

Original Article

Asian Pacific Journal of Tropical Medicine

doi:10.4103/1995-7645.374355

Impact Factor: 3.041

COVID-19 vaccine uptake and its determinants among teenagers and their parents in Zhejiang, China: An online cross-sectional study

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ABSTRACT

Objective: To examine COVID-19 vaccine uptake and its determinants among teenagers and their parents in Zhejiang, China.

Methods: An online cross-sectional study was conducted among parents of teenagers in Zhejiang, China from May 1 to 31, 2022. Data were interpreted *via* univariate and multivariate analyses using the statistical package for the social sciences (SPSS) program.

Results: A total of 11 115 (96.11%) participants and 11 449 (99.00%) of their children in Zhejiang, China had been vaccinated against COVID-19. Children whose parents did not receive COVID-19 vaccination were 19 times (*aOR* 18.96, 95%*CI* 12.36-29.08) more likely to be unvaccinated than their counterparts. In addition, children with no previous influenza vaccination, those whose parents doubted the COVID-19 vaccine's safety or effectiveness, were 6.11 times (*aOR* 6.11, 95%*CI* 2.80-13.34), 8.27 times (*aOR* 8.27, 95%*CI* 5.33-12.83), and 2.69 times (*aOR* 2.69, 95%*CI* 1.11-6.50) more likely to be unvaccinated than their counterparts, respectively. COVID-19 vaccine uptake varied between different sociodemographic groups. However, the odds of receiving the COVID-19 vaccine decreased as age and education level increased. The main refusal reasons claimed by participants were that they had medical conditions that may not qualify them for vaccination (53.78%), followed by safety concerns about the vaccine (13.56%), not knowing where to get vaccinated (6.44%), and concerns about fertility issues (5.56%).

Conclusions: Despite a highly encouraging level of COVID-19 vaccine uptake in Zhejiang, China, the elderly and highly educated people had lower COVID-19 vaccine uptake. It is suggested that tailored health education strategies should be taken to increase the COVID-19 vaccine uptake in such groups. Furthermore, with vaccination rates at such a high level, the pandemic is still ongoing, and public confidence in vaccines may decline. Thus, sufficient evidence-based information regarding COVID-19 vaccines should be provided to the public.

KEYWORDS: COVID-19; Vaccine uptake; China; Teenagers; Parents

1. Introduction

As of June 2022, over 500 million cases of the novel coronavirus disease 2019 (COVID-19) were recorded globally. Out of this figure, over 6 million people died[1]. In China, this disease affected 3015 155 individuals and caused 17702 deaths until June 7, 2022[2]. COVID-19 is caused by the severe acute respiratory syndrome corona virus-2 (SARS-CoV-2). On January 30, 2020, COVID-19 was declared as a public health emergency of international concern by the World Health Organization (WHO)[3].

At the early stage of the COVID-19 epidemic, the global public health response focused on non-pharmaceutical interventions such as social distancing, frequent handwashing, and the use of facial masks in public places[4]. Albeit these preventive measures remain

Significance

The study examined COVID-19 vaccine uptake and associated factors in a large population among teenagers and their parents in Zhejiang, China. Although we observed a highly encouraging level of COVID-19 vaccine uptake, we found that the elderly and highly educated parents had lower COVID-19 vaccine uptake and that non-vaccination of COVID-19 among parents is an important negative influencing factor for children's vaccination status. By establishing the factors contributing to hesitancy and resistance in taking any COVID-19 vaccine, targeting these factors through proper health and community education can help decrease vaccine hesitancy in China.

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How to cite this article: Huang Y, Wu QQ, Xu SY, Zhao X, Wang L, Lv QH, et al. COVID-19 vaccine uptake and its determinants among teenagers and their parents in Zhejiang, China: An online cross-sectional study. Asian Pac J Trop Med 2023; 16(4): 176-186.

Article history: Received 26 January 2023
Accepted 24 April 2023

Revision 15 April 2023
Available online 29 April 2023

essential in the fight against COVID-19, the widespread use of the COVID-19 vaccine, which helps build herd immunity, is an ultimate intervention to propel humans back to their normal lives[5].

The Chinese Sinopharm and Sinovac vaccines have been approved earlier in 2021 by the WHO for emergency use. China is the world's largest vaccine supplier, having supplied more than 480 million doses of COVID-19 vaccines to the international community, provided vaccine assistance to nearly 100 countries, and exported vaccines to more than 50 countries. With the Chinese vaccines being administered worldwide, they have been found, according to multiple studies, highly effective in preventing infection, hospitalization, severe illness and death from the virus[6].

China started rolling out COVID-19 vaccines in late 2020 in a three-stage manner. In the first stage, people with high risk for SARS-CoV-2 infection, including healthcare staff, inspection and quarantine personnels, international migrant workers, *etc.*, were prioritized[7,8]. Subsequently, vaccination in China was available to adult residents aged 18 years or above[9]. Now, all school students aged 3 to 17 years were eligible to get the COVID-19 vaccine[10]. Vaccines are provided for free by the Chinese government, and all residents can get access to it at the nearest primary health care center. However, research has found that a portion of the public is still hesitant in getting vaccinated with the COVID-19 vaccine. A national multicenter survey in China found that 23.9% of students, 21.2% of the general population, 13.1% of medical workers, and 10.4% of public health professionals still had vaccine hesitancy[11]. Globally, the average rate of vaccine hesitancy in April 2020 was 21%, which increased to 36% in July 2020, and later declined to 16% in October 2020[12].

Children played an important role in the coronavirus transmission in both families and schools. Many countries have adopted home quarantine measures to prevent the spread of COVID-19 in schools[13], which has seriously affected the children's normal schooling and outdoor activities[14], and may have a negative effect on their mental health and well-being[15]. The vaccination of juveniles is an important part of developing herd immunity and allowing the opening up of societies[16,17]. Personal experience, perceived effectiveness, and concerns regarding safety and adverse effects are the most influential factors in predicting parents' decision to vaccinate their children[18]. Acceptance among parents to vaccinate their children against COVID-19 varied largely across countries or regions. A scoping review found that the median acceptance rate of parents vaccinating their children against COVID-19 was 59.3%, ranging from 21.6% to 70.1% in American parents, and from 44.5% to 85.3% in Chinese parents[19].

Nevertheless, there are limitations to these studies. A large gap between the intention and actual behavior of receiving the vaccine against COVID-19 might exist[20,21]. Furthermore, determinants of

vaccine acceptance are context-dependent, and almost all studies were conducted before COVID-19 vaccines were widely available to the public[20,21]. Thus, it is important to carry out additional surveys to examine the real-world uptake of COVID-19 vaccines. An online survey in China found that among 786 respondents, 84.22% had been vaccinated; while the main reason for unvaccination in the unvaccinated population was their own personal health status[22]. However, the study is limited due to its small sample size and selection bias.

We conducted surveys with over 10000 parents of high school students in order to (1) to examine the uptake of COVID-19 vaccines among teenagers and their parents, (2) to find out whether vaccine uptake in parents may have an impact on their children's vaccine uptake, and if so, to which extent, and (3) to explore the factors associated with COVID-19 vaccine uptake. The results of this study may help guide the design and improvement of interventions and campaigns to sensitize parents to COVID-19 vaccination, which would consequently help in acquiring herd immunity.

2. Materials and methods

2.1. Questionnaire

The questionnaire was designed by the Zhejiang Provincial Center for Disease Control and Prevention. A pilot study was first conducted to check the reliability of the questionnaire. The questionnaire was then modified after feedbacks from the pilot study and two rounds of Delphi method collaboration, in which the face validity was checked by subject matter experts, and the literature was reviewed to assess for content validity. The questionnaire collected sociodemographic data, history of influenza vaccine for the children, COVID-19 vaccine uptake among participants and their children, participants' main reasons for not receiving the COVID-19 vaccine, and knowledge and attitude towards COVID-19 vaccines among the participants. The specific questions regarding knowledge and attitude towards COVID-19 vaccines were the following: (1) "Is COVID-19 vaccine safe?" (2) "Can COVID-19 vaccine reduce the possibility of symptomatic infection, hospitalization, serious illness and mortality?" (3) "Can people take the COVID-19 vaccine if they're pregnant or planning a pregnancy?" (4) "Do you need to wear a face mask after receiving COVID-19 vaccination?" (5) "Is booster dose of COVID-19 vaccine necessary?"

To control the quality of the questionnaire, we set up a quality control question in the questionnaire to identify participants who are not taking the survey seriously. The data of these participants will not be included in the analysis.

2.2. Recruitment

All high schools in Zhejiang were eligible to take part in the study. Zhejiang is one of the smallest provincial-level political units in the eastern part of China, but is also one of the most densely populated and affluent provinces. There are 11 administrative units in Zhejiang Province. One junior high school and one senior high school were randomly selected in each administrative unit. We assumed that, overall, the COVID-19 vaccine uptake would be about 50%, with 95% confidence in the estimate, precision of 5%, and 20% of non-response rate. Hence, the minimum required sample size for each administrative unit was 500 participants. In total, the minimum required sample size for our study was 5 500. An online survey questionnaire was distributed to parents of the students from these schools. High school students in China are usually aged between 12 and 17 years. The questionnaire was hosted on *wenjuan*. *Wenjuan* is a professional online questionnaire, test, assessment and voting platform, focusing on providing users with powerful and humanized online design questionnaires, data collection, customized reports, survey results analysis and other series of services. Compared with traditional survey methods, *wenjuan* has the advantages of speed, ease of use and low cost, and has been widely used by a large number of enterprises and individuals.

2.3. Statistical analysis

Data were exported from the *wenjuan* website to Excel (Microsoft), and were analyzed using the Statistical Package for the Social Sciences (SPSS), version 19.0 (IBM Corporation, Armonk, New

York, USA). Standard descriptive statistics were used for continuous and categorical variables. Univariate and multivariate logistic regression analyses were conducted to explore the factors associated with COVID-19 vaccine uptake among participants. The factors included sociodemographic variables, influenza vaccine for children, and knowledge and attitude towards COVID-19 vaccines among participants. Odds ratios with 95% confidence intervals were used to express measures of the associations. $P < 0.05$ were considered to represent significance (two-sided).

2.3. Ethics approval

The Zhejiang Provincial Center for Disease Control and Prevention Ethics Board approved the study protocol. The survey was anonymous. Participants were informed on the purpose and characteristics of the study and provided informed consent by clicking a box. Each participant received 25 RMB for their participation.

3. Results

3.1. Participants' characteristics

A total of 16000 parents were invited to participate in the online survey, 12450 parents completed the questionnaire, the response rate was 77.81% (12 450/16 000). After quality control, 885 questionnaires were excluded, and 11 565 (72.28%) questionnaires were included in the study (Figure 1).

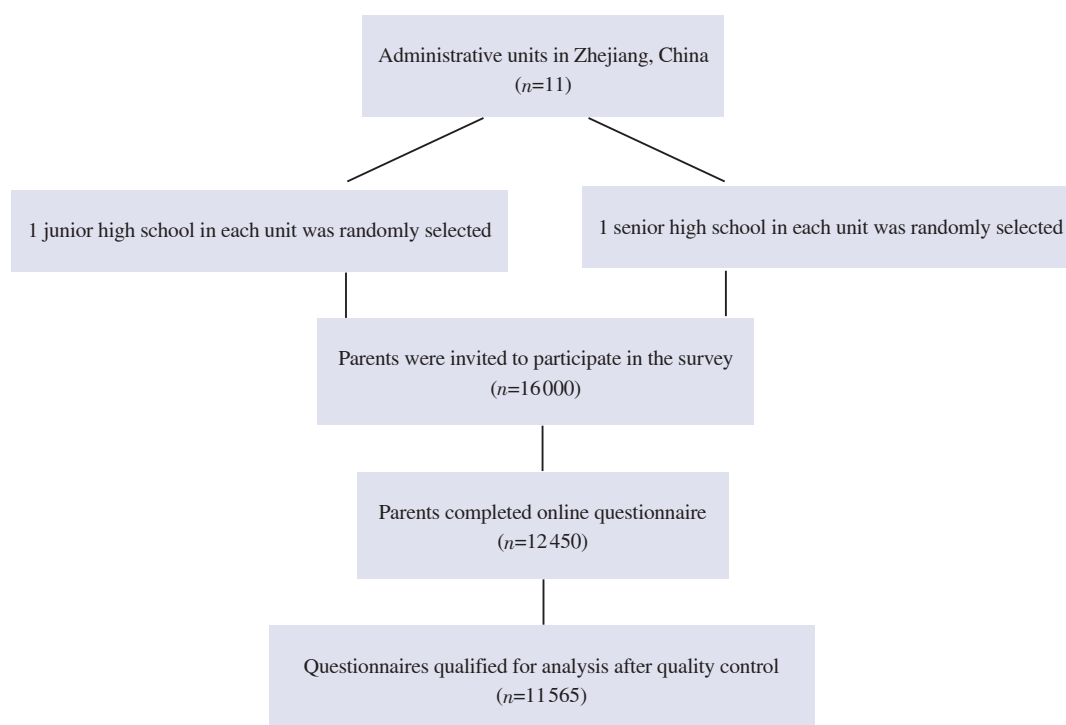


Figure 1. The flowchart of sample inclusion.

The median age of the parents was 43 years (range: 32-69), and their mean age was (43.2 ± 4.8) years. The participants mainly aged between 40 and 50 (68.42%), and 88.37% (10220/11565) of them were female. More than half of them had primary-level education or lower. The detailed sociodemographic characteristics of the parents are presented in Table 1.

Table 1. Sociodemographic characteristics of participants completing the online survey in May 2022 in Zhejiang Province, China (n=11565).

Characteristic	n (%)
Sex	
Male	1345 (11.63)
Female	10220 (88.37)
Age (years)	
<40	2374 (20.53)
40-50	7913 (68.42)
>50	1278 (11.05)
Mean	43.2 ± 4.8
Education level	
Primary or lower (< 9 years)	8083 (69.89)
Secondary (9-12 years)	2143 (18.53)
Postsecondary (>12 years)	1339 (11.58)
Occupation	
Government institution	583 (5.04)
Business or service industry staff	4042 (34.95)
Farmer	2073 (17.92)
Stay-at-home mother/stay-at-home father/unemployed	2461 (21.28)
Others (retired/business owner, etc.)	2406 (20.80)
Annual household income (RMB)	
<100000	6439 (55.68)
100000-200000	3433 (29.68)
>200000	1693 (14.64)
Immigration status	
Resident	9693 (83.81)
Migrant from other counties of China	1872 (16.19)
Influenza vaccine for children	
Yearly	1771 (15.31)
Some years	6670 (57.67)
Never	3124 (27.01)
Marital status	
Married	10540 (91.14)
Others (divorced/widowed/separated, etc.)	1025 (8.86)

3.2. COVID-19 vaccine uptake among teenagers and their parents

Table 2 shows that, of all the parents who were involved in the survey, 11115 (96.11%) were vaccinated with at least one dose of any of the COVID-19 vaccines available, whereas only 450 (3.89%) were not vaccinated.

Table 2. COVID-19 vaccine uptake among participants and their children of online survey in May 2022 in Zhejiang Province, China.

COVID-19 vaccine uptake among children	COVID-19 vaccine uptake among parents, n (%)		Total
	No	Yes	
No	49 (10.89)	67 (0.60)	116 (1.00)
Yes	401 (89.11)	11048 (99.40)	11449 (99.00)
Total	450 (3.89)	11115 (96.11)	11565 (100.00)

$$\chi^2=460.83, P<0.001, OR (95\% CI)=20.15 (13.76, 29.51)$$

OR: odds ratio; CI: confidence interval.

Based on the parents' answers, among 11565 high school students, 11449 (99.00%) were vaccinated with at least one dose of any of the available COVID-19 vaccines, whereas only 116 (1.00%) were not vaccinated.

Among the 450 parents who had not taken any COVID-19 vaccine, 10.89% of their children were not vaccinated, whereas 401 (89.1%) students were vaccinated. Among the 11115 parents who had taken the COVID-19 vaccine, only 0.60% of their children were not vaccinated, and 11048 (99.40%) students were vaccinated. Thus, the COVID-19 vaccine uptake rate of high school students whose parents had taken the COVID-19 vaccine was higher than that of students whose parents had not taken the COVID-19 vaccine. This difference between the two groups was significant ($\chi^2=460.83, P<0.0001$).

3.3. Reasons for not receiving COVID-19 vaccine among the participants

Figure 2 shows that, of the 450 participants who were not vaccinated COVID-19, 242 (53.78%) claimed that they have medical conditions that might not qualify themselves for COVID-19 vaccination, 61 (13.56%) feared the side effects of the COVID-19 vaccine, 29 (6.44%) claimed they didn't know where to get vaccinated, 25 (5.56%) were pregnant or planning to get pregnant, 23 (5.11%) thought that physiological immunity was better, 13 (2.89%) doubted the effectiveness of the vaccine, 8 (1.78%) were not worried about getting COVID-19 infection, 4 (0.89%) claimed that COVID-19 symptoms were mostly mild, and 45 (10.00%) claimed other reasons for not wanting to get vaccinated.

3.4. Knowledge and attitude towards COVID-19 vaccines among the participants

Among the total participants, 93.26% (10785/11565) agreed that the COVID-19 vaccine is safe. A total of 98.66% (11410/11565) agreed that the COVID-19 vaccine can reduce the possibility of symptomatic infection, hospitalization, serious illness and mortality. Totally, 37.10% (4291/11565) agreed that people can take the COVID-19 vaccine if they're pregnant or planning a pregnancy.

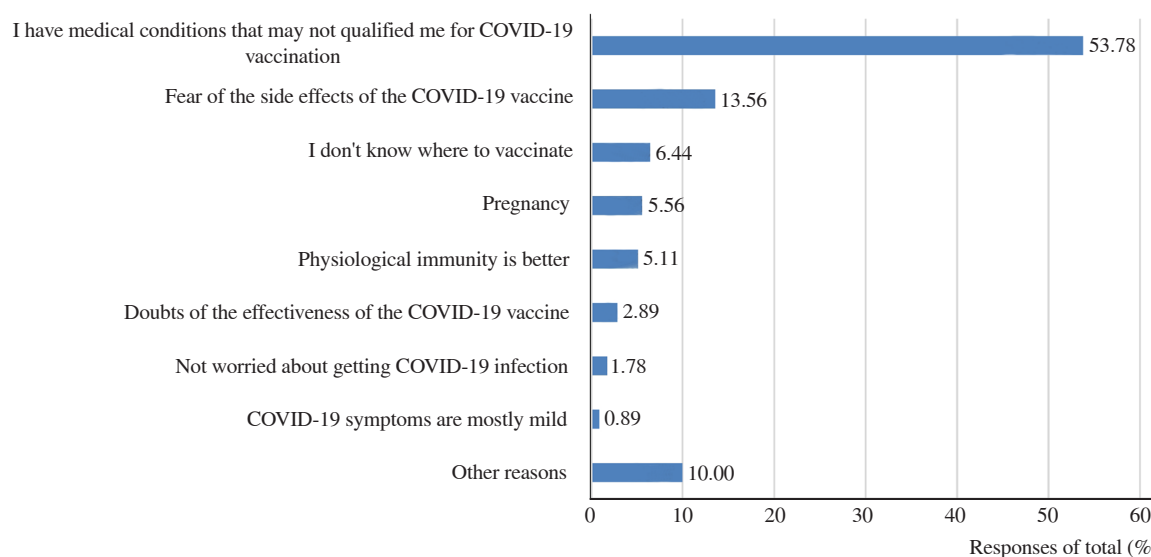


Figure 2. The main reasons why participants not receiving COVID-19 vaccine.

A total of 99.20% (11 472/11 565) agreed that people still need to wear face mask after receiving COVID-19 vaccination. 99.14% (11 465/11 565) agreed that taking a booster dose of COVID-19 vaccine is necessary.

3.5. Factors associated with COVID-19 vaccination among teenagers' parents

As shown in Table 3, sociodemographic characteristics, influenza vaccination for children, and attitudes towards the COVID-19 vaccine were statistically associated with parental COVID-19 vaccination. After controlling for other variables, parents with an age >50 years were 2.27 times more likely to be non-vaccinated with the COVID-19 vaccine (*aOR* 2.27, 95%*CI* 1.65-3.13) when compared to parents <40 years old. The odds of being non-vaccinated with the COVID-19 vaccine among participants with a postsecondary education level were 1.48 times higher (*aOR* 1.48, 95%*CI* 1.04-2.09) when compared to parents with primary or lower education level. The probability of being non-vaccinated with the COVID-19 vaccine among parents who never gave their children the influenza vaccine was 1.60 times higher (*aOR* 1.60, 95%*CI* 1.18-2.17) when compared to their counterparts. Parents who showed negative attitudes toward the COVID-19 vaccine were more likely to be non-vaccinated COVID-19 when compared to parents with positive attitudes. The odds of not getting vaccinated were 1.71 and 1.51 higher among parents who didn't agree that the COVID-19 vaccine is safe (*aOR* 1.71, 95%*CI* 1.24-2.34) and those that believed people can not take the COVID-19 vaccine if they are pregnant or planning for pregnancy (*aOR* 1.51, 95%*CI* 1.22-1.86), respectively, when compared to their counterparts.

3.6. Factors associated with COVID-19 vaccination among teenagers

As shown in Table 4, parents' sociodemographic characteristics had no influence on teenagers' vaccination status of COVID-19. However, parental COVID-19 vaccination status, teenagers' influenza vaccination history, and the parents' knowledge and attitudes towards COVID-19 vaccine were statistically significantly associated with uptake of the COVID-19 vaccine by teenagers. Teenagers whose parents were unvaccinated with COVID-19 vaccine were 18.96 times more likely to be unvaccinated themselves (*aOR* 18.96, 95%*CI* 12.36-29.08) when compared to their counterparts. The probability of being non-vaccinated with the COVID-19 vaccine among teenagers who never received influenza vaccine was 6.11 higher (*aOR* 6.11, 95%*CI* 2.80-13.34) when compared to their counterparts. Teenagers whose parents doubted the COVID-19 vaccine safety were 8.27 times more likely to be unvaccinated (*aOR* 8.27, 95%*CI* 5.33-12.83) when compared to those whose parents believed that the COVID-19 vaccine is safe. Teenagers whose parents doubted the effectiveness of the COVID-19 vaccine were 2.69 times more likely to be unvaccinated (*aOR* 2.69, 95%*CI* 1.11-6.50) when compared to those whose parents believed that the COVID-19 vaccine is effective. Teenagers whose parents believed that people cannot take the COVID-19 vaccine if they are pregnant or planning for pregnancy were 2.26 times more likely to be unvaccinated (*aOR* 2.26, 95%*CI* 1.33-3.83) when compared to those whose parents believed that pregnant women or those preparing for pregnancy can take the COVID-19 vaccine.

Table 3. Factors associated with COVID-19 vaccine uptake among teenagers’ parents of the online survey in May 2022 in Zhejiang Province.

Variables	COVID-19 vaccine		OR (95%CI)	aOR (95%CI)
	Non-vaccinated, n (%)	vaccinated, n (%)		
Sex				
Male	44 (3.27)	1301 (96.73)	1	1
Female	406 (3.97)	9814 (96.03)	1.22 (0.89, 1.68)	1.21 (0.88, 1.68)
Age (years)				
<40	83 (3.50)	2291 (96.50)	1	1
40-50	280 (3.54)	7633 (96.46)	1.01 (0.79, 1.30)	1.05 (0.82, 1.36)
>50	87 (6.81)	1191 (93.19)	2.02 (1.48, 2.75)	2.27 (1.65, 3.13)***
Education level				
Primary or lower (<9 years)	304 (3.76)	7779 (96.24)	1	1
Secondary (9-12 years)	84 (3.92)	2059 (96.08)	1.04 (0.82, 1.34)	1.16 (0.89, 1.50)
Postsecondary (>12 years)	62 (4.63)	1277 (95.37)	1.24 (0.94, 1.64)	1.48 (1.04, 2.09)*
Occupation				
Government institution	27 (4.63)	556 (95.37)	1	1
Business or service industry	138 (3.41)	3904 (96.59)	0.73 (0.48, 1.11)	0.82 (0.51, 1.31)
Farmer	57 (2.75)	2016 (97.25)	0.58 (0.37, 0.93)	0.62 (0.36, 1.07)
Stay-at-home mother/stay-at-home father/unemployed	131 (5.32)	2330 (94.68)	1.16 (0.76, 1.77)	1.31 (0.79, 2.17)
Others (retired/business owner, etc.)	97 (4.03)	2309 (95.97)	0.87 (0.56, 1.34)	0.96 (0.58, 1.59)
Annual household income (RMB)				
<100000	258 (4.01)	6181 (95.99)	1	1
100000-200000	127 (3.70)	3306 (96.30)	0.92 (0.74, 1.14)	0.90 (0.71, 1.13)
>200000	65 (3.84)	1628 (96.16)	0.96 (0.73, 1.26)	0.90 (0.67, 1.22)
Immigration status				
Resident	378 (3.90)	9315 (96.10)	1	1
Migrant from other counties of China	72 (3.85)	1800 (96.15)	0.99 (0.76, 1.28)	1.01 (0.78, 1.31)
Influenza vaccine for children				
Yearly	60 (3.39)	1711 (96.61)	1	1
Some years	227 (3.40)	6443 (96.60)	1.01 (0.75, 1.34)	0.99 (0.74, 1.33)
Never	163 (5.22)	2961 (94.78)	1.57 (1.16, 2.12)	1.60 (1.18, 2.17)**
Marital status				
Married	403 (3.82)	10137 (96.18)	1	1
Others (divorced/widowed/separated, etc.)	47 (4.59)	978 (95.41)	1.21 (0.89, 1.65)	1.23 (0.90, 1.69)
Is COVID-19 vaccine safe?				
Yes	402 (3.73)	10383 (96.27)	1	1
No	48 (6.15)	732 (93.85)	1.69 (1.24, 2.31)	1.71 (1.24, 2.34)***
Can COVID-19 vaccine reduce the possibilities of symptomatic infection, hospitalization, serious illness and mortality?				
Yes	444 (3.89)	10966 (96.11)	1	1
No	6 (3.87)	149 (96.13)	1.00 (0.44, 2.26)	0.81 (0.35, 1.88)
Can people take COVID-19 vaccination if they’re pregnant or planning a pregnancy?				
Yes	129 (3.01)	4162 (96.99)	1	1
No	321 (4.41)	6953 (95.59)	1.49 (1.21, 1.83)	1.51 (1.22, 1.86)***
Do you still need to wear face mask after receiving COVID-19 vaccination?				
Yes	445 (3.88)	11027 (96.12)	1	1
No	5 (5.38)	88 (94.62)	1.41 (0.57, 3.48)	1.27 (0.43, 3.76)
Is booster dose of COVID-19 vaccine necessary?				
Yes	444 (3.87)	11021 (96.13)	1	1
No	6 (6.00)	94 (94.00)	1.58 (0.69, 3.64)	1.71 (0.63, 4.59)

*P<0.05, **P<0.01, ***P<0.001 and 1=reference; OR: odds ratio; aOR: adjusted odds ratio; CI: confidence interval.

4. Discussion

This large-scale cross-sectional online survey was carried out during the third stage of the Chinese COVID-19 vaccine rollout, when all school students aged between 3 and 17 years were eligible for COVID-19 vaccination[10]. To our knowledge, this is the first study to examine the uptake of COVID-19 vaccines among high school students and their parents in Zhejiang, the most densely

populated and affluent provincial-level political unit in China.

Our results showing that the majority of the participants had been vaccinated against COVID-19 in Zhejiang, China are encouraging. In fact, the results showed that 96.11% of participants were vaccinated with at least one dose of any of the COVID-19 vaccines. The uptake rate of the COVID-19 vaccine among the participants’ children reached 99%. Data of our study showed a higher percentage of people having taken one dose of the COVID-19 vaccine in Zhejiang

Table 4. Factors associated with COVID-19 vaccine uptake among teenagers of the online survey in May 2022 in Zhejiang Province.

Variables	COVID-19 vaccine		OR (95%CI)	aOR (95%CI)
	Non-vaccinated, n (%)	vaccinated, n (%)		
Sex				
Male	10 (0.74)	1335 (99.26)	1	1
Female	106 (1.04)	10114 (98.96)	1.40 (0.73, 2.68)	1.32 (0.62, 2.72)
Age (years)				
<40	24 (1.01)	2350 (98.99)	1	1
40-50	80 (1.01)	7833 (98.99)	1.00 (0.63, 1.58)	0.96 (0.58, 1.57)
>50	12 (0.94)	1266 (99.06)	0.93 (0.46, 1.86)	0.69 (0.32, 1.51)
Education level				
Primary or lower (<9 years)	80 (0.99)	8003 (99.01)	1	1
Secondary (9-12 years)	24 (1.12)	2119 (98.88)	1.13 (0.72, 1.79)	1.19 (0.70, 2.00)
Postsecondary (>12 years)	12 (0.90)	1327 (99.10)	0.91 (0.49, 1.66)	0.95 (0.43, 2.07)
Occupation				
Government institution	5 (0.86)	578 (99.14)	1	1
Business or service industry	42 (1.04)	4000 (98.96)	1.21 (0.48, 3.80)	0.96 (0.33, 2.81)
Farmer	21 (1.01)	2052 (98.99)	1.18 (0.44, 3.15)	1.14 (0.35, 3.69)
Stay-at-home mother/stay-at-home father/unemployed	17 (0.69)	2444 (99.31)	0.80 (0.29, 2.19)	0.54 (0.17, 1.77)
Others (retired/business owner, etc.)	31 (1.29)	2375 (98.71)	1.51 (0.58, 3.90)	1.19 (0.39, 3.64)
Annual household income (RMB)				
<100000	63 (0.98)	6376 (99.02)	1	1
100000-200000	42 (1.22)	3391 (98.78)	1.25 (0.85, 1.86)	1.10 (0.69, 1.74)
>200000	11 (0.65)	1682 (99.35)	0.66 (0.35, 1.26)	0.65 (0.32, 1.32)
Immigration status				
Resident	96 (0.99)	9597 (99.01)	1	1
Migrant from other counties of China	20 (1.07)	1852 (98.93)	1.08 (0.66, 1.75)	1.01 (0.59, 1.73)
Influenza vaccine for children				
Yearly	8 (0.45)	1763 (99.55)	1	1
Some years	32 (0.48)	6638 (99.52)	1.06 (0.49, 2.31)	1.25 (0.55, 2.83)
Never	76 (2.43)	3048 (97.57)	5.50 (2.65, 11.41)***	6.11 (2.80, 13.34)***
Marital status				
Married	104 (0.99)	10436 (99.01)	1	1
Others (divorced/widowed/separated, etc.)	12 (1.17)	1013 (98.83)	1.19 (0.65, 2.17)	1.17 (0.61, 2.25)
COVID-19 vaccination in the parents				
Yes	67 (0.60)	11048 (99.40)	1	1
No	49 (10.89)	401 (89.11)	20.15 (13.76, 29.51)***	18.96 (12.36, 29.08)***
Is COVID-19 vaccine safe?				
Yes	71 (0.66)	10714 (99.34)	1	1
No	45 (5.77)	735 (94.23)	9.24 (6.31, 13.52)***	8.27 (5.33, 12.83)***
Can COVID-19 vaccine reduce the possibilities of symptomatic infection, hospitalization, serious illness and mortality?				
Yes	108 (0.95)	11302 (99.05)	1	1
No	8 (5.16)	147 (94.84)	5.69 (2.73, 11.89)***	2.69 (1.11, 6.50)*
Can people take COVID-19 vaccination if they're pregnant or planning a pregnancy?				
Yes	18 (0.42)	4273 (99.58)	1	1
No	98 (1.35)	7176 (98.65)	3.24 (1.96, 5.37)***	2.26 (1.33, 3.83)**
Do you still need to wear face mask after receiving COVID-19 vaccination?				
Yes	115 (1.00)	11357 (99.00)	1	1
No	1 (1.08)	92 (98.92)	1.08 (0.15, 7.77)	0.52 (0.04, 6.86)
Is booster dose of COVID-19 vaccine necessary?				
Yes	113 (0.99)	11352 (99.01)	1	1
No	3 (3.00)	97 (97.00)	3.11 (0.97, 9.95)	4.21 (0.94, 18.95)

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$ and 1=reference; OR: odds ratio; aOR: adjusted odds ratio; CI: confidence interval.

than average level in other countries[23]. At the time of writing, 67% of the world population had received at least one dose of vaccine against COVID-19, whereas only 19.9% of the population in low-income countries have received at least one dose[23]. The top five countries that had over 90% of its population receiving at least one

dose of the COVID-19 vaccine were Cuba (95%), Portugal (95%), Chile (93%), Singapore (92%), and China (91%)[23]. The reasons of Chinese high COVID-19 vaccination rate might be due to the remarkable progress made in vaccine production, successful social mobilization, government support, *et al*[24]. For example, posters

of catchy and amusing slogans about vaccination, adapted from the lyrics of pop music or created based on the Internet buzzwords, have appeared in city streets and are sweeping social media[24]. Sports stadiums and art museums have been converted into vaccination facilities[25]. The higher COVID-19 uptake in Zhejiang than the average level (91%) in China might be explained by its abundant economic and political resources which helps booster COVID-19 vaccine rollout.

Considering that over 95% coverage of vaccination against COVID-19 was present, the reasons behind a minority of the population not receiving the vaccine became a curiosity. Even though the rate of non-vaccinated individuals in Zhejiang, China, will not threaten the success of the COVID-19 vaccination program, finding out the reasons behind refusal of vaccination provided us with clues about future work that can be done in health education in vaccination program. Our study found that the major reason behind people not wanting to receive the COVID-19 vaccine is their belief that they have medical conditions that might not qualify them for COVID-19 vaccination (53.78%); while, in the United States, a study found that the most claimed reason for not getting vaccinated was concerns about possible side effects[26]. Our study showed that 13.56% of the participants did not want to get vaccinated due to concerns about side effects of the COVID-19 vaccine. Furthermore, 6.44% claimed they didn't know where to get vaccinated, and 5.56% were pregnant or planning on getting pregnant. A national cohort study in England showed that pregnant women who tested positive for COVID-19 at the time of delivery were more likely to have pre-eclampsia, and were twice as likely to have a stillbirth[27]. Even though over 5% of our participants were hesitant to get vaccinated due to fertility reasons, all evidence showed that there is no negative impact of vaccination on fertility[28]. These findings indicate that the positive effects of vaccination on the fetal health have not been widely emphasized or understood.

Our study found that children were more likely to be unvaccinated if their parents didn't take the COVID-19 vaccine. Among parents who had not taken the COVID-19 vaccine, 10.89% of their children were not vaccinated, whereas among parents who had taken COVID-19 vaccine, only 0.60% of their children were not vaccinated. After adjusting for other variables, children whose parents were unvaccinated with COVID-19 vaccine were 18.96 times more likely to be unvaccinated when compared to their counterparts. These findings were in line with a multi-country study from the Eastern Mediterranean Region[29], which could be explained by the fact that parents are key decision-makers in whether their children will receive the COVID-19 vaccine or not. Most studies focused on parents' willingness to vaccinate their children[30–34]. Studies in China reported that 45.5% to 89% of parents were accepting of a COVID-19 vaccine for their children[33,34]. These results are much

lower than the real-world data we found. In fact, studies on parents' acceptance of COVID-19 vaccination in China were much lower than results of real-world COVID-19 vaccine uptake behaviour. We thus conclude that determinants of vaccine acceptance are context-dependent, and a large gap between intention and actual behavior to receive a vaccine exists.

Apart from parental COVID-19 vaccine status, previous experience of receiving the influenza vaccine, and parents' knowledge and attitudes towards the COVID-19 vaccine were also found to be predictors of COVID-19 vaccine uptake of children. In this regard, children who never received the influenza vaccine were 6.11 times more likely to be non-vaccinated with the COVID-19 vaccine than children who had a history of influenza vaccination. Our results are consistent with the literature that shows lower acceptance of vaccination in people who do not get influenza vaccination[35–38].

Among our samples, parental COVID-19 vaccine misconceptions were found to decrease the odds of vaccine uptake in children. Children whose parents doubted the COVID-19 vaccine's safety, COVID-19 effectiveness, and those whose parents believed that pregnant women or those planning on getting pregnant cannot take the COVID-19 vaccine were 8.27 times, 2.69 times, and 2.26 times more likely to be unvaccinated when compared to their counterparts, respectively. These findings are in line with previous findings that parents' misconceptions about COVID-19 vaccination are significant barriers to vaccine acceptance[39–44].

Sex, race, age, education level, and income status were identified as determining factors of having a low or high COVID-19 vaccine uptake in previous studies[12,37,38,45,46]. In our study, sex, race and income status were not found to be associated with COVID-19 vaccine uptake, whereas older age and higher education levels were found to decrease the odds of vaccine uptake. Although, a previous study in Zhejiang, China indicated that older people had higher willingness to receive COVID-19 vaccination[47], our study found that participants aged >50 years were 2.27 times more likely to be non-vaccinated than those aged <40 years. A study in Bangladesh found a similar phenomenon in which older people were less likely to be vaccinated[45]. Consistent with that fact that since the beginning of the COVID-19 pandemic, increased age has been found to be associated with worse outcomes, such as admission to an intensive care unit and death, studies in other countries had found increased age to be associated with an increased likelihood of vaccination[48–50]. On the contrary, we found a lower COVID-19 vaccine uptake in older people in Zhejiang, China. This might be due to the fact that, under the circumstance that over 95% of the population is covered by COVID-19 vaccination, a main refusal reason often claimed by older people was the presence of a medical condition that would not qualify them to take the vaccine.

Another surprising finding was that participants with postsecondary

education were 1.48 times more likely to be non-vaccinated than those with primary or lower education level. This finding echoes a previous study in Zhejiang which revealed that highly educated people had lower willingness to vaccinate[47], but contradicts with a study conducted in Greece[38] which found that participants with high school education or university degree were 6.29 times and 7.78 times more likely to be vaccinated against COVID-19 than participants with elementary school education. However, the odds decreased to 1.68 when participants' education level increased to MSc/PhD. One possible explanation might be that highly educated people encounter and receive more information on the social network, in addition to more professional information, making them more concerned about the effectiveness and side effects of the COVID-19 vaccine, which may affect their decision to get vaccinated.

This study has some limitations. First, to expediently obtain the COVID-19 vaccination uptake status of the participants and their children, we kept the questionnaire short, which limited the depth of the study. Second, the participants of the online survey were parents of high school students and there were fewer males than females participated in our survey, which may limit the extent to which the results could be generalized to the whole population. Other Internet-based study also had a similar sex imbalance in terms of participants[51,52]. It may be that women are generally more concerned about health than men, so they are more willing to participate in health-related surveys. Third, the cross-sectional nature of study design prevents identification of causal factors.

In conclusion, we observed a highly encouraging level of COVID-19 vaccine uptake among teenagers and their parents in Zhejiang. Parental COVID-19 vaccination status was found to be the most important factor influencing children's vaccination behavior. Additionally, lower COVID-19 vaccine uptake was observed among the elderly and highly educated people. These findings suggest that tailored health education strategies targeting older people, highly educated, should be taken as a priority to increase the COVID-19 vaccine uptake in Zhejiang. Furthermore, with vaccination rates at such a high level, the pandemic is still ongoing, and public confidence in vaccines may decline. Thus, sufficient evidence-based information regarding COVID-19 vaccines should be provided to the public.

Data availability

The anonymized data set used in the analyses are available on request. Use of our data is only permitted for noncommercial purposes.

Conflicts of interest statement

The authors declare that there are no conflicts of interest.

Funding and Acknowledgements

The authors are grateful to the staff from the wenjuan platform that helped carrying out the online survey, and for the support of the Zhejiang Medicine and Health Technology project (2022KY716).

Authors' contributions

YH, XHZ contributed to the conception of the study. XHZ, YH, QQW, XZ performed the survey. XHZ, YH, SYX contributed significantly to data analysis and manuscript preparation. LW, QHL, SXW helped perform the analysis with constructive discussions. YH contributed to the final version of the manuscript, and supervised the project.

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