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# Using protection motivation theory to explain the intention to initiate human papillomavirus vaccination among men who have sex with men in China

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ABSTRACT

*Background:* Human papillomavirus (HPV) infection and related diseases are common among men who have sex with men (MSM). The most effective prevention is HPV vaccination. In China, however, men are not included in the HPV vaccination plan. We investigated the intention to initiate HPV vaccination and associated factors among MSM in China. Methods We surveyed 563 unvaccinated MSM aged 18 or older from six cities in China. Participants completed an electronic questionnaire about demographics, knowledge of and attitude towards HPV and HPV vaccine, intention to initiate HPV vaccination, willingness to recommend HPV vaccine to peers, feeling about government policy about HPV vaccination. We used the structural equation modeling (SEM) to analyze factors associated with HPV vaccine intention. Results The knowledge of HPV and HPV vaccine among participants was low. The mean score of knowledge about HPV and HPV vaccine was only 1.59 (range 0–11). The intention to initiate HPV vaccination within 6 months among participants was moderate (43.3% in total, 18.1% for 'very high' and 25.2% for 'above average').

## 1. Introduction

Human papillomavirus (HPV) is one of the leading sexually transmitted infections (STIs). In males, persistent infection with high-risk HPV types (mainly types 16 and 18) can cause penile cancer, anal cancer and oropharyngeal cancer [1], and low-risk HPV types (mainly type 6 and 11) are associated with anogenital warts and mild dysplasia [2]. Compared to heterosexual males, men who have sex with men (MSM) have significantly higher prevalence of HPV and HPV-related morbidities [3]. A systematic review and meta-analysis found that in China, the HPV prevalence in MSM (59.9%, 95% confidence interval52.2% to 67.6%) was significantly higher than that in heterosexual men (OR=8.81, 8.01 to 9.69) [4]. A meta-analysis published in 2021 found in China, the estimated prevalence of anal HPV among MSM was 85.1% (HIV-positive), 53.6% (HIV-negative) and 59.2% (unknown HIV status) [5].

The quadrivalent and nonavalent HPV vaccines have been proved to be both efficacious and cost-effective in preventing HPV-related

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morbidities in males [6–9]. In recent decades, an increasing number of countries are including males into their national HPV vaccination programs. In China, males are still excluded from the HPV vaccination strategy. It is important to understand the view on HPV vaccination among target populations prior to the actual implementation of vaccination policy. However nationwide data on the acceptability of HPV vaccination or intention to initiate HPV vaccination among MSM are scarce. Sporadic surveys in China showed the HPV vaccination intention among MSM fluctuated greatly, ranging from 18.8% in Wuxi to 73.5% in Hangzhou [10,11]. In high-income counties, studies about the knowledge and attitude of HPV vaccination among target populations were published, before the commencement of the national vaccination programs [12,13]. This inspired us to carry out the research in mainland China in order to inform future males' HPV vaccination strategies.

The objectives of this study were to assess the following items among MSM in China: 1) intention to initiate HPV vaccination and its associated factors; 2) knowledge of and attitude towards HPV and HPV vaccine. 2) facilitators of and barriers against HPV vaccination.

## 2. Material and methods

### 2.1. Study design and ethics statement

Data used in this paper were from the baseline survey of a randomized controlled trial assessing the efficacy of social-networking-app-based intervention in improving the knowledge of and intention to initiate HPV vaccination among MSM in China. The survey protocol was approved by the Ethics Committee of School of Public Health, Sun Yat-sen University (2019008) and was registered on the Chinese Clinical Trial Registry Website (http://www.chictr.org.cn, registration #: ChiCTR1900020981). Participants provided written consent.

### 2.2. Participants and sampling

We designed a poster including brief program introduction and QR code of the questionnaire, and then posted it at MSM community-based organizations (CBOs) or HIV Voluntary Counseling and Testing (VCT) clinics affiliated to local Centers for Disease Control and Prevention (CDCs). The recruitment was conducted in six sites, namely Shanghai and Wuxi in east China, Qingdao in north China, and Shenzhen, Guangzhou and Foshan in southern China, January to March 2019. The sampling method was convenient sampling. Trained volunteers introduced our study to every male coming for testing or counseling. After reading study information shown on the poster, men willing to participate could access the eligibility screening questionnaire by scanning the QR code. We calculated the sample size based on the following formula: $N = [\frac{Z_{1-\acute{\alpha}+Z_{1-\beta}}}{\delta}]^2 \times S^2$. N represents the total sample size in either intervention group or control group. s represents polled standard deviation of both groups. δ represents the significant difference between effect values, α=0.05, power=90%. The inclusion criteria were: 1) men aged 18 years and older. 2) never had any dose of HPV vaccine. 3) self-identified as being gay or bisexual, or had anal or oral sex with another man. Eligible participants were randomized into intervention group and control group in a ratio of 1:1. We pushed tailored message about HPV and HPV vaccine and sexual health education to men in the intervention group, and pushed message about sexual health education only to men in the control group at the same frequency via Wechat (a smartphone-based instant messaging app widely used in China, equivalent to Whatsapp) [14]. The primary outcome was the intention to initiate HPV vaccination within 6 months.

### 2.3. Data collection

The questionnaire was developed via three steps: 1) Drafting the original version by referring to previous related papers based on social cognition approaches or behavioral prediction models [3,15,16]. 2) Making a revision to adjust to the local context by working with 9 academics, professors majoring in public health and managers of NGOs. 3) Conducting a pilot study at the participating site in Guangzhou to verify the practicability.

Eligible participants completed a questionnaire to collect information on: 1) demographics such as age, educational level and monthly income 2) knowledge about HPV and HPV vaccine 3) PMT constructs and HPV vaccination intention 4) evaluation about the government's publicity for males' HPV vaccination and whether the government needs to subsidize it 5) reason for not initiating 6) whether willing to recommend it to people around them. The Likert scale was employed to create options for answer such as three-point scale 'Extremely', 'Moderately' and 'Not at all' as answers of question 'The level of impact on daily life if MSM get infected with HPV' belonging to the PMT variable 'severity'.

### 2.4. Variables and measurements

#### 2.4.1. Demographic characteristics

Age, educational level, occupation, monthly income, marital status and sexual orientation were included in the demographic characteristics.

#### 2.4.2. Knowledge of HPV and HPV vaccine

This variable was measured using 7 items, 4 for HPV knowledge (e.g. 'if males have risk of HPV infection?') and 3 for HPV vaccine knowledge (e.g. 'What diseases can be prevented for males by getting HPV vaccine?'). The total score was used as an exogenous variable in the structural equation model (SEM) and a higher score indicated a higher knowledge level of HPV and HPV vaccine.

#### 2.4.3. PMT scale

The Protection Motivation Theory (PMT) consists of two independent appraisal processes: threat appraisal and coping appraisal [17]. Threat appraisal, focusing on threat and factors that increase or decrease the probability of maladaptive responses, consists of intrinsic and extrinsic rewards, severity and vulnerability. Coping appraisal, focusing on threat and factors that increase or decrease the probability of adaptive response, consists of response efficacy, self-efficacy and response costs. Minimizing threat appraisal while maximizing the coping appraisal helps develop the intention to initiate protective actions, which facilitates actual protective behaviors. The PMT explains the intrinsic mechanism and process of behavior transformation [18] and has been widely used in recent decades as a framework for explaining harmful behaviors such as smoking [19] or predicting protective behaviors such as disease screening [20]. Because there is no conceptual distinction between the reward value of risk behavior and cost of preventative measure [21], the following five factors are normally included in a PMT model: severity, vulnerability, response efficacy, self-efficacy and response costs [22]. For example, the meaning of the opinion that 'not taking HPV vaccine would save money' is equivalent to the opinion that 'taking HPV vaccine would cost money'. We also included these five factors in our PMT model.

*2.4.3.1. Threat appraisal.* This construct consisted of two subconstructs: perceived severity (5 items) and perceived vulnerability (4 items). Perceived severity was designed to evaluate the perceived likelihood of adverse consequences if infected with HPV (e.g. 'Evaluation about the possibility of getting genital warts for MSM after infection with HPV'). Perceived vulnerability meant participants' assessment for the level of susceptibility of infection with HPV (e.g. 'Evaluation about the possibility of infection with HPV in your daily life'). A higher score indicated perceived more severity and vulnerability respectively.

*2.4.3.2. Coping appraisal.* Coping appraisal consisted of response

efficacy, self-efficacy and response costs. Response efficacy represented individuals' evaluation about the perceived effectiveness of getting the HPV vaccine for MSM (e.g. 'How strong the belief that HPV vaccine can reduce the risk of having genital warts'). Self-efficacy was used to assess one's belief of the ability in one's own confidence to get the first dose and complete all three doses of HPV vaccine (e.g. 'I will be able to purchase HPV vaccine when I want to'). Response costs were used to measure one's perceived cost of taking HPV vaccine (e.g. 'I have the ability to cover the total cost of three doses of HPV vaccine'). For all three subconstructs, higher score meant higher motivation to take action.

*2.4.3.3. Intention to initiate HPV vaccination.* The behavioral intention was assessed by a single item. Participants were asked 'How likely will you initiate HPV vaccination within the next 6 months?' (the total cost if they choose to initiate in Hong Kong was shown for reference, including three dose of vaccination and extra fare). A 5-point Likert scale was used to evaluate the level of intention (from 'very high' to 'very low'). The higher score meant a higher level of intention. In addition, the participants were asked about the opinions towards the government's publicity about males' HPV vaccination, the reason why they have not taken the HPV vaccine and whether they were willing to recommend HPV vaccine to their peers.

### 2.5. Statistical analysis

For descriptive analysis, mean, standard deviation (SD) and range were used to describe quantitative variables like age. A number of cases and percentage were applied to describe other categorical variables like occupation. SEM is a systematic instrument to evaluate the relations among latent variables and theoretical models in the field of sociology, etc. Complete SEM construction consisted of two parts: measurement model which is primitively based on confirmatory factor analysis (CFA) and structural model which is built by path analysis. The measurement model is used to verify the relation between observed variables and latent variables, reflecting the quality of the questionnaire. The structural model is applied to explore the relationship among latent variables and to verify the theoretical model. The following statistical analysis process was described by these two parts.

#### 2.5.1. Assessment of the measurement model

The measurement models were built by CFA. Factor loading of each item was used to evaluate the weight of influence in corresponding measurement models. Items whose factor loading values were lower than 0.5 were deleted from the scale and the final measurement models were guaranteed to include at least three items [23]. The final measurement models were tested by two metrics: construct validity and composite reliability (CR). The definition of the construct validity was mainly divided into two indicators: convergent and discriminate validities. The absolute value of standardized factor loading should be more than 0.5. The average variance extracted (AVE) criterion should be more than 0.5 to ensure good convergent validity. The discriminate validity was assured when the square root of AVEs were both larger than the correlation coefficients of these two subconstructs. The composite reliability for each of the study's constructs should be all above the recommended 0.7 level to indicate good internal consistency [24].

#### 2.5.2. Assessment of the structural model

One-way ANOVA was used to compare the knowledge score among different intention levels to initiate HPV vaccination. Maximum Likelihood Method was used in the process of constructing a structural equation model and Mardia's Kurtosis test was applied to evaluate multivariate normality [25]. The *p*-value for assessing the significance of path coefficient was set at 0.05. Six indices, representing absolute, comparative, and residual aspects of fit, were used for evaluating the fitting performance of the structural model: chi-square/*df* ratio, goodness of fit (GFI), adjusted goodness of fit (AGFI), comparative fit index (CFI), standardized root mean square residual (SRMR) and the root mean square error of approximation (RMSEA). The latent variables are represented by elliptical shapes and the observed variables are represented by rectangular shapes in the path diagram. All analyses were performed using SPSS 25.0 and Amos 21.0.

## 3. Results

### 3.1. Demographics of participants

A total of 610 men participated in the study, and 47 were excluded from the analysis because of incomplete answers and low quality of questionnaire (those completed within less than 5 min). The final sample size was 563 (response rate: 92.3%) from six sites, namely 55 from Foshan, 105 from Guangzhou, 102 from Qingdao, 109 from Shanghai, 92 from Shenzhen and 100 from Wuxi.

The mean age was 28.0 year (SD: 6.8). The majority (67.7%) had an educational level of technical diploma/undergraduate. For occupational distribution, except 13.3% were students and 12.3% were unemployed, most of the participants (74.4%) were employed. About 44.6% of participants had a monthly income of RMB 2000 – 5999 (USD 285-857). For marital status, most participants were unmarried (single or common-law relationship) (84.7%) and for sexual orientation, most reported homosexual (76.0%). All demographic results were shown in Table 1.

### 3.2. Knowledge about HPV and HPV vaccine

The mean score of knowledge was 1.59 (range 0–11). Only 27% of participants knew HPV vaccine also applies to males and 60% never heard of the HPV vaccine. The average score or proportion of correct answer for each item were also shown in Table 2. There was statistically significant difference among different levels of intention groups ($P<0.001$) thus the knowledge was considered to be included in the structural model as a covariate variable.

**Table 1**
Demographic characteristics of participants.

| Variable | N (%) |
|---|---|
| Age (years) [M (SD)] (range) | [27.95 (6.88)] (18-60) |
| Education | |
| Junior high school or less | 40 (7.1) |
| Senior high school/junior college | 107 (19.0) |
| Technical secondary school/undergraduate | 381 (67.7) |
| Post-undergraduate and above | 35 (6.2) |
| Occupation | |
| Student | 75 (13.3) |
| Unemployed | 69 (12.3) |
| Employed | 419 (74.4) |
| Personal monthly income (Chinese yuan) | |
| < 2000 | 66 (11.7) |
| 2000 - 5999 | 251 (44.6) |
| 6000 - 9999 | 159 (28.2) |
| > 10000 | 87 (15.5) |
| Marital status | |
| Married with a woman | 64 (11.4) |
| Married with a man (marriage registration abroad) | 0 (0.0) |
| Unmarried (single or common-law relationship) | 477 (84.7) |
| Widowed or divorced | 22 (3.9) |
| Sexual orientation | |
| Homosexual | 428 (76.0) |
| Bisexual | 112 (19.9) |
| Heterosexual | 2 (0.4) |
| Unsure | 21 (3.7) |

**Table 2**
The questionnaire's items and their item loadings.

| Construct | Item (Mean score/ Proportion for correct answer)[a] | Scale Measurement | Item loading |
|---|---|---|---|
| **Severity** | 1) The level of impact on daily life if MSM get infected with HPV (4.32) | Extremely high 5 Not at all 1 | 0.673 |
| | 2) The possibility MSM get genital warts after infection with HPV? (4.33) | | 0.884 |
| | 3) The possibility MSM get cancers (anal, penile, head and neck, oropharyngeal cancers, etc) after infection with HPV? (4.16) | | 0.731 |
| **Vulnerability** | 1) The possibility of contacting HPV in your daily life (3.13) | Extremely high 5 Not at all 1 | 0.851 |
| | 2) The possibility of infecting HPV in your daily life (2.94) | | 0.822 |
| | 3) In your opinion, the prevalence of HPV among MSM in China is (2.80) | High 4 None 1 | 0.581 |
| | 4) In your opinion, the infectivity of HPV is (3.06) | | 0.508 |
| **Response efficacy** | 1) Getting the HPV vaccine can reduce the risk of genital warts (4.03) | Strongly agree 5 Strongly disagree 1 | 0.941 |
| | 2) Getting the HPV vaccine can reduce the risk of HPV-related cancer (3.97) | | 0.891 |
| | 3) Getting the HPV vaccine can improve the quality of your life (3.96) | | 0.799 |
| **Self-efficacy** | 1) You can decide if you need HPV vaccination (4.15) | Strongly agree 5 Strongly disagree 1 | 0.699 |
| | 2) You are sure you can get the opportunity of HPV vaccination whenever you want (3.54) | | 0.686 |
| | 3) You are sure you can complete the whole procedure of HPV vaccination once you get the first dose (4.06) | | 0.719 |
| **Knowledge level** | 1) Males have a risk of HPV infection (37.8%) | Ture 1 False 0 | – |
| | 2) HPV infection can be treated with antibiotic (11.2%) | Ture 0 False 1 | – |
| | 3) HPV infection can be cured completely (18.7%) | Ture 1 False 0 | – |
| | 4) HPV infection is hereditary (17.6%) | Ture 0 False 1 | – |
| | 5) HPV vaccine could apply to males (27.0%) | Ture 1 False 0 | – |
| | 6) What diseases can be prevented by getting the HPV vaccine□(0.37)<br>□Anogenital warts<br>□Syphilis<br>□Anal cancer<br>□Oropharyngeal cancer<br>□Penis cancer □Gonorrhea<br>□Intraepithelial lesion<br>□HIV/AIDS<br>□Unknown | 0-5 (9 options, 5 true answers. Each true answer for 1 score) | – |
| | 7) How many doses the whole procedure of HPV vaccination involve□ (9.2%) | One dose 0 Two doses 0 Three doses 1 | – |
| **Intention to initiate HPV vaccination** | 1) How likely is it that you will initiate HPV vaccination within the next 6 months? (3.41) | Very High 5 Very low 1 | – |

[a] Rather than the mean score, the proportion for correct answer was chosen to be shown for logical questions in 'Knowledge Level' part.

### 3.3. Measurement model

The factor loadings of final items remaining in each measurement model, higher than 0.5, are presented in Table 2. For subconstruct perceived severity, the highest item loading was 'the perceived possibility of getting genital warts after infection with HPV' (0.884, $P$=0.048), reflecting the fear for infection of genital warts among participants. For perceived vulnerability, the highest item loading was 'the possibility of infection with HPV in your daily life' (0.851, $P$=0.032), again indicating fear for infection of genital warts. Similarly, the highest loading for response efficacy was about 'getting the HPV vaccine can reduce the risk of having genital warts' (0.941, $P$=0.020). As for self-efficacy, item that 'I am sure I can complete the whole procedure of HPV vaccination once I get the first dose' had the highest item loading (0.719, $P$=0.001).

Table 3 describes the mean, SD, CR, AVE and correlation coefficients of each subconstruct. The CRs were all above 0.7 indicating good internal consistency of the data and the AVEs were not less than 0.5 indicating good convergent validity. Meanwhile, the square root of AVEs were larger than all other correlation coefficients, showing acceptable discriminate validity.

### 3.4. Structural model

The rate of intention among 563 participants were 18.1% for 'very high', 25.2% for 'above average', 41.4% for 'unsure', 9.8% for 'below average' and 5.5% for 'very low', respectively. Fig. 1 shows the schematic map of the structural model with solid lines indicating standardized regression weights ($P$=0.010). The knowledge (the standardized total effect was 0.298, $P$=0.021) and the perceived severity (0.049, $P$<0.001) had indirect effect on the intention. The self-efficacy (0.093, $P$=0.011), response efficacy (0.172, $P$=0.020) and perceived vulnerability (0.230, $P$<0.001) had direct effect on the intention. Different from the hypothesized theory, the response costs had no effect on the outcome intention variable. The fit of the structural model was as following: $\chi^2/df$= 3.796, GFI= 0.937, AGFI= 0.900, SRMR= 0.111, CFI= 0.944 and RMSEA= 0.071.

### 3.5. Attitudes towards government's policies and reasons for not initiating HPV vaccination

For the question 'whether you expect the government's approval and promotion of HPV vaccination for MSM in the future?', 84.2% participants agreed. For the question 'Would you like to recommend HPV vaccine to MSM around you?', 86.1% chose yes. As for the government policy, 26.1% of participants thought the publicity about the HPV vaccination for MSM was insufficient and 34.8% thought it was extremely insufficient. For the question 'Do you think if it is necessary for the government to subsidize HPV vaccination for MSM', 63.8% thought it is definitely necessary (Table 4). Fig. 2 shows reasons why participants had not taken HPV vaccine and the proportion of people

**Table 3**
Descriptive statistics, composite reliability (CR), average variance extracted criterion (AVE) and inter-construct correlations.

| Construct | Mean | SD | CR | AVE | Construct | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1 | 2 | 3 | 4 | 5 | 6 |
| Knowledge | 1.59 | 2.29 | – | – | – | | | | | |
| Severity | 17.17 | 2.12 | 0.81 | 0.59 | -0.009 | **0.77** | | | | |
| Vulnerability | 11.93 | 2.96 | 0.80 | 0.50 | 0.222** | 0.088* | **0.71** | | | |
| Response Efficacy | 11.96 | 2.43 | 0.91 | 0.77 | 0.196** | 0.222* | 0.312** | **0.88** | | |
| Self-Efficacy | 11.75 | 2.31 | 0.74 | 0.50 | 0.159** | 0.131* | 0.247** | 0.612** | **0.71** | |
| Intention | 3.41 | 1.06 | – | – | 0.153** | -0.005 | 0.269** | 0.272** | 0.226** | – |

Notes: 1. The bold fonts in the leading diagonals are the square root of AVEs.Off-diagonal elements are correlations among constructs.
2. SD: Standard Deviation, CR: Composite Reliability, AVE: Average Variance Extracted.

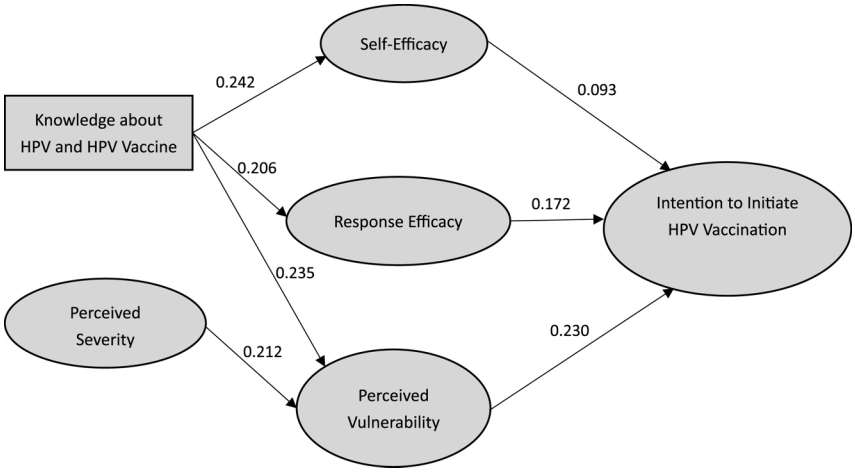



**Fig. 1.** The path diagram of structural model. Illustration: It is a schematic map of the structural modeling result with solid lines indicating standardized regression weights (P<0.05) of each latent variable.

**Table 4**
Attitude towards government policy on HPV vaccination for MSM.

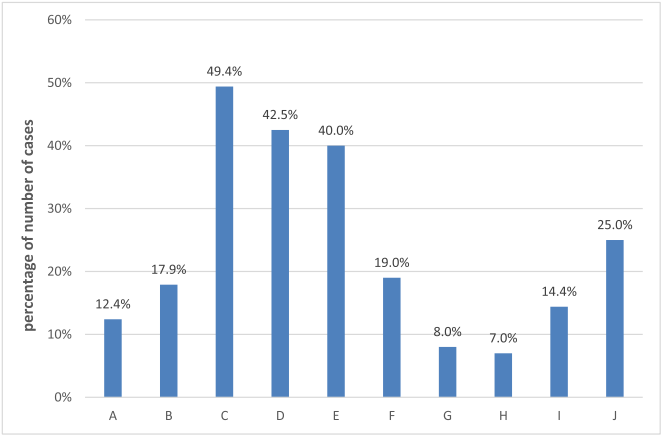
| Question | Answer for option | N(%) |
|---|---|---|
| Whether you expect the government's approval and promotion of HPV vaccination for MSM in the future? | Yes, I expect | 474 (84.2) |
| | No, I do not expect | 24 (4.3) |
| | I do not care | 65 (11.5) |
| Would you like to recommend HPV vaccine to your MSM peers around you? | Yes, I would | 485 (86.1) |
| | No, I would not | 78 (13.9) |
| What do you think of the publicity about HPV vaccination for MSM from the government | Extremely sufficient | 45 (8.0) |
| | Sufficient | 38 (5.7) |
| | Unsure | 137 (24.3) |
| | Insufficient | 147 (26.1) |
| | Extremely insufficient | 196 (34.8) |
| Do you think if the government should subsidize HPV vaccination for MSM? | Needed greatly | 359 (63.8) |
| | Needed | 120 (21.3) |
| | Unsure | 70 (12.4) |
| | Did not need | 12 (2.1) |
| | Did not need at all | 2 (0.4) |

who agreed with this statement. The top 3 answers were 'did not know where to get HPV vaccine' (49.4%), 'did not get HPV vaccination recommendation from the health care providers' (42.5%) and 'the cost is too high' (40.0%).

## 4. Discussion

Our study found that the knowledge about HPV and HPV vaccine among Chinese MSM was suboptimal and the intention to initiate HPV vaccination was low. This points to the need of disseminating science and information, so as to improve awareness and intention to initiate HPV vaccination.

Our study participants were young (73.2% were≤30 years). Studies found that young MSM had higher prevalence of high risk sexual behaviors [26–28]. However, sexual health education was lacking for most of the schools, especially in rural areas, still less about HPV [29,30]. The median age at first anal intercourse had been decreasing steadily from 33 years of age among MSM born from 1940 to 1959 to 18 years of age among MSM born from 1990 to 1996. This age is expected to decrease further among MSM born after the 1990s [31]. This points to the necessity of HPV educational intervention as early as possible and the inclusion of males in the national HPV immunization plan in China. Over half (56.3%) of participants' monthly income were less than RMB 5999 (USD 857). The majority of MSM would found it strenuous to afford HPV vaccine (ranging from RMB 2400, 343 dollars for 4v HPV vaccine to RMB 4000, 572 dollars for 9v HPV vaccine). This accorded with the reason why they would not initiate HPV vaccination (40.0% chose 'the cost is too high'). Congruously, 85.1% thought the government should subsidize HPV vaccination program. For the knowledge level, the mean score of knowledge about HPV and HPV vaccination was much lower than that among gay/bisexual or MSM in high-income countries [3,32].




A: Thinking the vaccine was only for females

B: Thinking males could not get vaccine in mainland China

C: Not knowing where to get HPV vaccine

D: Lack of HPV vaccination recommendation from health care providers

E: Price of HPV vaccine too high

F: Not having time to get HPV vaccine

G: Not knowing enough about the vaccine

H: Being afraid of needles or perceived pain

I: Worrying about sexual orientation disclosure

J: Thinking there is no need to get vaccine

**Fig. 2.** Reasons why MSM had not initiated HPV vaccination. Illustration It shows the proportion of answers for the multiple choice questions "why you had not taken HPV vaccine until now". There are 10 options: A: Thinking the vaccine was only for females; B: Thinking males could not get vaccine in mainland China; C: Not knowing where to get HPV vaccine; D: Lack of HPV vaccination recommendation from health care providers; E: Price of HPV vaccine too high; F: Not having time to get HPV vaccine; G: Not knowing enough about the vaccine; H: Being afraid of needles or perceived pain; I: Worrying about sexual orientation disclosure; J: Thinking there is no need to get vaccine.

This phenomenon could be partly attributed to the publicity education deficiency from the health authority as there was 60.9% of participants who thought the government's publicity towards MSM HPV vaccination was insufficient or extremely insufficient in China.

Except for response costs in PMT, other variables had influence, direct or indirect, on the intention to initiate HPV vaccination (Knowledge level and perceived severity had indirect effect. Vulnerability, response efficacy and self-efficacy had direct effect). Similar to many PMT-related studies, the knowledge level had indirect effect by influencing other variables, illustrating that gaining relevant knowledge could both increase threat appraisal and coping appraisal [20,33]. The path analysis showed perceived vulnerability mediated the association between perceived severity and intention. Participants might reevaluate the possibility of infection and serious outcomes if they were infected with HPV. Additionally, there was a conflict between no influence of response cost on the intention and the proportion result of the answer for the reason why they haven't initiated HPV vaccination (40.0% chose 'the economy cost is too high'). Perhaps it could be attributed to the main barrier of the cost for preventing MSM from initiating HPV vaccination, compared to other items involved in response costs such as time consumption, side effect and fear of needles or pain. Consequently, the total effect of this variable is not statistically significant.

The majority (84.2%) of participants expected the government's approval and promotion of HPV vaccination for MSM in the future. As of 2019, more than 100 countries have introduced national HPV vaccination programs [34] and an increasing number of countries are including boys and MSM. For example, the US licensed quadrivalent HPV vaccine for boys and young men in 2009, 3 years after girls. Quadrivalent HPV vaccine was recommended for boys aged 11–21 years and also MSM through the age of 26 [35]. However, in China, there is no national HPV vaccination for males even the HPV prevalence is not optimistic [36]. We hope our study will help remind the health authority in China to increase publicity of HPV vaccination and consider subsidizing HPV vaccination for MSM. Except the choice 'the cost is too high', the other top two reasons for why they did not get HPV vaccine were 'did not know where to get HPV vaccine' and 'did not get HPV vaccination recommendation from health care providers'. Consequently, not only for MSM, education should also be implemented on health care providers.

Our study has limitations. Study sites are economically well-off cities. MSM resident in rural regions were not recruited. As a result, our sample may not represent MSM from rural regions in China. The outcome was the perceived intention to initiate HPV vaccination, rather than the actual uptake. There might be a gap between these two stages. Despite these limitations, this study evaluated HPV vaccination intention and explored its influencing factors, which gave clues to interventional studies in the future. More effective intervention studies are warranted for this group of population to verify the availability of PMT-based education in China. The results of the model had potential ability to inspire the following intervention studies and health education. For example, based on the factor loading results, in term of the subconstruct perceived severity, education could focus on the negative influence on the quality of life and severe outcomes of HPV infection among MSM, i.e. anal cancer and genital warts.

In conclusion, the knowledge about HPV and HPV vaccine among Chinese MSM was suboptimal and the intention to initiate HPV vaccination was low. Knowledge level, perceived severity, perceived vulnerability and self-efficacy affect the intention to initiate HPV vaccination. MSM should be included in HPV vaccination strategies. Future HPV vaccination strategies should address these issues and involve both science and policy-making. Cost-effectiveness studies are needed to inform future HPV vaccination policies among MSM in China.

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## Author contributions

**Ruonan Huang:** Conceptualization, Methodology, Software, Investigation, Formal Analysis and Writing- Original draft preparation. **Zhenyu Wang and Tanwei Yuan:** Investigation, Data Curation, Formal Analysis and Project administration. **Tom Nadarzynski and Han-Zhu Qian:** Methodology and Writing - Review & Editing preparation.

**Peiyang Li:** Investigation, Data Curation and Project administration. **Xiaojun Meng, Guanghui Wang, Yepeng Zhou, Danyang Luo and Ying Wang:** Investigation, Supervision and Project administration. **Yong Cai:** Supervision, Project administration and Funding acquisition. **Huachun Zou:** Conceptualization, Writing - Review & Editing preparation, Supervision, Project administration and Funding acquisition.

## Declaration of competing interest

The authors declare that there is no conflict of interests.

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