

BMJ Open Vaccination practices, knowledge and attitudes regarding COVID-19 vaccines among Chinese university students: a cross-sectional study from a comprehensive university in Wuhan

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ABSTRACT

Objective In China, a free national COVID-19 vaccination programme has been launched in spring 2021 and is ongoing across the country. This study aimed to preliminarily understand the current COVID-19 vaccination practices and the associated knowledge/attitude factors among Chinese university students.

Design and setting A single-centre cross-sectional questionnaire-based study was conducted between 1 and 20 May 2021 among a convenience sample of Chinese university students recruited from a comprehensive university in Wuhan. A total of 359 valid questionnaires were obtained.

Results Just 1 month after the commencement of the university vaccination process, 75% of responding students had received the COVID-19 vaccination. Students without experience of COVID-19 infection were more likely to get vaccinated than those who had been infected. Most (57%) received information about COVID-19 vaccination through official announcements released by the university, and 67% were vaccinated at vaccination place arranged by the university. An interesting finding is that, although the overall vaccine uptake rate was 75%, nearly one-third of vaccinees did not know or incorrectly stated the type of COVID-19 vaccines that they had received. Mean knowledge test score was 3.05 out of 6, suggesting poor knowledge regarding COVID-19 vaccines. The vaccinated showed more positive attitudes towards the importance of establishing herd immunity through the COVID-19 vaccination programme for pandemic control than the non-vaccinated did. 'Effectiveness in preventing COVID-19' was perceived by 76% respondents as the most important factor contributing to COVID-19 vaccination. A total of 76% were worried about safety-related issues, including 'unknown long-term safety', 'vaccine allergy' and 'vaccine-caused COVID-19 infection'.

Conclusions Data suggested a rapid and effective progress of the national COVID-19 vaccination programme in China among university students. Taking effective official actions, as well as enhancing the belief in vaccines' effectiveness, might be necessary for the good implementation of COVID-19 vaccination programmes.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ This study highlighted the vaccination practices for COVID-19 vaccines, as well as their associated knowledge and attitude factors, among university students, an educated and active population group who can quickly respond to public health issues and might be more exposed to the risk of COVID-19 infection.
- ⇒ This cross-sectional survey based on a self-developed questionnaire included 359 valid student respondents from Wuhan University of Science and Technology, a comprehensive university located in Wuhan, China.
- ⇒ This study was conducted 1 month after the commencement of the university vaccination process, in order to acquire the real-time information about the situation of COVID-19 vaccination programme advancement.
- ⇒ Sampling selection bias is likely to occur because of the single-centre nature of the study and the convenience sample methodology.

INTRODUCTION

Since 11 March 2020, the COVID-19 caused by SARS-CoV-2 has been declared as a tragic global pandemic by the WHO.¹ As the most urgent public health emergency at present, this pandemic has attracted an unprecedented level of global attention and concern due to its high infectivity and substantial mortality. Although many interventions such as pharmacological agents, social distancing restrictions, mask wearing and gathering limits have currently been in place to combat the pandemic, COVID-19 has continued to further spread throughout the world.²⁻⁴ Based on the historical effectiveness of vaccines in controlling infectious disease epidemics, the establishment of herd immunity through the COVID-19 vaccination programme has

been well-accepted as the most reliable and cost-effective strategy to bring the pandemic to an end.²⁻⁴

Currently, a free national COVID-19 vaccination programme has been launched in spring 2021 and is ongoing across the country in China. In order to guide the programme implementation, the ‘*Technical Guideline for Vaccination against COVID-19 (1st Version)*’ was instituted by the National Health Commission on 29 March 2021.⁵ As this national guideline delineates, five COVID-19 vaccines (including three inactivated vaccines, an adenovirus vector vaccine and a recombinant subunit vaccine) have been granted conditional licensure or emergency use authorisation in China.⁵ To date, no prior study has been conducted to understand practical implementation of the Chinese vaccination programme against COVID-19.

University students have been included as the targeted population in several previous studies investigating their COVID-19 vaccine acceptance.⁶⁻¹⁰ As an insightful population, university students are considered to be generally open-minded and educated individuals who can quickly respond to public health issues.⁶⁻¹⁰ Moreover, because the university students mostly live with roommates in on-campus or off-campus housing, and frequently travel between their homes and universities, they might be more exposed to the risk of COVID-19 infection and act as active ‘*superspreaders*’.⁸ Therefore, assessing knowledge and attitudes regarding COVID-19 vaccines among the university students as well as their vaccination practices requires special attention.

Here, we conducted a questionnaire-based survey to preliminarily evaluate the practice of COVID-19 vaccination among the Chinese students from a comprehensive university in Wuhan, where the first cases of COVID-19 syndrome with unknown origin were identified in early December 2019. Moreover, the potential factors associated with the students’ knowledge, awareness and attitudes towards COVID-19 vaccines were assessed. Findings from this study could contribute to determine the motivating factors and barriers to the practical uptake of COVID-19 vaccines and provide guidance to better implement the COVID-19 vaccination programme in China and around the world.

METHODS

Study design

In this cross-sectional survey, a self-developed questionnaire was sent online to the Chinese university students to assess their vaccination practices, as well as knowledge and attitudes regarding COVID-19 vaccines. The student respondents were recruited from the Wuhan University of Science and Technology, a comprehensive university located in Wuhan City, Hubei Province, China. In response to the national COVID-19 vaccination programme, the sampled university officially began the vaccination campaign for all enrolled students and staff on 1 April 2021. This anonymous survey was conducted

between 1 and 20 May 2021, that is, at 1 month after the commencement of the university vaccination program. During this period, no indigenous case was reported in Wuhan, but imported cases from abroad continued to be found in Chinese cities outside Wuhan.

Questionnaire

The initial draft of the questionnaire was designed by the research team. The clarity, content validity, relevance and conciseness of the questionnaire items were evaluated by two specialists in survey research. Pretesting of the survey questionnaire was performed on a convenience sample, including 20 students in the sampled university who were not included in the final survey, to examine the acceptability and validity of the questionnaire. After a minor modification in the wording and contents based on feedbacks from 2 specialists and 20 student respondents mentioned previously, the survey questionnaire was finalised.

The final questionnaire included a total of 27 structured questions organised into four sections (see online supplemental file 1). The first section consisted of six questions (Q1–6) about the respondents’ sociodemographic indicators, including gender, grade, age and profession, and two additional questions about whether the respondents had ever been infected with COVID-19 and whether the respondents’ family members, relatives or friends had ever been infected with COVID-19.

The second section included five single-choice questions (Q7–11) to investigate the vaccination practices for COVID-19. Concretely speaking, the respondents were asked whether they had been vaccinated against COVID-19 (Q7), the type of COVID-19 vaccines that they received (Q8), the information sources about COVID-19 vaccination (Q9) and the place of vaccination (Q10). Furthermore, the respondents were required to describe their feelings when they heard that the COVID-19 vaccination programme had covered the university (Q11).

The third section included elements designed to measure the knowledge regarding COVID-19 vaccines. First, Q12 was designed to be answered on a 5-point Likert scale, ranging from ‘know nothing’ (score of 1) to ‘know everything/expert’ (score of 5), for a self-evaluation of knowledge levels pertaining to COVID-19 vaccines. Then, in order to objectively assess the respondents’ actual knowledge levels, students were asked six scoring knowledge questions about the contents of the ‘*Technical Guideline for Vaccination against COVID-19 (1st Version)*’,⁵ including the number of COVID-19 vaccines that have been granted conditional licensure or emergency-use authorisation in China (Q13), the required doses of vaccines (Q14) and the time interval of vaccination visits (Q15), the applicable population (Q16) and limits (Q17) of vaccination, as well as the necessity of nucleic acid and antibody testing for SARS-CoV-2 before vaccination (Q18). A knowledge score of 0 was received for each incorrectly answered question and 1 for correctly

answered question. The maximum objectively assessed knowledge score was 6 and the minimum was 0.

The last section was designed with nine questions, to capture the opinions and attitudes of university students towards COVID-19 vaccines and vaccination. The attitude-related questions in this section included six questions (Q19–Q24) framed into a 5-point Likert scale format (1: strongly disagree to 5: strongly agree), with the other three being single-choice questions (Q25–Q27). Just before the survey, the Chinese news media reported an incident that a hospital laboratorian still contracted COVID-19 after vaccination, and the attitude of respondents towards this incident was assessed in Q25. In addition, Q26 and Q27 were designed to evaluate the most important perceived contributing factor and the biggest concern regarding COVID-19 vaccination, respectively.

The Cronbach's α value or the Kaiser-Meyer-Olkin measure of the final questionnaire was higher than 0.700. The questionnaire was developed in English as the original language, and then translated into Chinese using forward and back translation to avoid misinterpretation.

Data collection and sample size

After obtaining written informed consent, an online questionnaire was administered face to face to students by the research team members during the class breaks to encourage students to participate in this survey. The student participants were informed about the aims of this survey as an explanatory letter at the beginning of the questionnaire. The respondents were required to complete the questionnaire within 15 min. The included study population was the enrolled university students who voluntarily participated in the survey and fully completed the questionnaire within the required time period.

A widely used sample size equation [sample size = $Z_{1-\alpha/2}^2 p(1-p)/d^2$] for cross-sectional study (qualitative variable), which was shown in a review conducted by Charan and Biswas,¹¹ was applied to determine the sample size. In this study, $Z_{1-\alpha/2}$ is standard normal variable at 5% type 1 error ($p < 0.05$), which is 1.96. The p is the expected proportion of participants received vaccination. Because the acquired vaccine uptake rate among the university student respondents was 75%, the p value was 0.75. The d value is the precision/absolute error of 5% and at type 1 error of 5%. Using the previous equation, a sample size of 288 was calculated for this study. The eventually collected data were from 359 participants.

Statistical analysis

The collected data were entered into SPSS V.25.0 for analysis. Results were shown as numbers (percentages) for categorical variables and mean \pm SD for quantitative variables. The categorical data were statistically analysed using the χ^2 test. The independent t-test was applied to compare the mean knowledge scores of the two groups. One-way analysis of variance with post hoc Tukey's honestly significant difference analysis for multiple comparisons was

conducted to detect differences between pairwise groups. $p < 0.05$ or $p < 0.01$ was deemed statistically significant.

Patient and public involvement

Patients and the public were not involved in the design and conception of this study.

RESULTS

Characteristics of the study cohort

By the end of the survey period, a total of 359 valid questionnaires were obtained. The other 16 questionnaires were excluded because they were not completed within the required time period (15 min). The included student respondents' characteristics are reported in table 1. The sample included a group of university students at an average age of 20.13 ± 1.70 years. The gender and profession distributions of respondents were balanced. Of the 359 respondents, most were studying in the undergraduate programme, whereas 3% were at postgraduate stage. Only a few respondents (12 out of 359; 3%) indicated that someone from their family, relatives or friends had ever been infected with SARS-CoV-2. This rate is in accord with the average disease morbidity calculated based on official data, which is 3.49% in Hubei Province.¹²

Vaccination practices for COVID-19 among Chinese university students

Among the 359 subjects studied, the overall coverage rate for COVID-19 vaccination was 75%. As shown in table 1, no statistically significant differences in vaccine uptake rates were identified in terms of sociodemographic features, including gender, grade, age and profession. The χ^2 test showed that, compared with respondents that reported being diagnosed with COVID-19, those without experience of COVID-19 infection were more likely to get vaccinated ($p = 0.018$).

Other aspects of COVID-19 vaccine uptake practices among Chinese university students are presented in figure 1. First, the respondents were required to choose the type of COVID-19 vaccines that they received. Five types of COVID-19 vaccines included in the 'Technical Guideline for Vaccination against COVID-19 (1st Version)⁵, were provided as options. With the exception of the non-vaccinated who accounted for 25% of the respondents, over half of all respondents chose 'the SARS-CoV-2 inactivated vaccine (Vero cells)' and 20% stated that they did not know clearly which type of COVID-19 vaccines they had received (figure 1A). As for the information sources about COVID-19 vaccination, approximately 57% of students get the related information through the official announcements released by the university and 30% through the social media (internet TV, etc) (figure 1B). With regard to the place of vaccination, the majority of participants got vaccinated at the vaccination place uniformly arranged by the university (figure 1C). In addition, most students reported that they felt 'strongly expectant' or 'expectant' when they heard that the COVID-19 vaccination programme had covered

Table 1 Demographic information, COVID-19 vaccine uptake rates and self-evaluated and objectively assessed knowledge scores of Chinese university student respondents (n=359).

Characteristics	Number (%)	Number of students who had received COVID-19 vaccination (%)	Self-evaluated knowledge score (mean±SD)	Objectively assessed knowledge score (mean±SD)
Gender				
Male	169 (47)	123 (34)	3.51±0.77*	2.95±1.28
Female	190 (53)	148 (41)	3.31±0.75	3.14±1.21
Age				
≥20 years	204 (57)	117 (32)	3.40±0.76	3.09±1.22
<20 years	155 (43)	154 (43)	3.41±0.77	2.99±1.27
Grade				
First-year undergraduates	124 (35)	95 (26)	3.44±0.80	2.94±1.29
Second-year undergraduates	91 (25)	70 (19)	3.42±0.72	3.04±1.13
Third-year undergraduates	22 (6)	13 (4)	3.14±0.64	3.41±1.44
Fourth-year undergraduates	95 (27)	69 (19)	3.41±0.79	3.04±1.20
Fifth-year undergraduates	15 (4)	14 (4)	3.33±0.90	2.87±0.99
Graduate students	12 (3)	10 (3)	3.50±0.52	3.83±1.59
Profession				
Healthcare professional	170 (47)	127 (35)	3.41±0.77	3.15±1.26
Non-medical professional	189 (53)	144 (40)	3.41±0.76	2.96±1.22
Whether the respondents had ever been infected with COVID-19?				
Yes	4 (1)	1 (0) *	3.50±1.29	2.25±0.96
No	355 (99)	270 (75)	3.41±0.76	3.06±1.24
Whether the respondents' family members, relatives or friends had ever been infected with COVID-19?				
Yes	12 (3)	10 (3)	3.25±0.87	3.00±1.13
No	347 (97)	261 (72)	3.41±0.76	3.05±1.25

*p value is less than 0.05.

the university, and only a fraction were 'neutral' and none 'strongly disliked' (figure 1D).

Knowledge levels regarding COVID-19 vaccines

First, the respondents' knowledge levels regarding COVID-19 vaccines were self-evaluated using a 5-point Likert scale. The mean self-evaluated knowledge score for 359 student participants was 3.41±0.76. As shown in table 1, the self-evaluated knowledge scores were found to be different between genders by conducting an independent t-test (p=0.011). The mean score for the males was higher than that of the females.

Then, the actual knowledge levels regarding COVID-19 vaccines were objectively tested using six close-ended questions (each question when answered correct had a score of 1, and the total score was 6). The mean objectively assessed knowledge test score for 359 student participants was 3.05±1.24. As shown in table 1, there was no significant difference in actual test score of the knowledge by gender, grade, age, profession or experience of COVID-19 infection (p>0.05).

Furthermore, we compared the knowledge scores of respondents who had and had not received the COVID-19

vaccination. As shown in table 2, the self-evaluated and objectively assessed knowledge scores of the vaccinated students were markedly higher than those of the non-vaccinated (p<0.05), suggesting that there might be a significant association between the successful uptake of COVID-19 vaccines and the knowledge level among Chinese university student respondents.

Chinese university students' attitudes towards COVID-19 vaccines and vaccination

As shown in table 3, Chinese university students' overall attitudes towards COVID-19 vaccines and vaccination were very positive. The importance of the establishment of herd immunity through the COVID-19 vaccination programme for pandemic control was supported or strongly supported by an overwhelming majority of student respondents. Of all respondents, 74% had the opinion that the imported COVID-19 vaccines produced by international pharmaceuticals in America or Europe are no better than the domestically produced vaccines in China, and approximately 87% disagreed or strongly disagreed with the statement 'if everyone else was vaccinated, I wouldn't need to get vaccinated'. Most of the

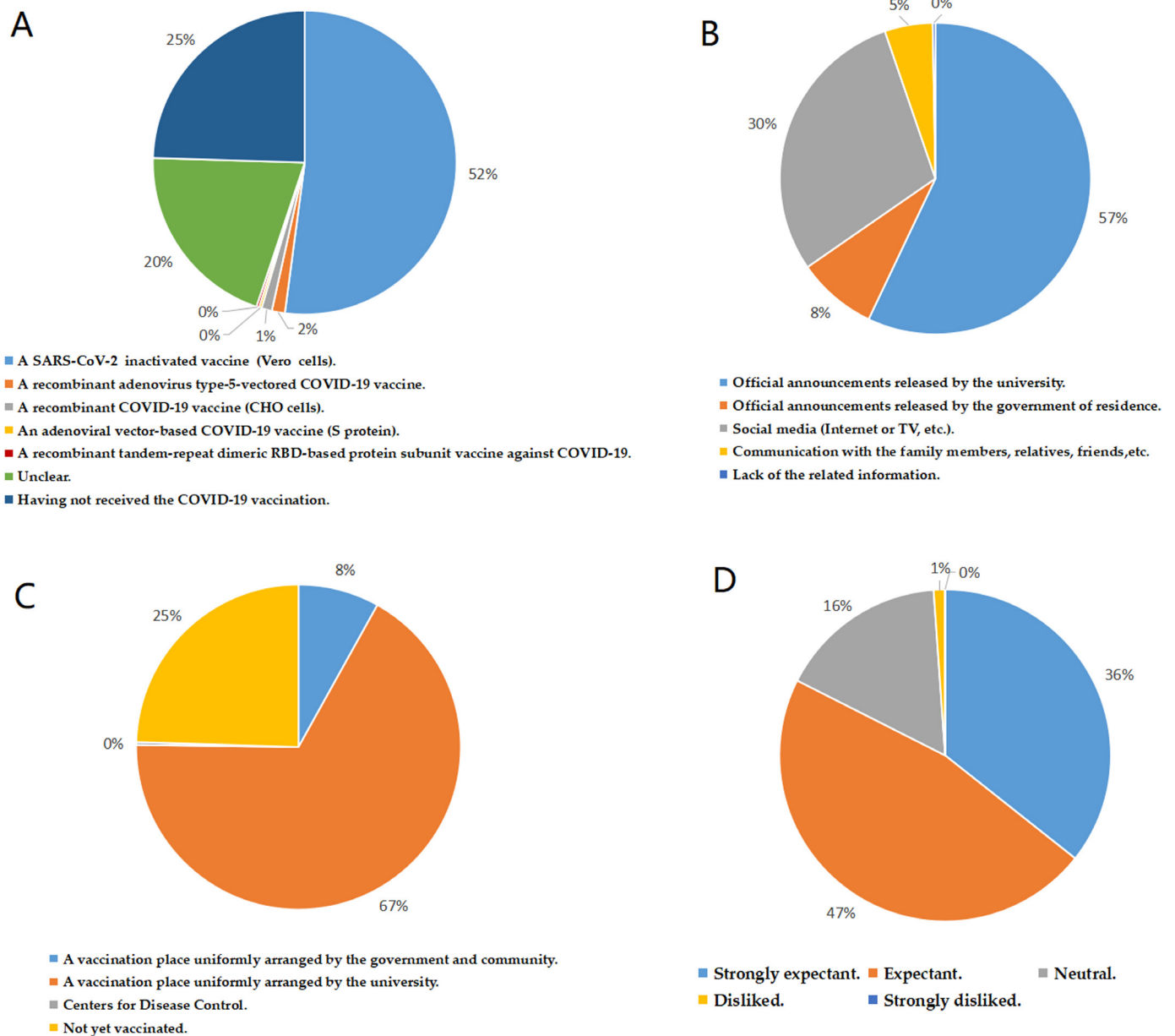


Figure 1 The COVID-19 vaccine uptake practices among Chinese university students (n=359). (A) Type of COVID-19 vaccines that the respondents had received; (B) information sources about COVID-19 vaccination; (C) place of vaccination; (D) the respondents' feelings when they heard that the COVID-19 vaccination programme had covered the university.

respondents (64%) stated that they were willing to pay for the COVID-19 vaccine if payment was required. Moreover, the majority of (66%) participants believed that the current supply of COVID-19 vaccines was adequate, and

the safety of COVID-19 vaccination was supported by the vast majority of (89%) respondents.

Then, we investigated the attitudes of respondents towards a social news report saying that a hospital

Table 2 Association between the successful uptake of COVID-19 vaccines and the self-evaluated or objectively assessed knowledge scores of Chinese university student respondents (n=359)

Vaccination practice	Self-evaluated knowledge score		Objectively assessed knowledge score	
	Mean±SD	p value	Mean±SD	p value
Respondents who had received the COVID-19 vaccination (n=271)	3.46±0.75	0.026	3.14±1.21	0.012
Respondents who had not received the COVID-19 vaccination (n=88)	3.25±0.78		2.76±1.30	

Table 3 Chinese university students' attitudes towards COVID-19 vaccines and vaccination (n=359)

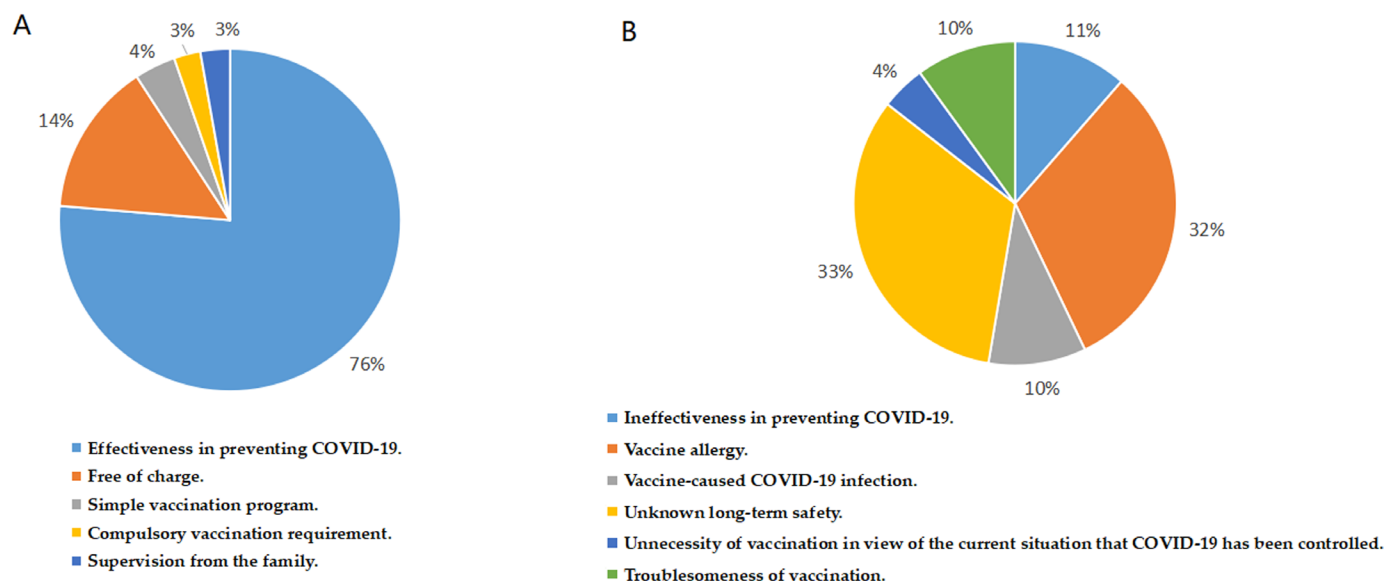
Survey question/statement	Responses, number (%)				
	Strongly agree	Agree	Undecided	Disagree	Strongly disagree
Q19: In order to bring the pandemic to an end, it is important to establish herd immunity through a COVID-19 vaccination programme.	213 (59)	135 (37)	9 (3)	2 (1)	0 (0)
Q20: The imported COVID-19 vaccines produced by international pharmaceuticals in America or Europe are better than the domestically produced vaccines in China.	18 (5)	20 (6)	53 (15)	184 (51)	84 (23)
Q21: If everyone else is vaccinated, I wouldn't need to get vaccinated.	12 (3)	17 (5)	20 (5)	189 (53)	121 (34)
Q22: I am willing to pay for the COVID-19 vaccine if payment is required.	30 (8)	192 (54)	87 (24)	44 (12)	6 (2)
Q23: Based on the vaccination experience of myself or of others, I think the current supply of COVID-19 vaccines is adequate.	66 (18)	173 (48)	78 (22)	37 (10)	5 (2)
Q24: Based the vaccination experience of myself or of others, I think the COVID-19 vaccination is safe.	118 (33)	202 (56)	38 (11)	1 (0)	0 (0)

laboratorian still contracted COVID-19 after vaccination. Results showed that the vast majority of (89%) respondents still showed a very positive attitude to COVID-19 vaccination. They advocated that 'All for one and one for all'. In addition, 6% claimed that 'It doesn't matter', and only few (5%) student respondents showed negative attitudes towards this incident and agreed with the statement that 'Since the effectiveness of the vaccines in preventing COVID-19 cannot be 100%, I don't want to get vaccinated'.

At the end of the questionnaire, the student participants were asked the question, 'What is the most important perceived factor contributing to the COVID-19 vaccination?' (figure 2A). Majority of (76%) students chose the factor 'effectiveness in preventing COVID-19' and 14% chose 'free of charge'. As for the biggest concern about COVID-19

vaccination (figure 2B), approximately one-third of students (33%) were worried about 'unknown long-term safety' of the vaccines; another one-third (32%) were afraid of 'vaccine allergy'.

There were no significant attitude differences regarding the sociodemographic variables ($p>0.05$). When assessing for the differences in attitudes towards COVID-19 vaccines between respondents who had and had not received the COVID-19 vaccination, we only found the responses from the question on the importance of establishing herd immunity through the COVID-19 vaccination programme for pandemic control (Q19) to be significantly different. When answering this question, the vaccinated students showed more positive attitudes than the non-vaccinated ones did ($p=0.011$).

**Figure 2** The most important perceived contributing factor (A) and the biggest concern (B) regarding COVID-19 vaccination.

DISCUSSION

Although there has been a growing body of literature studying the COVID-19 vaccination intention of university and college students,^{6–10} to date, few studies¹³ have emerged describing the actual vaccination behaviour of this population group. Moreover, it has been demonstrated that vaccine intentions do not always follow uptake.¹³ Therefore, more studies monitoring the COVID-19 vaccination coverage are needed. To the best of our knowledge, our study is the first to examine the vaccination practices for COVID-19 vaccines among Chinese university students and to analyse their associated knowledge and attitude factors. Researchers estimated that, in order to achieve herd immunity against SARS-CoV-2, up to 55%–82% of the population might need to be vaccinated.^{14,15} In the present study, we found that, just 1 month after the commencement of the university vaccination process, 75% of responding university students recruited from a university located in Wuhan City, Hubei Province, China, had received the COVID-19 vaccination, reaching or almost reaching the suggested vaccine-derived COVID-19 herd immunity threshold. The COVID-19 vaccination coverage rate of 75% obtained in our study is in line with the previous finding from a cross-sectional study conducted among Chinese college students nationwide from 27 December 2020 to 18 January 2021,⁶ reporting that 76.3% were willing to accept COVID-19 vaccination in the future but is higher than data from a recently published study examining the COVID-19 vaccination coverage among American college students during February and March 2021.¹³ In this cross-sectional survey conducted in a university in New Jersey,¹³ the authors found that only 23% of American college student respondents reported already being vaccinated, despite the fact that 52.8% of the non-vaccinated students expressed the intention to receive the vaccines. Therefore, our preliminary finding suggested a rapid and effective progress of the national COVID-19 vaccination programme in China among the university students.

Keckojevic *et al.*¹³ proposed that family encouragement might play an important role in COVID-19 vaccine acceptance among American college students. In this study, the sampled university is located at Wuhan city, where the first cases of COVID-19 were identified. This comprehensive university enrolls students from all over the country. Most enrolled students are not locals to the Wuhan City. Conceivably, their family members, relatives or friends might be anxious about the possible COVID-19 infection of students in Wuhan during the postepidemic period. However, only 6% of student respondents received information about the COVID-19 vaccination through communication with their family members, relatives, friends, etc. In fact, more than half reported that their information source was the official announcements released by the university. Moreover, we found that most student respondents were vaccinated against COVID-19 at the university hospital, a vaccination place uniformly arranged by the university. These data suggested that taking official

actions using administrative powers in a rapid, organised and detailed fashion might be necessary to ensure the implementation of a COVID-19 vaccination programme.

Some previous surveys on the university/college students' COVID-19 vaccination intention^{6,9} indicated that those studying health-related courses were more likely to have positive attitudes towards COVID-19 vaccines and report higher acceptance of COVID-19 vaccination. The study conducted by Keckojevic *et al.*¹³ also showed that students employed as healthcare workers were more likely to get vaccinated. Therefore, our study designed expressly a balanced profession distribution of respondents for comparing the vaccine uptake practice in healthcare professionals and nonmedical professionals. However, we found no difference in COVID-19 vaccine uptake practice between healthcare professional and non-medical professional participants, which is in accordance with a study in Italy⁸ showing no difference in COVID-19 vaccine acceptance between healthcare and non-healthcare students. Such a discrepancy might be due to the possible gap between vaccination intention and practice, or the different study periods, areas and social backgrounds.

In the Wuhan area, only the SARS-CoV-2 inactivated vaccines (Vero cells) were available during the survey period. During that time, the sampled university was continuously provided with the inactivated vaccines produced by Sinopharm Group, China, Wuhan Institute of Biological Products Research Institute Co Ltd, which were granted conditional licensure on 25 February 2021. Interestingly, although the overall vaccine uptake rate was 75% among the responding university students, nearly one-third of the vaccinated respondents (84/271 vaccinees) did not clearly know or mistakenly stated the type of COVID-19 vaccines that they had received. This finding indicated that a considerable proportion of students had relatively poor knowledge regarding COVID-19 vaccination and vaccines, despite the fact that they had experienced good vaccination practice, which was in line with the results of knowledge level assessment. In this study, although the mean value of self-evaluated scores for knowledge about COVID-19 vaccines was 3.41 out of a total of 5, the average score for the objective knowledge test was only 3.05 out of a total of 6. Results suggested that many respondents, particularly the males, had an inaccurate self-evaluation of their COVID-19 vaccine knowledge levels, and the actual knowledge was poor. As the uptake of vaccines is a voluntary health behaviour, generally, any vaccination programme's effectiveness is to some extent dependent on the participants' awareness towards the vaccines.^{15–17} However, emerging evidence has shown that the vaccine/virus knowledge is not associated with the intent to vaccinate with COVID-19 vaccines.^{18,19} Nevertheless, we found that higher self-evaluated and actual knowledge scores were obtained among the vaccinated participants. As this survey is a retrospective study, it is unclear whether a deep understanding of vaccines acted as a driver for increased vaccine uptake, or whether the

vaccination experience enhanced the related knowledge of the vaccinated students. Thus, the association between knowledge and practices regarding vaccination was still indeterminate.

Besides vaccine knowledge, the attitude towards vaccines is believed to be another important predictor of vaccination.^{15–17} The present survey demonstrated that the Chinese university students' overall attitudes towards COVID-19 vaccination and vaccines were very positive. The vast majority of students agreed or strongly agreed with the importance of herd immunity and vaccination programme for COVID-19. Although the current COVID-19 vaccination programme in China is free of charge, more than half of student respondents showed the willingness to pay for the COVID-19 vaccine if payment was required. Accordingly, most students reported that they looked forward to getting COVID-19 vaccines when they heard that the COVID-19 vaccination programme had covered the university. Especially, when expressing their attitudes towards the fact that the effectiveness of vaccines in preventing COVID-19 cannot be 100%, most students still claim that they will actively participate in the national COVID-19 vaccination programme to achieve herd immunity. Similar positive attitudes and opinions towards COVID-19 vaccination have been reported in previous surveys conducted among US medical students²⁰ and college students in New Jersey,¹³ which were in accordance with the positive and responsible personality characteristics in this population group. Moreover, most responding students expressed their positive appreciation for the domestically produced vaccines in China, as well as their current supply and safety. Patriotism and nationalism among Chinese university students might be a reason for their active participation in the national COVID-19 vaccination programme.

No difference in either of the involved sociodemographic features, including gender, grade, age or profession, was found between the vaccinated and non-vaccinated groups, suggesting that these demographic variables were not predictive of COVID-19 vaccine uptake. However, we found that students who had been infected with COVID-19 were less likely to receive the COVID-19 vaccines, which might be because they thought they had developed immunity against COVID-19. Furthermore, we found that vaccinated students were more sure of the importance of establishing herd immunity through the COVID-19 vaccination programme for pandemic control than the non-vaccinated students were, suggesting that the likelihood of receiving the COVID-19 vaccine increased when the significance of vaccination and herd immunity was valued. Accordingly, the '*effectiveness in preventing COVID-19*' was almost unanimously perceived by respondents as the most important factor contributing to the COVID-19 vaccination. Therefore, enhancing the belief in vaccines' effectiveness will be able to encourage COVID-19 vaccine uptake. However, the answers about the biggest concern regarding COVID-19 vaccination were divergent. Previous studies^{18–21} have shown that

continually hearing about the severe adverse effects of the vaccines from vaccinees made others feel more hesitant towards vaccination. Among the options for candidate concerns (Q27), the items '*unknown long-term safety*', '*vaccine allergy*' and '*vaccine-caused COVID-19 infection*' are all the possible adverse effects of COVID-19 vaccines. We found that a total of 76% of respondents were worried about these vaccine safety-related issues. In spite of this, the vaccination rate observed in the present study was 75%, suggesting that the concerns about safety issues appeared not to affect the actual uptake of COVID-19 vaccines.

One of major limitations of this survey was that it only captured the vaccination practices, knowledge and attitudes of respondents in a certain stage of the pandemic (between 1 and 20 May 2021); consequently, the results might not be generalisable outside the defined scope of the current study. Moreover, during our survey period (between 1 and 20 May 2021), the Chinese national COVID-19 vaccination programme was rapidly advancing across the country. Considering dynamically updated data on the vaccination practices, in order to quickly acquire the real-time information about the situation of COVID-19 vaccination programme advancement among Chinese university students at 1 month after the commencement of the university vaccination process, we used the easiest convenient sampling in this survey by which data collection can be facilitated in short duration of time. The survey was based on a convenience sample who were voluntarily recruited from a certain university. This methodological issue of convenience sample is another major limitation of this survey, which might be vulnerable to selection bias and sampling error. Because of the single-centre nature of the study and the convenience sample methodology, it is unclear whether the involved respondents were well representative of the university student population. Better sampling methodology is needed to replicate and expand our preliminary findings. Nevertheless, our study provided some real-time information about the practical implementation of the Chinese national COVID-19 vaccination programme.

In conclusion, this cross-sectional study about the vaccination practices for COVID-19 vaccines were surveyed among 359 student respondents recruited from a comprehensive university in Wuhan City, Hubei Province, China, and the associated knowledge and attitude factors were analysed. We found that, just 1 month after the commencement of the university vaccination process, the overall coverage rate for COVID-19 vaccination among the responding students was 75%. The demographic variables, including gender, grade, age and profession, were not predictive of COVID-19 vaccine uptake. However, students who had been infected with COVID-19 were less likely to receive the COVID-19 vaccines than the uninfected. The official announcements released by the university were the main sources of information about COVID-19 vaccination, and the university hospital was the most popular place of vaccination. However, the student

respondents lacked knowledge about COVID-19 vaccines. In addition, Chinese university students' overall attitudes towards COVID-19 vaccines and vaccination were very positive. The vaccinated students showed more positive attitudes than the non-vaccinated did. The effectiveness in preventing COVID-19 was perceived as the most important contributing factor for COVID-19 vaccination. These preliminary findings suggested that taking official actions in a rapid, organised and detailed fashion, as well as enhancing the belief in vaccines' effectiveness, might be necessary to ensure the good implementation of a COVID-19 vaccination programme among the university students.

Contributors XH and DY contributed to the study design, interpretation of results and commented on drafts of the paper. ML and SW contributed to the preparation of the data set and interpreted results. JW conceived of the original idea for the study, designed the questionnaire, obtained ethical approval, carried out the statistical analysis, drafted the paper and is overall guarantor.

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TRANSLATED QUESTIONNAIRE**1- Socio-demographic characteristics.**

Q1: Gender Male Female

Q2: Age () years

Q3: Grade First-year undergraduate Second-year undergraduate
 Third-year undergraduate Fourth-year undergraduate
 Fifth-year undergraduate Graduate student

Q4: Profession Healthcare professional Nonmedical professional

Q5: Whether you had ever been infected with COVID-19?

Yes No

Q6: Whether your family members, relatives or friends had ever been infected with COVID-19?

Yes No

2- Vaccination practices for COVID-19

Q7: Whether you had been vaccinated against COVID-19?

Yes No

Q8: Which type of COVID-19 vaccines have you received?

- A SARS-CoV-2 inactivated vaccine (Vero cells).
- A recombinant adenovirus type-5-vectored COVID-19 vaccine.
- A recombinant COVID-19 vaccine (CHO cells).
- An adenoviral vector-based COVID-19 vaccine (S protein).
- A recombinant tandem-repeat dimeric RBD-based protein subunit vaccine against COVID-19.
- Unclear.
- Having not received the COVID-19 vaccination.

Q9: Where did you get information about COVID-19 vaccination?

- Official announcements released by the university.
- Official announcements released by the government of residence.
- Social media (Internet or TV, etc.).
- Communication with the family members, relatives, friends, etc.
- Lack of the related information.

Q10: Where did you receive the COVID-19 vaccines?

- A vaccination place uniformly arranged by the government and community.
- A vaccination place uniformly arranged by the university.
- Centers for Disease Control.
- Not yet vaccinated.

Q11: How did you feel when you heard that the COVID-19 vaccination program had covered the university?

- Strongly expectant.
- Expectant.
- Neutral.
- Disliked.
- Strongly disliked.

3- Knowledge regarding COVID-19 vaccines.

Q12: Please self-evaluate your knowledge levels pertaining to COVID-19 vaccines:

“know nothing” (score of 1) to “know everything/expert” (score of 5)

- Score of 1.
- Score of 2.
- Score of 3.
- Score of 4.
- Score of 5.

Q13: How many COVID-19 vaccines have been granted conditional licensure or emergency-use authorization in China?

- 1
- 2
- 3
- 4
- 5

Q14: How many doses of SARS-CoV-2 inactivated vaccine (Vero cells) should be administered?

- 1
- 2
- 3
- 4
- 5

Q15: If an individual receives the SARS-CoV-2 inactivated vaccines (Vero cells), how long should the time interval of vaccination visits be?

- ≥ 1 week.
- ≥ 2 weeks.
- ≥ 3 weeks.
- ≥ 4 weeks.
- ≥ 5 weeks.

Q16: Who should receive COVID-19 vaccines?

- Healthy people without experience of COVID-19 infection.
- People with experience of COVID-19 infection.
- People aged 18 and above.
- People aged 3 and above.
- All the people.

Q17: Which is NOT contraindication to COVID-19 vaccination?

- Someone with a fever.
- Pregnant woman.
- Someone with a history of an allergic reaction to similar vaccines.
- Someone with uncontrolled epilepsy.
- Chronic disease patients aged 65 and above.

Q18: Is it necessary to undergo nucleic acid and antibody testing for SARS-CoV-2 before vaccination?

- Yes No

4- Opinions and attitudes toward COVID-19 vaccines and vaccination

Q19: In order to bring the pandemic to an end, it is important to establish herd immunity through a COVID-19 vaccination program.

- Strongly disagree. Disagree. Neutral. Agree. Strongly agree.

Q20: The imported COVID-19 vaccines produced by international pharmaceuticals in America or Europe are better than the domestically produced vaccines in China.

- Strongly disagree. Disagree. Neutral. Agree. Strongly agree.

Q21: If everyone else is vaccinated, I wouldn't need to get vaccinated.

- Strongly disagree. Disagree. Neutral. Agree. Strongly agree.

Q22: I am willing to pay for the COVID-19 vaccine if payment is required.

- Strongly disagree. Disagree. Neutral. Agree. Strongly agree.

Q23: Based on the vaccination experience of myself or of others, I think the current supply of COVID-19 vaccines is adequate.

- Strongly disagree. Disagree. Neutral. Agree. Strongly agree.

Q24: Based the vaccination experience of myself or of others, I think the COVID-19 vaccination is safe.

- Strongly disagree. Disagree. Neutral. Agree. Strongly agree.

Q25: What do you think about a social news report saying that a hospital laboratorian still contracted COVID-19 after vaccination?

Negative. Since the effectiveness of the vaccines in preventing COVID-19 cannot be 100%, I don't want to get vaccinated.

Positive. All for one and one for all. I will actively participate in the national COVID-19 vaccination program to achieve the herd immunity.

- It doesn't matter.

Q26: What is the most important perceived factor contributing to the COVID-19 vaccination?

- Effectiveness in preventing COVID-19.
 Free of charge.
 Simple vaccination program.
 Compulsory vaccination requirement.

- Supervision from the family.

Q27: What is your biggest concern about COVID-19 vaccination?

- Ineffectiveness in preventing COVID-19.
- Vaccine allergy.
- Vaccine-caused COVID-19 infection.
- Unknown long-term safety.
- Unnecessity of vaccination in view of the current situation that COVID-19 has been controlled.
- Troublesomeness of vaccination.