI (median: 10.2) ranked first and second respectively.

Table 3 showed the differences in individual knowledge items across HCP professions. The overall correct response rate was higher than 65% on most of the basic knowledge items. HCPs from DEPI were predominant on all items except on detailed risk stratifications. Obstetrician-gynecologist were more competent on HPV related questions, while HCPs from CHC showed relative advantage on HPV vaccine related items. All professions shared most significant knowledge incompetency on identification of specific high-risk and low-risk HPV strains. Whilst 70.6% of respondents reported knowing the meaning of valent, only around half of the HCPs understood that HPV could actually be classified into low-risk types and high-risk types. The correct response rate regarding the most virulent oncogenic types (HPV 16 and HPV 18) varied between 24.2% and 61.5%. This was even lower on the other five common high-risk types (HPV31, 33, 45, 52, 58) covered in 9-valent HPV vaccine, ranging from 4.5% to 20.4%. Other knowledge gaps included risk factors of HPV infection, best time for vaccination and prophylactic functions of HPV vaccine.

Among the 4308 respondents who have heard of both HPV and HPV vaccine, multivariate logistic regression showed that obstetrician-gynecologists (aOR = 3.52, 95% CI: 3.02–4.11), HCPs from DEPI (aOR = 3.50, 95% CI: 2.83–4.33) and HCPs from CHC (aOR = 2.39, 95% CI: 1.90–3.00) were 3.5, 3.5 and 2.4 times more likely to have higher HPV and HPV vaccine knowledge score than “other” HCPs (Table 4). Other factors associated with HPV and HPV vaccine knowledge scores included area, age, education background, title and ethnicity (Table 4).

3.4. Vaccination recommendation willingness and behavior

Among the 4422 respondents who have heard of HPV vaccine, the majority of respondents (94.8%, $n = 4192$) reported willingness to recommend HPV vaccination while fewer (74.8%, $n = 3306$) have ever recommended (Table 2). Multivariate logistic regression showed that HCPs from CHC (aOR = 2.94, 95% CI: 2.17–4.04), HCPs from DEPI (aOR = 2.47, 95% CI: 1.87–3.32) and obstetrician-gynecologists (aOR = 1.31, 95% CI: 1.10–1.55) were 2.9, 2.5 and 1.3 times more likely than “other” HCPs to recommend HPV vaccination (Table 4). HCPs with more competent HPV and HPV vaccine knowledge (aOR = 2.74, 95% CI: 2.34–3.21) were more likely to recommend others to receive the HPV vaccination. Other factors independently related to recommendation behavior included area, age, ethnicity, and education (Table 4).

3.5. Opinion on HPV vaccination

More than half of respondents (58.9%, $n = 2606$) believed that only

Table 2HPV and HPV vaccine awareness (n/%), knowledge (median/IQR^a) and recommendation (n/%) among all professional groups.

Variable	Overall	HCPs from DEPI	HCPs from CHC	Obstetrician-gynecologist	Other HCPs	P value
Awareness^a						
Whether heard of HPV (n = 5270)	4988 (94.6)	538 (98.7)	447 (96.3)	1539 (97.3)	2464 (92.0)	<0.001
Whether heard of HPV vaccine (n = 5270)	4422 (83.9)	528 (96.9)	423 (91.2)	1410 (89.1)	2061 (76.9)	<0.001
Knowledge^b						
HPV and HPV vaccine knowledge score (n = 4350)	9.5 (7.5–11.6)	10.2 (8.6–12.1)	9.5 (7.9–11.2)	10.8 (8.4–13.1)	8.6 (7.0–10.2)	< 0.001
Recommendation^c						
Whether be willing to recommend others to get HPV vaccination (n = 4422)	4192 (94.8)	511 (96.8)	407 (96.2)	1339 (95.0)	1935 (93.9)	0.023
Whether recommended others to get HPV vaccination (n = 4422)	3306 (74.8)	461 (87.3)	367 (86.8)	1099 (77.9)	1379 (66.9)	<0.001

HCPs: Healthcare Providers; DEPI: Division of Expanded Program on Immunization; CHC: Community Health Center.

^a IQR: Interquartile range.^a Total N (awareness) = 5270, chi-square tests.^b Total N (knowledge) = 4350 only respondents heard of both HPV and HPV vaccine counted in this analysis, Kruskal-Wallis tests.^c Total N (recommendation) = 4422 only respondents heard of HPV vaccine counted in this analysis, chi-square tests.**Table 3**

Correct responses (n/%) to individual knowledge of HPV and HPV vaccine items among all professional groups (n = 5270).

Variable	Overall (n = 5270)	HCPs from DEPI (n = 545)	HCPs from CHC (n = 464)	Obstetrician-gynecologist (n = 1582)	Other HCPs (n = 2679)	P value ^a
HPV infection can cause cervical cancer	4636 (88.0)	521 (95.6)	423 (91.2)	1460 (92.3)	2232 (83.3)	<0.001
HPV infection can cause other diseases except for cervical cancer	3885 (73.7)	452 (82.9)	350 (75.4)	1235 (78.1)	1848 (69.0)	<0.001
HPV can be transmitted through direct sexual contact	4183 (79.4)	474 (87.0)	380 (81.9)	1318 (83.3)	2011 (75.1)	<0.001
Premature sexual intercourse and multiple sex partners are risk factors for HPV infection	3497 (66.4)	408 (74.9)	326 (70.3)	1179 (74.5)	1584 (59.1)	<0.001
HPV can be classified into low-risk and high-risk types	2670 (50.7)	380 (69.7)	261 (56.3)	1108 (70.0)	921 (34.4)	<0.001
HPV 16 and 18 are high-risk types	2161 (41.0)	335 (61.5)	225 (48.5)	952 (60.2)	649 (24.2)	<0.001
HPV 6 and 11 are not high-risk types	1926 (36.5)	273 (50.1)	182 (39.2)	854 (54.0)	617 (23.0)	<0.001
HPV 31, 33, 45, 52 and 58 are high-risk types	552 (10.5)	64 (11.7)	46 (9.9)	322 (20.4)	120 (4.5)	<0.001
Knowing the meaning of “valent”	3722 (70.6)	514 (94.3)	388 (83.6)	1198 (75.7)	1622 (60.5)	<0.001
HPV vaccination can help prevent cervical cancer	4302 (81.6)	523 (96.0)	419 (90.3)	1378 (87.1)	1982 (74.0)	<0.001
Cervical screening is still needed after HPV vaccination	4279 (81.2)	505 (92.7)	392 (84.5)	1390 (87.9)	1992 (74.4)	<0.001
The best time for HPV vaccination is before first sexual intercourse	3668 (69.6)	505 (92.7)	383 (82.5)	1168 (73.8)	1612 (60.2)	<0.001
HPV vaccination could not cure existed HPV infection	3492 (66.3)	445 (81.7)	329 (70.9)	1090 (68.9)	1628 (60.8)	<0.001

HCPs: Healthcare Providers; DEPI: Division of Expanded Program on Immunization; CHC: Community Health Center.

^a Chi-square tests.

“women” needed to be vaccinated against HPV and 40.4% (n = 1786) selected “both men and women” should be vaccinated. Very few respondents perceived only “men” needed to be vaccinated (0.4%, n = 16) or neither men nor women should be vaccinated (0.3%, n = 14).

Fig. 1 showed the answers of respondents to other three multiple survey questions about the perceived appropriate population (Part A, Part B) or education stage (Part C) for HPV vaccination, by dichotomous profession categories (HCPs related to HPV vaccination; other HCPs). Three most frequently cited appropriate groups of women to receive HPV vaccination by both HCPs categories were the same: “sexually active women with multiple partners”, “women with a family history of cervical cancer”, and “sexually active women”. Fewer HCPs selected “Women not yet sexually active” as an appropriate population for vaccination: 69.5% for HPV vaccine-related HCPs and 56.0% for other HCPs (Part A). The distribution of perceived appropriate characteristic groups of men was quite similar (Part B). Both groups of HCPs agreed that “junior high school” was the most appropriate stage to get vaccinated (Part C).

Fig. 2 visualized the sources of information on HPV vaccine by profession categories. For both HCPs related to vaccination and “other” HCPs, over half reported obtaining information through reading medical journals, reviewing WeChat public account and other social media (radio/TV/Newspaper/Magazine/Internet). For HCPs related to HPV and HPV vaccination, attending academic conferences was also a highly cited pathway gaining HPV and HPV vaccine related knowledge.

4. Discussion

To our best knowledge, this is the first nationwide quantitative study to evaluate HCP’s knowledge of HPV and HPV vaccine, attitudes towards and practice of recommendation on HPV vaccination after the licensure in mainland China. In general, HCPs showed basic knowledge on HPV and HPV vaccination and relatively high recommendation behavior. However, some profession-specific gaps and key characteristics on knowledge and recommendation practice were identified to inform future health education efforts.

In the present study, around 95% and 84% of HCPs had heard of HPV and HPV vaccine, respectively, which were higher than the pre-licensure period in mainland China (88% and 63%, respectively) (Zhao et al., 2012). Among HCPs with HPV and HPV vaccine awareness, an adequate basic knowledge was indicated, but still lower than some other countries such as England and New Zealand (Patel et al., 2017; Sherman et al., 2018). This may be due to the late approval and no NIP introduction for HPV vaccines in China.

Knowledge gaps on risk factors of HPV infection, best time to vaccinate, prophylactic functions of HPV vaccine and especially risk stratification on high-risk and low-risk types were identified. The finding that more HCPs reported knowing meaning of valent than identification capacity on high-risk and low-risk HPV strains would merit special attention, since there has been a prevailing misinformation among Chinese general population on “higher valent, higher protection

Table 4
Factors associated with HPV and HPV vaccine knowledge score ($n = 4308$) and HPV vaccination recommendation behavior ($n = 4379$).

Characteristics	HPV and HPV vaccine knowledge score ^a		HPV vaccination recommendation behavior ^b	
	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Area				
Eastern	1 (ref)	1 (ref)	1 (ref)	1 (ref)
Central	0.97 (0.85–1.11)	0.78 (0.67–0.91)	1.38 (1.18–1.62)	1.12 (0.95–1.33)
Western	1.16 (0.98–1.37)	1.09 (0.91–1.31)	1.35 (1.11–1.65)	1.26 (1.02–1.56)
Age group				
<40	1 (ref)	1 (ref)	1 (ref)	1 (ref)
≥40	1.40 (1.24–1.58)	1.25 (1.05–1.49)	1.53 (1.33–1.77)	1.45 (1.19–1.78)
Sex				
Male	1 (ref)	1 (ref)	1 (ref)	1 (ref)
Female	1.06 (0.90–1.24)	1.07 (0.89–1.28)	0.86 (0.71–1.04)	0.93 (0.76–1.15)
Ethnicity				
Han	1 (ref)	1 (ref)	1 (ref)	1 (ref)
Minority	0.54 (0.45–0.63)	0.68 (0.56–0.81)	0.52 (0.44–0.62)	0.70 (0.58–0.84)
Education				
High school and below	1 (ref)	1 (ref)	1 (ref)	1 (ref)
Professional degree	1.34 (0.97–1.86)	1.29 (0.92–1.83)	0.57 (0.39–0.83)	0.59 (0.39–0.87)
Bachelor	2.30 (1.68–3.17)	2.36 (1.68–3.35)	0.79 (0.54–1.13)	0.82 (0.55–1.21)
Master and above	2.72 (1.94–3.84)	3.00 (2.05–4.42)	0.72 (0.48–1.06)	0.72 (0.46–1.11)
Profession				
HCPs from DEPI	3.37 (2.76–4.13)	3.50 (2.83–4.33)	3.45 (2.64–4.58)	2.47 (1.87–3.32)
HCPs from CHC	1.82 (1.47–2.26)	2.39 (1.90–3.00)	3.31 (2.48–4.51)	2.94 (2.17–4.04)
Obstetrician-gynecologist	3.37 (2.92–3.89)	3.52 (3.02–4.11)	1.74 (1.49–2.04)	1.31 (1.10–1.55)
Other HCPs	1 (ref)	1 (ref)	1 (ref)	1 (ref)
Title				
Junior	1 (ref)	1 (ref)	1 (ref)	1 (ref)
Middle	1.51 (1.32–1.73)	1.23 (1.05–1.44)	1.28 (1.09–1.49)	1.01 (0.84–1.20)
Associate senior & senior	2.31 (1.97–2.72)	1.56 (1.24–1.97)	1.42 (1.18–1.72)	0.84 (0.64–1.09)
HPV and HPV vaccine knowledge score				
≤9.50	–	–	1 (ref)	1 (ref)
>9.50	–	–	3.17 (2.74–3.68)	2.74 (2.34–3.21)

HCPs: Healthcare Providers; DEPI: Division of Expanded Program on Immunization; CHC: Community Health Center.

^a Total $N = 4308$ only respondents heard of both HPV and HPV and had valid age information vaccine counted in analysis, chi-square tests and binary logistic regression, significance level: $P < 0.05$.

^b Total $N = 4379$ only respondents heard of HPV vaccine and had valid age information counted in analysis, chi-square tests and binary logistic regression.

on cervical cancer” (Zhang et al., 2019). These knowledge gaps also suggest that most HCPs might only focus on the practical aspects on HPV and HPV vaccination but are incompetent in understanding and explaining the benefits of HPV vaccination. Future education packages or training sessions should pay attention on explaining these knowledge items.

Professions closely related to HPV and HPV vaccine, older age, higher title and education background predict higher knowledge score, while HCPs who are minorities and from central China showed disadvantage. These HCPs characteristics would inform additional attention in future vaccine roll-out activities. It has been indicated a brief

structured presentation and scenario simulations on HPV and HPV vaccines among HCPs have positive short-term effectiveness in improving their knowledge (Chen et al., 2020). Considering that around half of HCPs in China still had a degree lower than bachelor’s degree, organizing regular internal training session and developing education packages might facilitate HCPs to acquire accurate knowledge and recent progress. Being highly cited by HCPs as source of information, WeChat should be utilized as channels for disseminating high-quality content about HPV and HPV vaccines.

Findings highlight high recommendation behavior among HCPs while HPV vaccine is still the Class two vaccine borne by out-of-pocket money in China and highlight key variables associated with recommendation practice. Aligning with previous findings (Zhao et al., 2012; Warner et al., 2017; Anfinan, 2019), higher knowledge is demonstrated as one of the key predictors of HCP’s recommendation practice as increased knowledge could lead to greater confidence of HCPs in presenting and discussing the HPV vaccine (Chen et al., 2020). This further reinforces the need of efforts to improve HCP’s knowledge for potentially facilitating advocacy work. Besides, recommendation behavior shared similar independent determinants to knowledge on professions, age and ethnicity. Additional research could be conducted to elucidate concerns or obstacles that hinder their recommendations on HPV vaccination and what are the misconceptions about HPV vaccines.

Different from previous studies mainly investigating medical students (Liu et al., 2020a; Liu et al., 2018), this study comprehensively involved respondents from the three professions mostly related to HPV vaccines in current Chinese healthcare practice, including the DEPI, CHC, obstetrician-gynecologists and other non-HPV closely related HCPs. Results demonstrated profession is a prime key independent predictor in both knowledge and recommendation practice.

In China, CHC is the main unit for implementing the vaccination service. They hold the promise to play an overwhelming role in improving HPV vaccine uptake in adolescent girls and might confront inquiries more frequently in routine work. Since HCPs from CHC showed higher knowledge on HPV vaccination while were suboptimal on HPV, strengthening HPV education to this profession group is of great necessity.

Obstetrician-gynecologists are important pathways in acquiring knowledge of HPV related disease prevention and recommendation for vaccinating themselves and their daughters. Despite the highest total knowledge score, obstetrician-gynecologists were less competent on HPV vaccine knowledge and still underperformed on HPV related knowledge considering their professional background. About 30% of them do not know HPV could be classified into high risk and low risk types and HPV vaccine could not cure pre-existing HPV infection. Given that mid-adult women might face more uncertainties regarding the effectiveness, immunogenicity and benefit of vaccine initiation, it raised higher standards for obstetrician-gynecologists to be equipped with associated knowledge, motivation and necessary communication skills (Saslow et al., 2020). Besides, further research could be conducted to figure out the barriers in obstetrician-gynecologists’ recommendation practice.

The main responsibility of DEPI affiliated to CDC is to lead immunization activities covering technical guideline formulation, surveillance as well as health education and public communication of vaccination within the area under their administration (Immunization Programme Centre, 2005). Generally, HCPs from DEPI showed optimistic performance on HPV and HPV vaccine knowledge and recommendation behaviors but presented a relatively weak understanding of detailed knowledge on HPV transmission and risk stratifications. Addressing these knowledge gaps may assist their competency in guiding HPV immunization routine service and promoting education activities. Future studies should investigate the reasons why HCPs are unwilling to recommend HPV vaccines and what are the misconceptions about HPV vaccines.

Unsurprisingly, HCPs who are not directly related to HPV and HPV

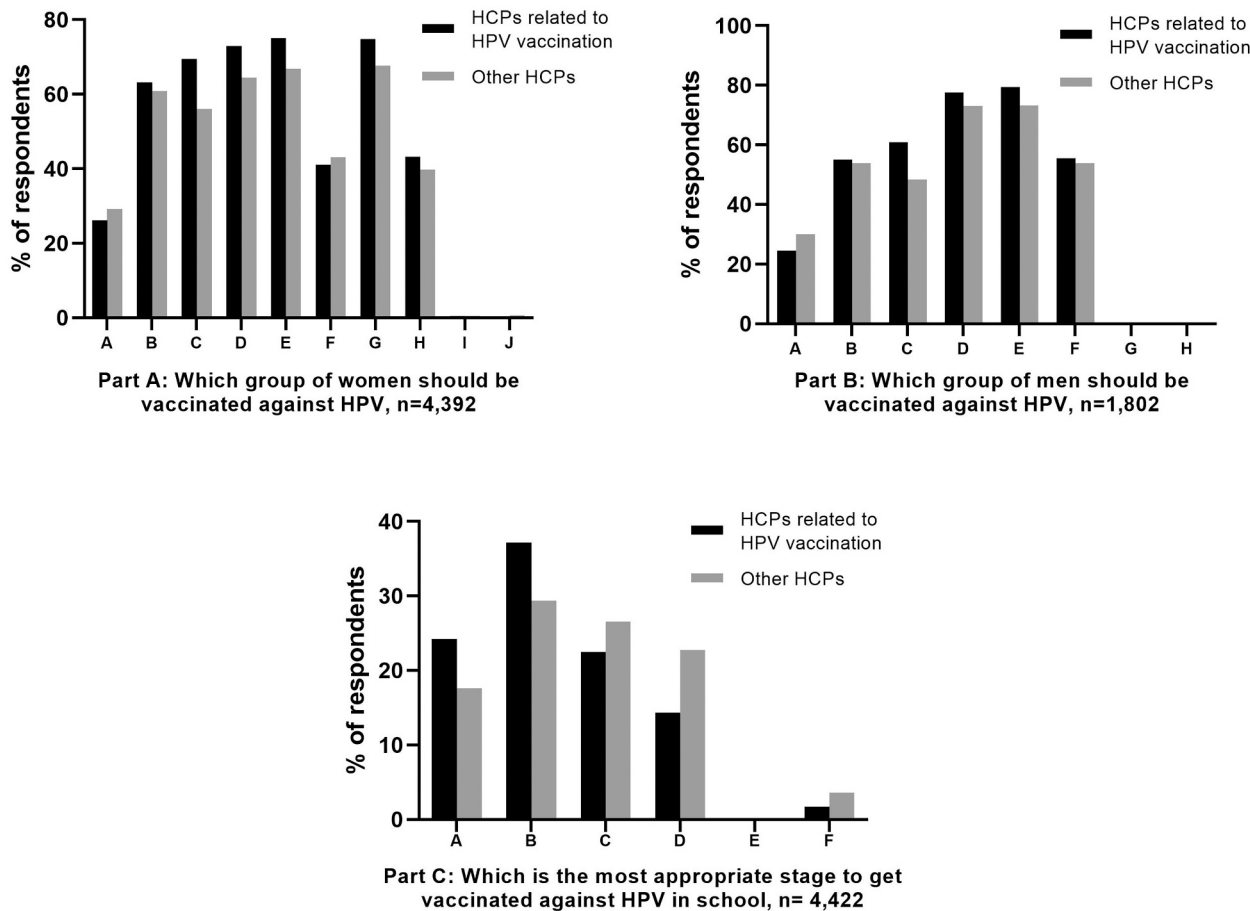


Fig. 1. Opinions on the appropriate population to receive HPV vaccination.*In Part A (Multiple selection allowed), A: Women of all ages, B: Married women, C: Women not yet sexually active, D: Sexually active women, E: Sexually active women with multiple partners, F: Women with previously abnormal cytology, G: Women with a family history of cervical cancer, H: Women with poor personal hygiene, I: Other, J: Do not know; In Part B (Multiple selection allowed), A: Men of all ages, B: Men who are married, C: Men who never engaged in sexual behavior before, D: Men who are sexually active, E: Sexually active men with multiple partners, F: Men with poor personal hygiene, G: Others, H: Do not know; In Part C (Only one selection allowed), A: Elementary school, B: Junior high school, C: High school (including technical secondary school and technical school), D: University (including colleges), E: Others, F: Do not know.

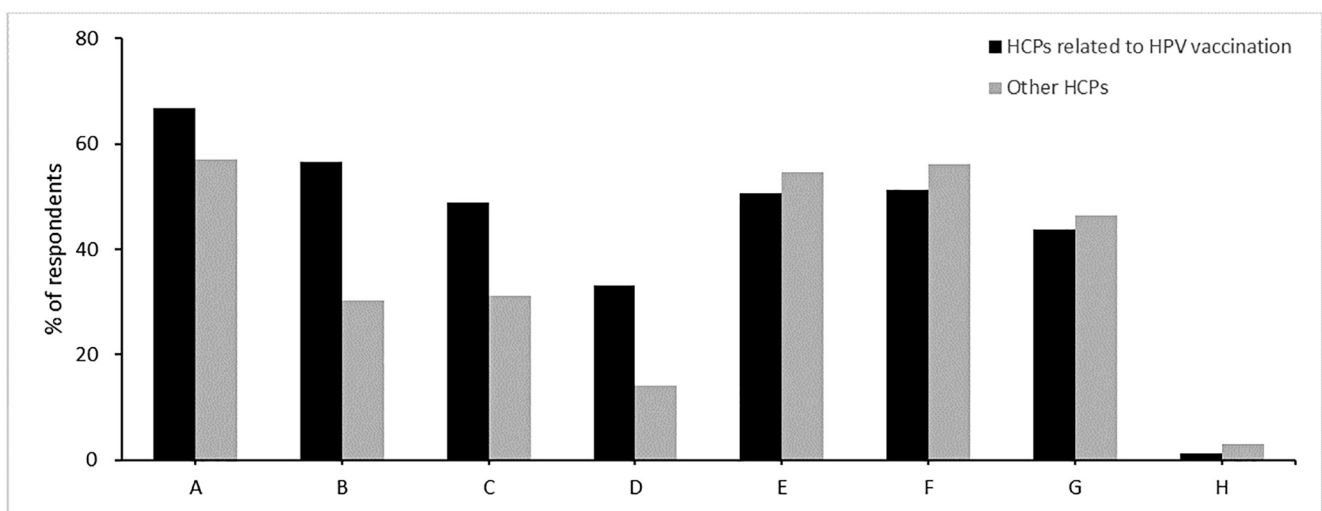


Fig. 2. Sources for HCPs to obtain information on HPV vaccines. A: Medical Journal, B: Academic conference, C: Public presentation, D: Product introduction from company, E: WeChat public account, F: Other social media, G: Social publicity, H: Others.

vaccination reported lower knowledge and recommendation behavior. Considering the patient trust in doctors' recommendations and the increasing discussion of non-cervical cancer associated with HPV among professions like dentists (Stull et al., 2020; Shetty et al., 2019), these professions may play roles in disseminating the knowledge and recommending HPV vaccine initiation. Introducing related elements in the medical curriculum or continuing medical education and utilizing trusted WeChat public account might be effective options.

HPV vaccines are intended to be administered before the onset of sexual activity and at younger age (e.g. 9–14 years old) (World Health Organization, 2017). However, about 30% surveyed HCPs did not recognize that HPV vaccination should occur before sexual debut. Remaining unchanged since pre-licensure period, more HCPs perceived that women with high risk factors associated with HPV infection and cervical cancer are appropriate target population than those not yet sexually active (Zhao et al., 2012). While HCPs' support on "Women not yet sexually active" is higher than before and more HCPs are choosing "junior high school" as the most appropriate stage to get vaccinated as opposed to "high school" during pre-licensure period (Zhao et al., 2012). This indicates that HCPs are increasingly recognizing the importance of getting HPV vaccination at an earlier stage. Nevertheless, according to a regional report in Ningbo China, only 8% of doses were administered in 9–15 year-old girls (Liu et al., 2020b). Future efforts should inform the importance of getting HPV vaccination at early age.

The findings in the present study are subject to some limitations. First, using multi-stage sampling in this study, the sample may not be an accurate representation of the whole population. Second, since the study participation was purely voluntary, nonresponse bias would be hard to avoid. The awareness, knowledge, willingness, and behavior of recommending HPV vaccination might be exaggerated to some extent, which warrants cautious interpretation when extrapolating to the whole HCP population. Third, the questionnaire was developed from previous studies (Wang et al., 2014; Wang et al., 2015). However, since the majority of the survey questions had been used several times before in China, modified according to recent vaccine updates by multidisciplinary experts and pre-tested, the reliability of this study should be acceptable.

5. Conclusions

In conclusion, this study provides a national profile of adequate basic knowledge and relatively high recommendation practice in HCPs when HPV vaccine is available but not yet incorporated in national immunization program in China. Profession-specific knowledge gaps on understanding of HPV infections and HPV vaccines, especially on risk classification of HPV types across all professions as well as insufficient recommendation behavior in obstetrician-gynecologists are still to be improved. The highlighted key determinants would inform additional efforts distribution among HCPs with lower title or education and from minorities in future health education campaigns.

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Declaration of Competing Interest

F. Z. has received grants through her institution from GlaxoSmithKline Biologicals SA, MSD China and Xiamen Inovax Biotech Co, Ltd. to undertake clinical trials or studies on HPV vaccine. R. B. and X. Z. report other from MSD China, outside the submitted work; X. C. and L. X. had been employed by MSD China during the study, and outside the

submitted work. The remaining authors declare no conflict of interest.

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