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Willingness to pay and financing preferences for COVID-19 vaccination in China

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ABSTRACT

Background: The COVID-19 pandemic has caused significant diseases and economic burdens in the world. Vaccines are often considered as a cost-effective way to prevent and control infectious diseases, and the research and development of COVID-19 vaccines have been progressing unprecedently. It is needed to understand individuals' willingness to pay (WTP) among general population, which provides information about social demand, access and financing for future COVID-19 vaccination.
Objective: To investigate individuals' WTP and financing mechanism preference for COVID-19 vaccination during the pandemic period in China.
Methods: During March 1–18, 2020, we conducted a network stratified random sampling survey with 2058 respondents in China. The survey questionnaires included out-of-pocket WTP, financing mechanism preference as well as basic characteristics of the respondents; risk perception and impact of the COVID-19 pandemic; attitude for future COVID-19 vaccination. Multivariable Tobit regression was used to determine impact factors for respondents' out-of-pocket WTP.
Results: The individuals' mean WTP for full COVID-19 vaccination was CNY 254 (USD 36.8) with median of CNY 100 (USD 14.5). Most respondents believed that governments (90.9%) and health insurance (78.0%) needed to pay for some or full portions of COVID-19 vaccination, although 84.3% stated that individuals needed to pay. Annual family income, employee size in the workplace, and whether considering the COVID-19 pandemic in China in a declining trend affected respondents' WTP significantly.
Conclusion: The findings demonstrated the individuals' WTP for COVID-19 vaccination in China and their preferences for financing sources from individuals, governments and health insurance. And to suggest an effective and optimal financing strategy, the public health perspective with equal access to COVID-19 vaccination should be prioritized to ensure a high vaccination rate.

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1. Introduction

The coronavirus disease 2019 (COVID-19) pandemic has been causing severe diseases and economic burdens around the world [1,2]. As there are no effective treatments or drugs against COVID-19 at the current stage, vaccination has been considered to be of great importance to combat the COVID-19 pandemic [3-6]. Governments, research institutes, pharmaceuticals and organizations around the world are working together to accelerate the COVID-19 vaccination for the public, by making full effort and preparation in the progress of research, development, logistics and manufacturing [4,7].

Although COVID-19 vaccines seem promising in the supply side, in the demand side the unknown about the perception, assessment or valuation for future COVID-19 vaccination by the public so far may hinder the successful establishment of future vaccination campaigns. Vaccination cost is predicted to be very high, including expenses for vaccines, distribution, administration, adverse events

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following immunization (AEFI), and others [8,9]. To control and prevent the current COVID-19 pandemic and future outbreaks, vaccination strategies designed to reach a high vaccination coverage should address problems in terms of vaccination accessibility and financial affordability [10]. To understand individuals' willingness to pay (WTP) among general population would provide relevant information about social demand, access and financing for future COVID-19 vaccination. The willingness to pay (WTP) for vaccination is a monetary measure of the public's preference and perception for vaccination, reflecting the tradeoff between the benefits of the vaccination from preventing infectious diseases and the personal economic cost in public [11-13]. Previous studies have found various factors affecting WTP of vaccination, such as the type of diseases, social-economic characteristics, previous history of vaccination, the knowledge, attitudes and practices about vaccination, and recommendations of peers or doctors [12-16].

Lessons from the 2009 H1N1 pandemic Influenza has stressed that the shortcoming of financial affordability and distributing for enough vaccines in a timely basis could lead to the failure of making a good preparedness and response for pandemics, especially in low-and-middle income countries [17,18]. This reflected the importance of proper pricing and financing mechanisms for pandemic vaccination [17,18]. Based on the immunization financing mechanisms in China, which divided vaccines into Expanded Program on Immunization (EPI) vaccines and non-EPI vaccines, EPI vaccines are fully covered by the government tax, while non-EPI vaccines are completely paid out of pocket without any subsidy or insurance, resulting in very low coverage rates of non-EPI vaccines in China, such as vaccines against influenza [12,19,20]. Increasing the acceptance and coverage rate for vaccines, especially pandemic vaccines, remains a challenge in China [21]. The significant vaccine production costs, vaccination costs and other indirect costs in future COVID-19 vaccination will inevitably lead to a huge economic burden on individuals and governments in China. This suggests that it is not feasible to rely on individual's out-of-pocket payment for establishing the financing mechanism of COVID-19 vaccination in China. The financing for COVID-19 vaccination would be of great importance and complicity, as many factors should be taken into consideration, including the public health effect (e.g. protecting population, achieving optimal coverage and equity in health outcomes), financing sources and fiscal capacity, manufacturing cost and capacity, perception of the public, policy makers and stakeholders, etc. [22-26]. It may be an ideal strategy to make vaccination free of charge for individuals, if it is feasible. And the public WTP and financing perception for future COVID-19 vaccination would provide references from the demand side in the pricing, marketing and financing of the vaccines.

During the outbreak period of COVID-19, we aimed to investigate and evaluate individuals' WTP and financing preferences for future COVID-19 vaccination in China in order to prepare for its public availability. By considering the comprehensive cost of vaccination and the economic burden, we discussed feasible financing strategies for future COVID-19 vaccination in China.

2. Materials and methods

2.1. Study design, population and sampling

During March 1–18, 2020, we conducted a cross-sectional anonymous survey on the largest online survey platform in China, Wen Juan Xing (Changsha Ranxing Information Technology Co., Ltd., Hunan, China). Wen Juan Xing, equivalent to Qualtrics, SurveyMonkey or CloudResearch, provides online questionnaire design and survey functions for enterprises, research institutions and individuals. Its sample database consists of over 2.6 million respondents with confirmed personal information, allowing for an authentic, diverse and representative sample. The target population of the survey was adults living in Mainland China; thus, we adopted a random sample procedure stratified by ages and locations to match Chinese adults in the Wen Juan Xing sample database. Chinese respondents who aged 18 years and above and resided in Mainland China in the Wen Juan Xing sample database were eligible to participate in the survey. In general, 2100 respondents were randomly selected, and the final sample consisted of 2058 respondents after excluding incomplete and invalid questionnaires by quality control and manual check procedures.

2.2. Measures

The self-administered questionnaire was designed based on previous studies and frameworks on assessing WTP for vaccination against newly emerging infectious diseases such as H1N1 and Ebola [12-14,27,28]. The questionnaire included: (1) Respondents' socio-demographic characteristics; (2) Risk perception and impact of the COVID-19 pandemic; (3) Attitude for future COVID-19 vaccination; (4) The out-of-pocket WTP, preferences of financing mechanism and self-paid proportion for COVID-19 vaccination. The main outcome measures were the out-of-pocket WTP and financing mechanism preferences for COVID-19 vaccination, if COVID-19 vaccines could be licensed and available in the future. Respondents were asked whether they thought that individuals, governments or health insurance needed to pay for COVID-19 vaccination and if yes, whether to pay partially or fully. And respondents were further asked to report their preferred self-paid proportion in an open-ended question. Regarding the out-of-pocket WTP, different approaches have been used to elicit WTP valuations in the previous studies, such as bidding game, open-ended (OE) format and payment scale (PS) format, but each approach has its limitation [29]. Starting-point bias existed in the bidding game, while OE format might be difficult to answer, and PS format scale itself might influence the subjects' decisions [29]. Given the methods available online and to reduce the bias by methods, we adopted two types of questions to evaluated the WTP for COVID-19 vaccination, the OE format and the PS format. The monetary amount used in the questionnaire was Chinese yuan (CNY). Participants were asked "What is the maximum amount that you are willing to pay for COVID-19 vaccination (receiving all doses of the series as the vaccination schedule), if you want to get vaccinated?" according to the definition and question frame of the WTP [30]. The choices provided for respondents in the PS format were: "refused vaccination", "willing to get vaccinated if free", "CNY 10", "CNY 50", "CNY 100", "CNY 200", "CNY 500", "willing to pay for any price". The price range was set to cover private market prices of basically all adult vaccines in China [33]. The OE question asked respondents to report WTP by themselves. The PS question was deployed in the middle of the questionnaire, and the OE question was set at the end of the questionnaire to double check the WTP value from the PS question. The setting of the questions about the WTP and self-paid proportion was based on the considerations of the two ways, copay and coinsurance, which were adopted in the payment for vaccinations, and that there are various possibilities in financing for the COVID-19 vaccination [31,32].Most questions were treated as categorical variables except for the OE format of WTP and self-paid proportion, and self-reported questions were assessed on a five-point Likert scale, such as health status, risk perception of the COVID-19 pandemic.

2.3. Statistical analysis

We present the distribution of the WTP value and the self-paid proportion from the OE format. The financing mechanism

preferences were described as constituent ratio variables. Descriptive statistics were used to present baseline characteristics, the risk perception, impact of the pandemic and attitude for future COVID-19 vaccination. We provided an equivalence of the monetary amount in US Dollars (USD) at an exchange rate of 6.9 yuan per dollar in 2020. We conducted a multivariate Tobit regression to identify impact factors on the WTP, with coefficient, standard errors (SE) and p-value reported, as the OE WTP measures were truncated. Respondents who refused to vaccinate were excluded when calculating the WTP and conducting the regression, as suggested by the previous studies [12-14,27,28]. We presented the distribution of the WTP value from the PS format for reference and minimizing the bias on WTP valuations. Analyses were performed using STATA 16.0 with two-tailed tests.

3. Results

3.1. Respondent characteristics

In total, 2058 out of 2100 respondents completed the questionnaires during March 1–18, 2020, with a response rate of 98.0%. Respondents were located in all 31 provincial administrative regions of Mainland China (Appendix Table A1). The distribution of respondents' age is 23.1% in 18 ~ 25 years old, 19.4% in 25–30 years old, 25.4% in 31–40 years old, 24.8% in 41–50 years old, and 7.3% in 50 years old and above. 54.2% were female, 67.3% were married and 80.2% were employed. 38.2% of respondents had an education level of high school or below, and 55.4% had an associate or bachelor degree. The annual family income in 2019 of respondents were mainly (51.2%) in the range of CNY 50,000 ~ 150,000 (USD 7,246 to 21,739). The respondents mainly (61.6%) worked in workplaces with the employee size of 30 or more.

During the survey, 74.7% of respondents stated that there were confirmed or suspected cases in the county in which they lived at that time and 55.2% lacked protective equipment. But in this pandemic period, only 12.2% perceived the risk of being infected personally with COVID-19 as high or very high, and the majority (69.8%) believed that the COVID-19 pandemic in China was in a declining trend (in March 2020 when the survey was conducted) (Appendix Table A2).

3.2. Financing mechanism preference for COVID-19 vaccination

Table 1 presents the respondents' financing mechanism preference for COVID-19 vaccination. A portion (15.7%) of respondents believed that individuals did not need to pay out of pocket of the COVID-19 vaccination costs, and only few people (6.4%) stated that individuals needed to pay fully for COVID-19 vaccination out of pocket. 77.9% of the respondents thought that individuals needed to pay for a portion of COVID-19 vaccination costs. In contrast, most respondents believed that governments and health insurance needed to pay for some or all portions of COVID-19 vaccination costs, accounting for 90.9% and 78.0% respectively.

Table 1
Financing mechanism preference for COVID-19 vaccination of respondents.

Characteristics	Respondents (N = 2058) N	%
Individuals need to pay out of pocket for COVID-19 vaccination		
No	323	15.7
Yes, pay for a portion	1604	77.9
Yes, pay fully	131	6.4
Governments need to pay for COVID-19 vaccination		
No	188	9.1
Yes, pay for a portion	1,605	78.0
Yes, pay fully	265	12.9
Health insurance needs to pay for COVID-19 vaccination		
No	452	22.0
Yes, pay for a portion	1,334	64.8
Yes, pay fully	272	13.2

3.3. Willingness to pay and self-paid proportion for future COVID-19 vaccination

Table 2 presents the distribution of WTP by the OE format and self-paid proportion for COVID-19 vaccination. Among the total 2058 respondents, 1879 (91.3%) would accept future COVID-19 vaccination, and 1847 (89.7%) were willing to pay at the price of CNY 10 and above. The mean WTP for the COVID-19 vaccination in the OE format was CNY 254 (SD = 677), and the median was CNY 100. The maximum WTP in the OE question was CNY 10,000. With some respondents reported much higher WTP value compared with that of the majority (e.g. CNY 1000 and above), the distribution of WTP data showed a right skewed trend and the mean WTP was higher than the median. More respondents had lower willingness to pay for COVID-19 vaccination than the mean. The mean self-paid proportion for COVID-19 vaccination was 45% (SD = 22), with the median about 47%.

Table 3 shows the distribution of the WTP value from the PS format. 31.1% of the respondents were willing to pay for COVID-19 vaccination at the price of CNY 50 or less. In addition, the proportions of respondents who were willing to pay at the price of CNY 100 and 200 accounted for 27.0% and 18.7%, respectively, which were similar with those in the OE format in Table 2. The WTP in the OE format and PS format were fairly consistent and robust.

3.4. Influencing factors of willingness to pay

The results of the multivariate Tobit regression are presented in Table 4 by estimating the WTP in the OE format on influencing factors. The annual family income and the employee size in the workplace were positively correlated with WTP. Compared with respondents whose annual family income were below CNY 50,000, those with annual family income of CNY 150,000 ~ 200,000, 200,000 ~ 300,000, 300,000 and above had CNY 68, 66 and 136 higher WTP, respectively. Respondents who worked in the workplaces with the size of 10 ~ 29, 30 ~ 100, 100 ~ 300, 300 and above had higher WTP of CNY 54, 47, 46 and 66 than those who worked in the workplace with less than 10 employees. Respondents who considered the pandemic COVID-19 in China in a declining trend had CNY 28 lower WTP than that of those who did not have the same perception.

4. Discussion

Our study reports the willingness to pay (WTP) and financing preference for future COVID-19 vaccination among the Chinese population sampled during the COVID-19 pandemic. Most respondents were willing to pay for a portion of vaccination costs, reflecting the strong demand for COVID-19 vaccination to control and prevent the COVID-19 pandemic. The average out-of-pocket WTP for full COVID-19 vaccination was CNY 254 (USD 36.8), while the median was declined to CNY 100 (USD 14.5). Regarding the financing mechanism preference, most respondents believed that governments and health insurance both needed to pay some or all portions for COVID-19 vaccination.

The use of two approaches of the OE format and the PS format provided a comprehensive result in evaluating the WTP. In general, we found that most respondents were willing to pay out of pocket

Table 2
The distribution of WTP (CNY) and self-paid proportion for COVID-19 vaccination of respondents.

WTP value (CNY)				Self-paid proportion (%)			
	Frequency	Percent (%)	Cumulative Percent (%)		Frequency	Percent (%)	Cumulative Percent (%)
Refused [a]	179	8.7	8.7	Refused [a]	179	8.7	8.7
0	20	1.0	9.7	0	38	1.9	10.5
1 ~ 9	12	0.6	10.3	1 ~ 9	25	1.2	11.8
10	51	2.5	12.7	10	49	2.4	14.1
11 ~ 49	66	3.2	15.9	11 ~ 19	53	2.6	16.7
50	298	14.5	30.4	20	156	7.6	24.3
51 ~ 99	37	1.8	32.2	21 ~ 29	127	6.2	30.5
100	526	25.6	57.8	30	101	4.9	35.4
101 ~ 149	15	0.7	58.5	31 ~ 39	78	3.8	39.2
150	52	2.5	61.0	40	177	8.6	47.8
151 ~ 199	10	0.5	61.5	41 ~ 49	177	8.6	56.4
200	382	18.6	80.1	50	269	13.1	69.4
201 ~ 299	15	0.7	80.8	51 ~ 59	130	6.3	75.8
300	89	4.3	85.1	60	131	6.4	82.1
301 ~ 499	24	1.2	86.3	61 ~ 69	117	5.7	87.8
500	190	9.2	95.5	70	39	1.9	89.7
501 ~ 999	19	0.9	96.5	71 ~ 79	47	2.3	92.0
1000	48	2.3	98.8	80	49	2.4	94.4
1001 ~ 2000	10	0.5	99.3	81 ~ 89	25	1.2	95.6
3000	1	0.1	99.3	90	3	0.2	95.7
5000	8	0.4	99.7	91 ~ 99	13	0.6	96.4
10,000	6	0.3	100.0	100	75	3.6	100.0

Table 3
The distribution of WTP (CNY) in the PS format for COVID-19 vaccination of respondents.

	Frequency	Percent (%)	Cumulative Percent (%)
Refused [a]	179	8.7	8.7
0	115	5.6	14.3
10	104	5.1	19.3
50	419	20.4	39.7
100	556	27.0	66.7
200	385	18.7	85.4
500	130	6.3	91.7
Willing to pay for any price	170	8.3	100.0

Note: Refused [a] means that they refused vaccination.

for COVID-19 vaccination. More than 20% of the respondents were willing to pay CNY 50 or less and the majority (71.4%) were willing to pay CNY 200 or less. The PS format also showed that the majority (65.8%) were willing to pay CNY 50 (20.4%), 100 (27.0%) or 200 (18.7%). In general, the distribution as well as the median value (CNY 100, USD 14.5) of the WTP reflected the economic affordability and valuation of Chinese individuals regarding the vaccination costs and perceived benefit from preventing COVID-19 during the pandemic period. However, the WTP value was not very high. Compared with the WTP of other adult vaccines investigated in China, the WTP for COVID-19 vaccination was higher than that of influenza vaccine (CNY 60) or hepatitis B vaccine (CNY 19–67) [12,54]. But compared with prices of adult vaccines in Chinese private market, the WTP of COVID-19 vaccination was not significantly higher [33]. For example, the market prices of hepatitis A vaccine, hepatitis B vaccine and varicella vaccine are about CNY 60–110, CNY 13.5–88 and CNY 131–155 [33]. The average WTP (CNY 254) of Chinese respondents accounted for approximately 10% of the average monthly per capita disposable income in China [34]. The mean WTP were reported about MYR$134.0 (USD 30.6) in Malaysia and USD 184.7 in Chile [35,36]. When measured in purchasing parity power equivalents, the mean WTP of our result was USD 60.8, and it was about USD 79.7 in Malaysia and USD 269.7 in Chile [35–37]. So the mean WTP in China was roughly at the same level with that in Malaysia, but much lower than that in Chile. This might be explained by the context-specific factors such as perception of the severity and risk about diseases, which varied across disease types or locations [12,27,35,36]. COVID-19 has demonstrated higher severity in terms of transmissibility and mortality than seasonal influenza, so respondents were willing to pay more for COVID-19 vaccination [12,38,39]. While the perceived risk of getting sick by COVID-19 was 99.1% among Chile population, only a small portion (12.2%) of the respondents in China perceived a high or very high level of risk due to the effective measures and public health interventions China has taken to control the transmission of COVID-19 since the outbreak [35,40,41]. Therefore, the WTP from our study was lower than that in Chile [35].

Some factors were found to have an impact on the WTP of respondents. Respondents with higher annual family income were willing to pay more for COVID-19 vaccination substantially, which was consistent with previous findings that the economic factor was reported as the main factor affecting the WTP and the acceptance of self-paid vaccination in China and other low-and-middle-income countries [11,12,42]. Respondents who worked in the workplace with more employees had higher WTP, while those who considered the COVID-19 pandemic in China in a declining trend had CNY 28 less WTP, both reflecting the effects of disease threat appraisal on WTP based on the Protection Motivation Theory [12,27]. We found that the WTP for COVID-19 vaccination did not vary much by regions after other variables was controlled in the regression, such as factors of socio-economic, risk perception and pandemic impact. This might be due to the fact that most infected cases and deaths in China were in one province: Hubei province in the central region, and other provinces and counties had very few cases and deaths[43]. In addition to the socio-economic factors, some of the vaccine characteristics would also affect the WTP for COVID-19 vaccination as reported by studies of other countries [22,44]. For example, people in Australia would be willing to pay USD 41, USD 34 and USD 23 to reduce waiting time of the vaccination by 1 month, reduce the severe reactions rate by 1/10,000, and increase the vaccine effectiveness, respectively, indicating the relative importance of vaccine characteristics [22]. While in Ecuador, only the protection duration was found to influence individuals WTP while the vaccine efficacy was not [44].

Table 4
Influencing factors of willingness to pay from the Tobit regression.

Characteristics	Coefficients	SE	p-value	95%CI
Age group				
18 ~ 25	Ref			
26 ~ 30	−12.23	19.07	0.521	−49.62 ~ 25.16
31 ~ 40	−38.99	20.44	0.057	−79.08 ~ 1.10
41 ~ 50	−37.08	20.67	0.073	−77.61 ~ 3.45
> 51	−25.71	28.25	0.363	−81.11 ~ 29.70
Gender				
Female	Ref			
Male	−7.33	10.04	0.465	−27.02 ~ 12.36
Education level				
Middle school and below	Ref			
High school	−33.27	23.00	0.148	−78.37 ~ 11.83
Bachelor	−44.28	23.65	0.061	−90.68 ~ 2.10
Master and above	−8.95	31.03	0.773	−69.81 ~ 51.92
Marriage status				
Others (single, divorced or widowed)	Ref			
Married	13.08	15.27	0.393	−16.88 ~ 43.03
Region				
Rural	Ref			
Urban	13.69	13.38	0.306	−12.56 ~ 39.94
Health status				
Fair or below (fair, poor, very poor)	Ref			
Good and above (good, very good)	−10.18	12.02	0.397	−33.76 ~ 13.40
Having the chronic disease				
No	Ref			
Yes	−10.07	17.76	0.571	−44.89 ~ 24.76
Annual family income in 2019				
≤ CNY 50,000 (USD 7,246)	Ref			
CNY 50,000–100,000 (USD 7,246–14,492)	13.76	17.18	0.423	−19.93 ~ 47.45
CNY 100,000–150,000 (USD 14,492–21,739)	34.44	17.93	0.055	−0.73 ~ 69.61
CNY 150,000–200,000 (USD 21,739–28,986)	68.01	19.54	0.001	29.70 ~ 106.32
CNY 200,000–300,000 (USD 28,986–43,478)	66.35	22.11	0.003	22.98 ~ 109.71
≥ CNY 300,000 (USD 43,478)	135.64	25.04	less than0.001	86.52 ~ 184.76
Employment status				
Unemployed	Ref			
Employed	25.76	41.71	0.537	56.05 ~ 107.57
Employee size in workplace				
≤ 10	Ref			
10 ~ 29	54.30	23.76	0.022	7.71 ~ 100.89
30 ~ 100	47.00	21.63	0.032	4.57 ~ 89.43
100 ~ 300	45.68	22.77	0.045	1.02 ~ 90.34
≥ 300	66.12	22.14	0.003	22.70 ~ 109.53
Pandemic impact on income				
Fair	Ref			
Large or very large	10.78	12.99	0.406	−14.69 ~ 36.26
Small or very small	3.38	16.52	0.838	−29.03 ~ 35.79
There are confirmed or suspected cases in the county				
No or not clear	Ref			
Yes	3.82	11.91	0.748	−19.54 ~ 27.18
Lacking of protective equipment (e.g. masks, etc)				
No	Ref			
Yes	−18.98	10.25	0.064	−39.08 ~ 1.13
Perceived risk of infection				
Fair	Ref			
High or very high	2.84	16.93	0.867	−30.37 ~ 36.05
Low or very low	0.63	11.67	0.957	−22.25 ~ 23.51
The COVID-19 pandemic in China was in a declining trend				
No	Ref			
Yes	−28.03	11.06	0.011	−49.72 ~ -6.34

By July 2020, the direct medical treatment expenses for confirmed and suspected COVID-19 patients in China reached CNY 1.847 billion (USD 0.268 billion), of which 67% were paid by health insurance and the rests were paid by governments with fiscal funding [45]. Over 100 million Chinese people had taken COVID-19 nucleic acid amplification testing (NAT), with the total testing cost over CNY 12 billion [46]. By further considering the enormous economic loss that the COVID-19 pandemic has affected on the national economic growth, it is likely that COVID-19 vaccination is cost-effective if it has high vaccine effectiveness, long immunity duration, and low side-effects. As large investment has been put into the development of COVID-19 vaccines and the future manufacture may apply with high technology such as recombinant DNA technology, the price of the COVID-19 vaccine might be more expensive than traditional non-EPI vaccines in China [33,47,48]. Other operational activities and logistics also account for a large amount in the total vaccination cost, including remuneration, cold chain, surveillance, publicity, training, supervision [20]. Therefore, appropriate financing strategies for future COVID-19 vaccination including both vaccine costs and vaccination services costs should be carefully considered in China and other countries, if a successful vaccination campaign and a good public health impact are to establish. The current financing channels for non-EPI vaccination in China are completely paid out of pocket [19,20]. When extrapolating our findings for population in China (approximately 1.4 billion people), it results in a total self-payment or individual

assessment of approximately CNY 324.6 billion (USD 47.0 billion) for COVID-19 vaccination, accounting for about 0.33% of Chinese national GDP in 2019 [55]. This may be limited in a national vaccination campaign against COVID-19. In our findings, 84.3% of respondents accepted the duty to pay for some or full potions out of pocket for COVID-19 vaccination, but the majority stated that governments (90.9%) or health insurance (78.0%) needed to pay for COVID-19 vaccination. Since the central government and health insurance have spent a significant amount of money on COVID-19 treatments and testing in China, this provides a reasonable foundation for government and/or health insurance to finance the COVID-19 vaccination.

More importantly, the COVID-19 vaccination strategies, including the financing, should take various aspects of factors into account, especially the public health effect [22-26]. The national authorities and public health institutions in China intended to have every Chinese citizen be vaccinated according to their vaccination priorities, and no payment from individuals would be the ideal policy [49]. But it was reported that the basic medical insurance funds in China could not afford, and might not be used for nationwide free COVID-19 vaccination, leaving detailed (national and regional) financing strategies to be considered [50]. Different pilot financing strategies have been adopted in some areas. Several provinces in China (e.g. Guangdong, Zhejiang) have rolled out free vaccinations to key and high-risk groups, while in some places such as Wuhan, people from key groups, including students going abroad, paid CNY 234 (USD 35.8) for each dose [47]. And in December 2020, two provinces (Jiangsu and Anhui) became the first two places to reach a deal with vaccine manufacturers [47,48]. Vaccine producers (Sinopharm and Sinovac) would charge the government CNY 200 (USD 30.6) per dose [47,48]. Based on our study, even if the total price of a full vaccination consisted of 2 doses is CNY 400 (USD 61.2), only about 10% of respondents will be willing to pay and accept the vaccination, which will greatly hinder the public health effect of vaccination campaign against COVID-19. Besides, uncertainties about the timing, efficacy, innocuity, safety, number of doses required, and potential side effects will affect perception and willingness to pay for the vaccination. These uncertainties (particularly safety) will also be barriers for Chinese citizens to accept COVID-19 vaccination, which may lead to the low coverage of COVID-19 vaccination. In China, there are almost no EPI vaccines for adults, so adult vaccines need to be paid 100% by individuals [19,20]. Very few areas have provided free flu and/or pneumococcal vaccines to the elderly, and previous studies showed that free vaccination raised the coverage of these vaccines substantially [51,56,57]. And most Chinese adults did not have experiences in paying for non-EPI vaccines [51]. So if feasible, it would be simpler and most cost-effective to consider COVID-19 vaccination as a "public good" and have it financed by the central and local governments in China, given the enormous national economic and social cost of the pandemic. No fees should be charged for people in order to eliminate financial barriers to uptake. Considering the current situation that cost of essential public health programs in China (including EPI vaccination) was funded by government appropriation, while health insurance does not cover the cost of vaccination as stipulated by the national policy, COVID-19 vaccine is therefore suggested to be included into the essential public health program as one expanded program on immunization (EPI) vaccine. However, the total cost of COVID-19 vaccination still remains to be a heavy burden for governments both at the national and regional level, since it would be hard to allocate limited resources between different programs in policy-making. To address the above concern, firstly, the government could negotiate with manufacturers to reduce the vaccine price as much as possible, which ensures the affordability of COVID-19 vaccines for the general population in the demand side. This is feasible as the production cost of the vaccine would decline with the growth of scale in production and vaccination use, and manufacturers could also benefit from bulk-buying. Secondly, it is suggested that part of the cost of COVID-19 vaccination could be paid by the health insurance fund to alleviate fiscal burden, which has been adopted in other countries [52]. In further consideration to better assess and finance for vaccination campaign against COVID-19 at the provincial and county level, local fiscal capacity needs to be examined carefully, and additional support from superior governments or health insurance fund is suggested to be considered [10]. For example, for government financing between the central and provincial governments in China, the central government has raised 5-level expenditure responsibility standards for essential public health programs in 2018 [53]. The standards indicate 5 different proportions of expenditure for essential public health services that the central government bears with regards to the provinces with different social-economic situation [53]. This standard can be applied for reference in the government financing distribution mechanism of COVID-19 vaccination.

Our study has several limitations. First of all, as the use of an offline survey was not feasible during the pandemic period, the online survey may limit the representativeness of the current study's sample. To address this problem, we enrolled a large sample size and used a random sampling method stratified by demographic characteristics to increase the sample diversity and representativeness. Secondly, given the hypothetical nature, the study results may differ from real practice, and some self-reported answers may lead to information bias. Thirdly, the present study did not examine the level of knowledge of immunization financing or the previous experiences of having or paying for non-EPI or children vaccines among respondents, which would affect their willingness to pay for COVID-19 vaccination. In particular, the study was carried out without any target product profile for the COVID-19 vaccine or no hypothetical information, such as the efficacy, immunity duration, number of doses required, etc. Though the present results provide a general view of WTP value and range for respondents in the pandemic phase, it should be interpreted with cautions as uncertainties of COVID 19 vaccine would also influence respondents' perception and WTP. Besides, it would be possible for self-paid proportion to be overestimated as the 'if required to pay' words might have an impact on the responses provided. And the WTP may vary depending on the stage of the pandemic in different regions of China and the perception from the population towards the level of control by the authorities. We did not find significant differences in willingness to pay between regions, and the effects of the pandemic could not be examined in this cross-sectional study. Finally, the results provide only a preliminary view of the public perception about the financing for the vaccination during the pandemic phase, comprehensive evidence by further researches should be needed for designing a proper, effective and optimal strategy, especially among the policy makers and other stakeholders. The findings of this survey should be interpreted in light of the above-mentioned limitations. To our knowledge, this is the first survey to investigate WTP and financing preference for COVID-19 vaccination based on a large population in China during the pandemic period, which provide relevant information about social demand, access and financing for future COVID-19 vaccination. Further study could be considered to assess the change of willingness to pay of the vaccination under different phases of the pandemic and vaccine or vaccination attributes.

5. Conclusion

During the COVID-19 pandemic period in China, the study reported the individuals' WTP and their preferences for financing

sources, which reflected the economic valuation and affordability for future vaccination. The public stated individuals, governments and insurances could all be considered in financing COVID-19 vaccination. But to suggest an effective and optimal financing strategy in controlling and preventing the COVID-19 pandemic, the public health perspective with equal access to COVID-19 vaccination should be prioritized to ensure a high vaccination rate, with further and comprehensive information needed.

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Declaration of Competing 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.

Appendix A

Tables A1, A2 and A3.

Table A1
Comparison of the regional distribution between respondents in the study and that in total population from 2020 China statistical yearbook [a].

Provincial administrative regions	Respondents in the study (N = 2058)		Total population in China (N = 1401.85 million)	
	N	%	N (in million)	%
Beijing	138	6.7	21.54	1.5
Tianjin	37	1.8	15.62	1.1
Hebei	96	4.7	75.92	5.4
Shanxi	68	3.3	37.29	2.7
Inner Mongolia	24	1.2	25.4	1.8
Liaoning	69	3.4	43.52	3.1
Jilin	24	1.2	26.91	1.9
Heilongjiang	38	1.8	37.51	2.7
Shanghai	146	7.1	24.28	1.7
Jiangsu	130	6.3	80.7	5.8
Zhejiang	88	4.3	58.5	4.2
Anhui	62	3.0	63.66	4.5
Fujian	62	3.0	39.73	2.8
Jiangxi	38	1.8	46.66	3.3
Shandong	129	6.3	100.7	7.2
Henan	134	6.5	96.4	6.9
Hubei	99	4.8	59.27	4.2
Hunan	68	3.3	69.18	4.9
Guangdong	295	14.3	115.21	8.2
Guangxi	64	3.1	49.6	3.5
Hainan	5	0.2	9.45	0.7
Chongqing	30	1.5	31.24	2.2
Sichuan	86	4.2	83.75	6.0
Guizhou	19	0.9	36.23	2.6
Yunnan	18	0.9	48.58	3.5
Tibet	1	0.0	3.51	0.3
Shaanxi	51	2.5	38.76	2.8
Gansu	17	0.8	26.47	1.9
Qinghai	2	0.1	6.08	0.4
Ningxia	7	0.3	6.95	0.5
Xinjiang	13	0.6	23.23	1.7

Table A2
Respondent characteristics.

Characteristics	Respondents (N = 2058)	
	N	%
Age group		
18 ~ 25	475	23.1
26 ~ 30	400	19.4
31 ~ 40	523	25.4
41 ~ 50	510	24.8
51 and above	150	7.3
Gender		
Female	1115	54.2
Male	943	45.8
Education level		
Middle school and below	123	6.0
High school	663	32.2
Associate or bachelor	1140	55.4
Master and above	132	6.4
Marriage status		
Married	1385	67.3
Others (single, divorced or widowed)	673	32.7
Region		
Rural	420	20.4
Urban	1638	79.6
Health status		
Good and above (good, very good)	1527	74.2
Fair or below (fair, poor, very poor)	531	25.8
Having the chronic disease		
Yes	193	9.4
No	1865	90.6
Annual family income in 2019		
≤ CNY 50,000 (USD 7,246)	277	13.4
CNY 50,000 ~ 100,000 (USD 7,246–14,492)	548	26.6
CNY 100,000 ~ 150,000 (USD 14,492–21,739)	506	24.6
CNY 150,000 ~ 200,000 (USD 21,739–28,986)	352	17.1
CNY 200,000 ~ 300,000 (USD 28,986–43,478)	239	11.7
≥ CNY 300,000 (USD 43,478)	136	6.6
Employment status		
Employed	1651	80.2
Unemployed	407	19.8
Employee size in the workplace		
≤ 10	156	7.6
10 ~ 29	227	11.0
30 ~ 100	448	21.7
100 ~ 300	356	17.3
≥ 300	464	22.6
Missing	407	19.8
Pandemic impact on income		
Large or very large	905	44.0
Fair	467	22.7
Small or very small	325	15.8
Missing	361	17.5
There are confirmed or suspected cases in the county		
Yes	1538	74.7
No or not clear	520	25.3
Lacking of protective equipment (e.g. masks, etc)		
Yes	1136	55.2
No	922	44.8
Perceived risk of infection		
High or very high	251	12.2
Fair	575	27.9
Low or very low	1232	59.9
The COVID-19 pandemic in China was in a declining trend		
Yes	1436	69.8
No	622	30.2

Table A3
Key questions and items in the survey questionnaire (translated from the Chinese version used).

Construct	Question No. and type	Items	Response Scale
Perception for financing mechanism	37 [Single Choice]	Do you think that individuals need to pay out of pocket for COVID-19 vaccination?	1 = No 2 = Yes, pay for a portion 3 = Yes, pay fully
	40 [Single Choice]	Do you think that governments need to pay for COVID-19 vaccination?	1 = No 2 = Yes, pay for a portion 3 = Yes, pay fully
	41 [Single Choice]	Do you think that health insurance needs to pay for COVID-19 vaccination?	1 = No 2 = Yes, pay for a portion 3 = Yes, pay fully
The out of pocket WTP	38 [Open-ended]	If individuals are required to pay for COVID-19 vaccination to complete a full immunization, what is the self-paid proportion that you are willing to pay?	[Range:0–100%]
	39 [Single Choice]	What is the maximum amount that you are willing to pay for COVID-19 vaccination (receiving all doses of the series as the vaccination schedule), if you want to get vaccinated?	1 = Refused vaccination 2 = Willing to get vaccinated if free 3 = CNY 10 4 = CNY 50 5 = CNY 100 6 = CNY 200 7 = CNY 500 8 = Willing to pay for any price
	50 [Open-ended]	What is the maximum amount that you are willing to pay for COVID-19 vaccination (receiving all doses of the series as the vaccination schedule), if you want to get vaccinated?	[For respondents who choose 'Refused vaccination' in Q39, skip Q50]

Note: [. . .] Brackets indicate text that participants did not see, including question type and response options.

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