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RESEARCH ARTICLE

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Change in willingness to COVID-19 vaccination in China: Two online surveys during the pandemic

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Abstract

Objective: As the variants of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) continue to emerge, periodic vaccine booster immunization may become a normal policy. This study investigated the changes and factors associated with vaccination intentions in various epidemic situations, which can provide suggestions for the construction and modification of routine vaccination program strategies.

Methods: Two cross-sectional online surveys were conducted in January and June of 2021. The willingness and confidence of the coronavirus disease 2019 (COVID-19) vaccination were measured following propensity score matching (PSM) treatment. The difference in the willingness for COVID-19 Vaccination in the two surveys was analyzed by single or multi-factor analyses.

Results: The willingness to accept the SARS-CoV-2 vaccine was higher in the second survey than that in the first survey (90.5% vs. 66.6%, $p < 0.001$). Concerns about the vaccine's safety declined (71.0% vs. 47.6%, $p < 0.001$), but concerns about the efficacy increased (22.4% vs. 30.9%, $p < 0.001$). Confidence in the SARS-CoV-2 vaccine had an important impact on the increased uptake willingness (odds ratio = 3.19, 95% confidence interval: 2.23–4.58, $p < 0.001$).

Conclusions: There has been a significant increase in attitudes towards the SARS-CoV-2 vaccine which was associated with higher vaccine confidence. Vaccine effectiveness received more concerns from respondents rather than safety after nearly 6 months' utilization of the SARS-CoV-2 vaccine. It indicates that aggressive communication and timely disclosure of vaccine data can build vaccine confidence.

KEYWORDS

propensity score matching, SARS-CoV-2 vaccine, vaccine acceptance, vaccine confidence, vaccine willingness

Ninghua Huang and Chao Wang should be considered of equal contributions.

1 | INTRODUCTION

As Omicron spreads over the world, the coronavirus disease 2019 (COVID-19) booster vaccination is considered to be a necessary long-term strategy to sustain the fight against the pandemic.[1,2] As of June 23, 2022, 91.74% of the population aged ≥3 years has received the full primary schedule of the COVID-19 vaccination; 62.6% of those vaccinated have received a booster shot.[3] However, compared with Delta, Omicron showed higher transmissibility and immune escape ability.[4,5] A study based on epidemiological data from Shanghai found that the level of immunity induced by the March 2022 vaccination campaign was insufficient to prevent Omicron's endemic. It would result in exceeding critical care capacity with a projected intensive care unit peak demand of 15.6 times of the existing capacity and causing approximately 1.55 million deaths.[6] The elderly and other vulnerable groups in China continue to receive insufficient vaccine protection against Omicron. Completed vaccination still bears the risk of decline of antibody levels and the emergence of variants with stronger infectivity, immune escape ability and even stronger virulence. China adopts a dynamic zero COVID strategy to deal with the highly transmissible severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) variant, vaccine boosters, and vaccination of the elderly are therefore essential in enhancing public health.

Vaccine hesitancy is a major barrier to the effectiveness of the COVID-19 vaccination programmers. Since the COVID-19 outbreak, a variety of surveys have been conducted to assess vaccine acceptance, with wide variation between countries, ranging from 40% to 90%.[7]

When China's COVID-19 immunization program began in December 2020, healthcare workers and high-risk groups were the priority to be vaccinated. A big countrywide online cross-sectional survey of 8743 people was conducted to examine public attitudes towards COVID-19 vaccination, as well as their desire and hesitation to be vaccinated. According to our previous findings, 67.1% of respondents were willing to get the SARS-CoV-2 vaccine, while 35.5% were apprehensive, and demographic characteristics such as education, gender, and occupation were found as key predictors at this stage.[8]

On the other side, the willingness to uptake the newly developed vaccine fluctuated throughout the pandemic.[9,10] More quantitative and qualitative studies of long-term vaccine promotion strategies should be conducted to track vaccination coverages and the related impactors over time. In this context, we repeated the survey in June 2021, during the peak of China's vaccination campaign, with the same questionnaire instrument, and a similar target group.

At present, it is impossible to predict the virulence trend of the new mutant of the virus, but it can be clearly judged that the COVID-19 epidemic has had significant periodic fluctuations. Therefore, it may be a normal measure to strengthen vaccination with periodic vaccinations. The purpose of this study was to compare the differences in willingness to uptake the SARS-CoV-2SARS-CoV-2 vaccine in these two stages, as well as to assess the attitude toward the SARS-CoV-2 vaccine, the reason behind the unwillingness to receive it, and factors associated with changes in willingness to be vaccinated under different epidemic backgrounds. We are about to provide evidence for the formulation and timely adjustment of normalized vaccination strategies.

2 | METHODS

2.1 | Study sampling and data collection

We conducted two cross-sectional surveys in January and June 2021, using the same questionnaire. The first survey was conducted when the priority populations were being vaccinated, and the second survey was the period after vaccination was permitted among people aged 3–17 years. An electronic questionnaire was created using the online survey platform of www.wjx.cn. The first questionnaire was available from January 21 to January 29, and the second was available from June 14 to June 29. The timeline of surveys, vaccination, and COVID-19 cases are shown in Figure 1.

2.2 | Vaccine confidence

We used seven items to assess the three aspects of vaccine confidence: trust in vaccine, delivery system, and government.

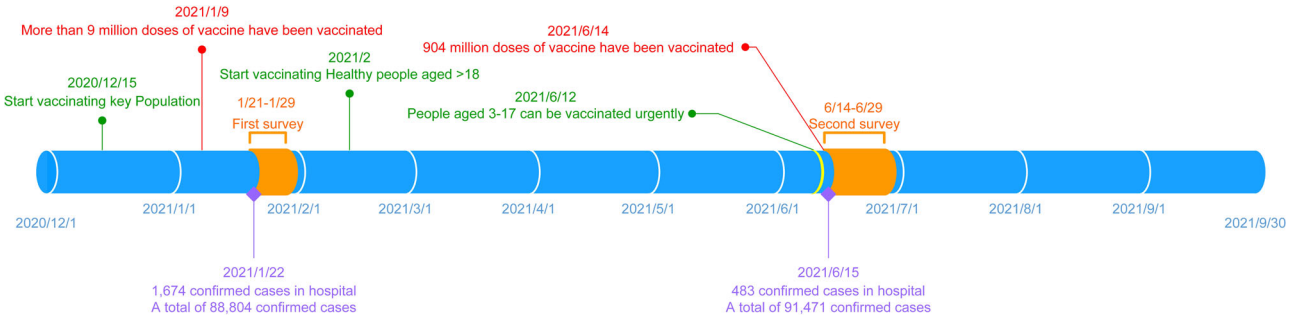

FIGURE 1 The timeline of surveys, vaccination and coronavirus disease 2019 (COVID-19) cases.

Trust in the SARS-CoV-2 vaccine was assessed by the extent to which people agree with the importance, effectiveness, and safety of the vaccine. Trust in the delivery system was measured based on confidence in healthcare providers, professional institutes, and vaccine manufacturers. Total trust in vaccines and delivery systems was scored from 3 to 9 on a scale of agree (trust score of 5) and disagree (trust score of 4). Confidence in government was measured by a question that was categorized as agree, uncertain or outright disagree and divided into agree and disagree (uncertain and disagree).

2.3 | Vaccination willingness

Participants were asked whether they were willing to vaccinate with SARS-CoV-2 vaccine. If they answered that they were very looking forward to or wanted to be vaccinated, it was defined as with vaccination willingness.

2.4 | Statistical analysis

Categorical variables are reported as absolute and relative frequencies, and the Chi-square test is used to determine discrepancies in their distributions. We utilized logistic regression to obtain an association of confidence (including vaccines, delivery, and government), anxiety state, degree of risk perception with vaccination willingness. The general characteristics including age, gender, education level, profession, and residence were involed as covariant. We maintained these variables and then examined the impact of each component separately. Odds ratio (OR) and the 95% confidence interval (CI) were estimated.

To minimize potential confounding bias arising from differences in baseline characteristics, propensity scores were calculated and matched to balanced covariates for the first and second surveys. Propensity score matching (PSM) is a statistical technique that helps to strengthen causal arguments in quasi-experimental and observational studies by reducing selection bias.[11] The first and second survey groups were paired 1:1 based on propensity scores from the nearest neighbor matching method. SPSS (version 22.0, IBM) was used for data cleaning and statistical analysis. PSM was conducted using R for statistical computing software (version 4.0.2; R Foundation for Statistical Computing, Vienna Austria). The difference was statistically significant at $p < 0.05$.

2.5 | Ethical approval

This study was approved by Peking University Institutional Review Board (IRB00001052-21001); exemption for informed consent was granted.

3 | RESULTS

3.1 | Socio-demographic characteristics of the sample

A total of 2579 questionnaires were received at the second survey. Ten were eliminated owing to IP addresses, and 67 were excluded due to quality issues or logical errors. Finally, the 2502 questionnaires were involved for analyses, with a 97.0% valid response rate. Participants came from mainland China, including South China (561, 22.4%), North China (546, 21.8%), and East China (502, 20.1%) as the top three regions.

In this survey, the inactivated vaccine had the highest vaccination rate among those who had had vaccinations (1911/2096, 91.1%), followed by the recombinant protein vaccine (83/2096, 3.96%) and the adenovirus vaccine (27/2096, 1.29%). A small percentage of the population was likewise unaware of the vaccine they had taken(75/2096, 3.58%).

3.2 | Comparison between two cross-sectional surveys

The demographic characteristics of the first survey group ($n = 8743$) and the second survey group ($n = 2502$) were shown in Table 1. Before PSM operation, there were significant differences in the following variables between the two surveys: region, sex, age, education level, and district ($p < 0.050$). After PSM, participants in the first ($n = 1992$) and the second ($n = 1992$) groups had similar demographic characteristics (Table 1). There were no statistically significant differences in demographic characteristics between respondents from the two surveys (SMD < 0.1, $p > 0.05$).

The participants from the second survey had a relatively higher vaccine willingness in accepting SARS-CoV-2 vaccines (66.6% vs. 90.5% $p < 0.001$) than in the first survey ($p < 0.001$) (Table 2). Trust in vaccines, delivery, and governance were also significantly increased at the second survey comparing to the first ($p < 0.001$).

3.3 | Willingness of COVID-19 vaccination

Participants who were hesitant or unsure about receiving the vaccination were asked to explain their rejection or reluctance. The results show that the safety and effectiveness of vaccines were among the top two concerns in both surveys (Table 3). Compared with the first survey, concerns about the vaccine's safety declined (71.0% vs. 47.6%, $p < 0.001$), while concerns about the vaccine's effectiveness grew significantly (22.4% vs. 30.9%, $p < 0.001$) in the second survey.

TABLE 1 PSM treatment to balance the participants' characteristics in two surveys

Demographic items		Unmatched			Matched		
		First	Second	*p* Value	First	Second	*p* Value
Sample size		8743	2502		1992	1992	
	Sex (%)			< 0.001			0.974
	Male	5535 (63.3%)	1380 (55.2%)		1164 (58.4%)	1163 (58.4%)	
	Female	3207 (36.7%)	1122 (44.8%)		828 (41.6%)	829 (41.6%)	
Age interval in years (%)				< 0.001			0.999
	<20	228 (2.6%)	227 (9.1%)		98 (4.9%)	98 (4.9%)	
	20–24	848 (9.7%)	231 (9.2%)		207 (10.4%)	206 (10.3%)	
	25–29	1556 (17.8%)	336 (13.4%)		285 (14.3%)	287 (14.4%)	
	30–34	1977 (22.6%)	324 (12.9%)		280 (14.1%)	280 (14.1%)	
	35–39	1300 (14.9%)	362 (14.5%)		326 (16.4%)	326 (16.4%)	
	40–44	915 (10.5%)	539 (21.5%)		400 (20.1%)	400 (20.1%)	
	45–49	762 (8.7%)	257 (10.3%)		224 (11.2%)	224 (11.2%)	
	50–54	615 (7%)	119 (4.8%)		111 (5.6%)	111 (5.6%)	
	55–59	279 (3.2%)	31 (1.2%)		29 (1.5%)	29 (1.5%)	
	60–64	76 (0.9%)	29 (1.2%)		12 (0.6%)	12 (0.6%)	
	65–69	62 (0.7%)	22 (0.9%)		10 (0.5%)	10 (0.5%)	
	70–74	60 (0.7%)	23 (0.9%)		8 (0.4%)	9 (0.5%)	
	≥75	64 (0.7%)	2 (0.1%)		2 (0.1%)	0 (0%)	
Education							0.999
	Junior high and below	474 (5.4%)	191 (7.6%)		465 (23.3%)	464 (23.3%)	
	Senior high	801 (9.2%)	223 (8.9%)		1797 (90.2%)	1794 (90.1%)	
	Bachelor	5547 (63.5%)	1572 (62.8%)		147 (7.4%)	147 (7.4%)	
	≥Master's degree	1920 (22%)	516 (20.6%)		48 (2.4%)	51 (2.6%)	
Residence				< 0.001			0.954
	Urban	6895 (78.9%)	2107 (84.2%)		76 (3.8%)	78 (3.9%)	
	Township	1331 (15.2%)	251 (10%)		145 (7.3%)	144 (7.2%)	
	Countryside	516 (5.9%)	144 (5.8%)		1306 (65.6%)	1306 (65.6%)	
Geographical zoning				< 0.001			1
	North China	356 (4.1%)	230 (9.2%)		159 (8%)	161 (8.1%)	
	Northeast region	2345 (26.8%)	546 (21.8%)		462 (23.2%)	462 (23.2%)	
	East China	2005 (22.9%)	502 (20.1%)		487 (24.4%)	486 (24.4%)	
	Central China	807 (9.2%)	561 (22.4%)		353 (17.7%)	351 (17.6%)	
	South China	657 (7.5%)	319 (12.7%)		224 (11.2%)	224 (11.2%)	
	Northwest	1739 (19.9%)	183 (7.3%)		176 (8.8%)	176 (8.8%)	
	Southwest	833 (9.5%)	161 (6.4%)		131 (6.6%)	132 (6.6%)	

Abbreviation: PSM, propensity score matching.

3.4 | Confidence in COVID-19 vaccination

There was no statistical difference in an increased willingness to COVID-19 vaccination among people of different gender, ages, education, residence, and geographical location (Table 4). Increased confidence in the SARS-CoV-2 vaccines had an important impact on the increased willingness, which was statistically significant (OR = 3.19, 95% CI: 2.23–4.58, $p < 0.001$). However, the changes of

confidence in vaccination institutions ($p = 0.084$) and the government ($p = 0.067$) had no statistically significant impact on the increased willingness to COVID-19 vaccination.

4 | DISCUSSION

We conducted two online surveys in mainland China, with data from the first survey (January 10–January 22, 2021) and the second survey (June 11–June 29, 2021). We found that attitudes toward vaccination became more positive, with increased confidence in vaccine trust, delivery system trust, and government trust in the second survey comparing to the first. The first survey was conducted during the first phase of the SARS-CoV-2 vaccine immunization strategy in China.[12] The second survey was during the third phase of China's immunization wave, and the vaccination population covers all people over 3 years of age. As of June 29, 2021, the total number of COVID-19 patients in China was 91 834, and the entire immunization coverage for the SARS-CoV-2 vaccine was 85.16%.[13] The gap in vaccination willingness between the two surveys can be interpreted in the context of different epidemics. The following reasons might be mostly responsible for the increase in vaccination willingness. First, the government was actively promoting the public's scientific understanding that the overall benefits of vaccination far outweigh the risk of the SARS-CoV-2 vaccine. Second, vaccination convenience was largely improved as vaccine supply had risen and immunization locations had been distributed more rationally. Finally, some sporadic outbreaks occurred in different areas of China between the first and second surveys.[14,15] The emergence of transmissible outbreaks had increased public awareness of the greater risk of contracting viruses than vaccine side effects, which contributes to their decisions to vaccinate.

The findings of both surveys suggested that many people expressed doubts or worries about the effectiveness and safety of vaccination. However, the focus of public confidence in the vaccine was not consistent at different phases. The focus of public concerns at initial phase of vaccination was more focused on the safety of the vaccine. According to the reasons for refusal and hesitation reported by participants in the first survey, people expressed more doubts or concerns about the safety of vaccination than other reasons. This finding is consistent with those of prior research.[16–20] However, compared to the first survey, the main concern for vaccine willingness in the second survey converted to effectiveness rather than the safety of the vaccine. This may be due to the rapid pace of current vaccine research, the short time to market, and the special emergency use procedures, all of which have led to a lack of public confidence in vaccine safety. Once the vaccine was administered on a large scale and safety has been proven, the lack of data on vaccine effectiveness and long-term sustainability ultimately leads to a decline in safety concerns and a rise in concerns about vaccine effectiveness.

TABLE 2 Analysis of willingness and vaccine confidence between two surveys after PSM treatment

Characteristics	First survey *n* (%)	Second survey *n* (%)	*p* value
Total willingness			
No	176 (8.8%)	49 (2.5%)	<0.001
Unsure	489 (24.5%)	141 (7.1%)	
Yes	1327 (66.6%)	1802 (90.5%)	
Vaccine trust			
No	639 (32.1%)	287 (14.4%)	<0.001
Yes	1353 (67.9%)	1705 (85.6%)	
Deliver trust			
No	419 (21%)	183 (9.2%)	<0.001
Yes	1573 (79%)	1809 (90.8%)	
Government trust			
No	368 (18.5%)	156 (7.8%)	<0.001
Yes	1624 (81.5%)	1836 (92.2%)	

Abbreviation: PSM, propensity score matching.

TABLE 3 Reasons for SARS-CoV-2 vaccine refusal or hesitancy in two surveys

Reasons	The first survey *n* (%)	The second survey *n* (%)	p-value
Worry about the SARS-CoV-2 vaccine safety	2041 (71.0%)	111 (47.6%)	<0.001
Low effectiveness of the SARS-CoV-2 vaccine	644 (22.4%)	72 (30.9%)	0.01
The leaders and colleagues do not take	149 (5.2%)	9 (3.9%)	0.44
The relatives and friends do not support the SARS-CoV-2 vaccine	91 (3.2%)	8 (3.4%)	0.85
Heathy enough and no need to receive the SARS-CoV-2 vaccine	214 (7.5%)	21 (9.0%)	0.37
It's safe in the country and no need to be vaccinated at this moment	528 (18.9%)	37 (15.9%)	0.38
Other reasons	651 (22.7%)	92 (39.5%)	<0.001

Abbreviation: SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

TABLE 4 Association between demographic characteristics, confidence, and increased willingness to COVID-19 vaccination

	Increased willingness to vaccinate	
	OR	*p*
Gender		
Female	Ref	
Male	1.16 (0.92–1.46)	0.204
Age		
<30	Ref	
30–39	1.04 (0.77–1.40)	0.802
40–49	1.29 (0.97–1.72)	0.085
50–59	0.70 (0.42–1.17)	0.174
≥60	0.54 (0.18–1.63)	0.277
Residence		
Urban	Ref	
Township	1.12 (0.73–1.73)	0.597
Countryside	1.00 (0.48–2.10)	0.996
Education		
Junior high and below	Ref	
Senior high	1.07 (0.55–2.09)	0.837
Bachelor	0.71 (0.40–1.26)	0.239
Master and above	0.62 (0.33–1.15)	0.127
Geographical location		
Northeast China	Ref	
North China	1.05 (0.65–1.72)	0.836
East China	1.52 (0.95–2.44)	0.081
South China	0.79 (0.47–1.32)	0.372
Central China	0.99 (0.58–1.70)	0.973
Northwest China	1.24 (0.72–2.16)	0.441
Southwest China	1.40 (0.77–2.54)	0.264
Confidence in vaccines	3.19 (2.23–4.58)	<0.001
Confidence in vaccination institutions	1.58 (0.94–2.66)	0.084
Confidence in the government	1.67 (0.96–2.90)	0.067

Abbreviations: COVID-19, coronavirus disease 2019; OR, odds ratio.
Ref: Compared with this group.

These two surveys sought to identify predictors of willingness to take the SARS-CoV-2 vaccine. According to the majority of previous studies, sociodemographic characteristics were significantly associated with the intention to receive the SARS-CoV-2 vaccine.[21–24] For instance, age,[8,22,25–29] income,[17,30–32] and education are all important factors that associate with the willingness to vaccination. However, our results did not provide comparable findings. This finding also implies that socio-demographic factors did not have a significant impact on vaccination intentions. Furthermore, socio-demographic variables are at most a collection of possible reasons for certain behaviors and can never fully account for them without additional research.

In our study, trust in the vaccine had the greatest impact on vaccination willingness, which was likely due to the rapid introduction of the SARS-CoV-2 vaccine, which had a greater impact on vaccination intention compared to other established vaccine products. In most studies, vaccine confidence was identified as having a positive impact on vaccination intention and vaccination coverages, including trust in the health system, government, and vaccine products.[18,19,30,33]

With the advent of the SARS-CoV-2 variants, the question of booster vaccination and the willingness of elderly persons to be vaccinated has become especially pressing. The duration of the epidemic boosts the public's risk perception of the SARS-CoV-2 vaccine, resulting in increased vaccination intentions. Health authorities, and regulatory agencies use health communication techniques on various media platforms to ensure that individuals are aware of their perceived risk of disease and positively promote vaccination. Moreover, timely disclosure of vaccine information is important for vaccination intentions, including data on vaccine effectiveness, safety, and persistence. Timely disclosure of data on vaccine durability and validity in the real world plays an important role in vaccine confidence, especially at a time when booster and elderly vaccination rates are being increased, which allows individuals to build vaccine trust and make informed decisions with confidence in the information they receive.

When considering the findings of this study, there are still some limitations of this study as follows. First, there are limitations in population representation. Although this study was designed to reflect the socio-demographic characteristics of the entire Chinese population, there was no random sampling in the selection of survey participants. In addition, this study is an internet-based survey, the sample size of older adults is relatively small due to difficulties in accessing the internet. Second, potential important confounders may not have been adjusted in this study. Information on risk perception, other potential confounders such as income, and health status were not included in this study due to data limitations. Therefore, it remains possible that the relationship between the variable factors included in the study and vaccine hesitancy is spurious. Finally, this study was an observational study, and therefore a causal relationship between explanatory and outcome variables could not be demonstrated.

5 | CONCLUSIONS

This study discovered a significant increase in willingness to get the COVID-19 vaccination during pandemics, and such change was connected with higher public trust in the vaccine, regardless of socio-demographic characteristics. Compared to the first survey,

respondents in the second survey were more concerned about vaccine effectiveness rather than safety. To ensure that vaccination can be regularized in the context of different epidemics, it is crucial to maintain public confidence in vaccines, and vaccine data must be actively communicated and disclosed in a timely manner.

AUTHOR CONTRIBUTIONS

Conceptualization: Fuqiang Cui, Chao Wang, and Ninghua Huang. Methodology: Bingfeng Han, Chao Wang, and Ninghua Huang. Investigation: Tianshuo Zhao, Bei Liu, Linyi Chen, Mingzhu Xie, Hui Zheng, Sihui Zhang, Yu Wang, Juan Du, YaQiong Liu, and QingBin Lu. Writing—Original draft preparation: Bingfeng Han and Ninghua Huang. Writing—review and editing: Fuqiang Cui, QingBin Lu, Chao Wang, and Ninghua Huang. All authors have read and agreed to the published version of the manuscript. N.H and C.W contributed equally to this study.

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CONFLICTS OF INTEREST

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

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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