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Development and validation of the COVID-19 vaccine beliefs scale for the Chinese population

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Abstract

Background At present, there is no culturally appropriate scale designed to measure Chinese people's attitudes and beliefs about COVID-19 vaccines. Understanding people's attitudes and beliefs about vaccines can help policy makers and health care professionals better evaluate local beliefs to increase vaccine coverage and minimize COVID-19 vaccine hesitancy.

Methods We developed a COVID-19 vaccine attitudes and beliefs scale comprising items based on qualitative research data. We then conducted an explorative and confirmatory factor analysis using data from two online sources.

Results The 26-item vaccine belief scale includes a five-factor model: vaccine benefit (VB), vaccine concern (VC), observing others' reactions to vaccination (VR), the influence of authority and others toward vaccination (VI), and common sense about vaccination (VS). The multivariate analysis results showed that VB (OR = 1.065, 95% CI 1.035–1.097), VR (OR = 0.878, 95% CI 0.832–0.927), and VS (OR = 1.076, 95% CI 1.032–1.122) were associated with the intention to receive the vaccine. These results implied that VC (OR = 0.957, 95% CI 0.928–0.987) could predict the choice not to be vaccinated. A correlation between beliefs about vaccines and conspiracy theories and fear of COVID-19 was also found and discussed.

Conclusions These findings suggest that the locally designed and culturally sensitive scale has good reliability and validity. The questionnaire provides researchers with a standardized assessment tool to measure Chinese people's beliefs about the COVID-19 vaccine.

Keywords Vaccine Beliefs, COVID-19, Scale development, Vaccination, Culture

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Background

The global impact of the COVID-19 pandemic has had detrimental effects on public health, leading to an increased susceptibility to severe illness and mortality. Individuals aged 65 and older, as well as those with preexisting conditions such as hypertension, diabetes, cardiovascular ailments, cancer, and chronic respiratory disease, are particularly vulnerable. The pandemic has created burdens and challenges for health care systems and hospitals worldwide. An increasing number of studies have confirmed that vaccines can effectively prevent infected people from developing severe disease, and vaccines are also considered a safe and effective way to control the spread of the disease. Converging research has shown that some vaccines, such as the Pfizer–BioNTech vaccine, have high efficacy against infections and prevent hospital admissions, and the data show that compared to that of the two-dose vaccine, the relative effectiveness of the three-dose vaccine in mitigating infections and preventing hospital admissions was 75% and 70%, respectively [1]. In China, studies have confirmed that the three-dose vaccine can also effectively prevent severe disease incidence, symptomatic COVID-19, ICU admissions, and mortality [2]. Despite these health benefits, comprehensive vaccination among the general population is significantly lower than the national goals. The factors contributing to vaccine beliefs likely vary depending on the specific vaccine, an overabundance of information, conspiracy theories, general lack of trust, and individual and community cultural and political influences. These factors significantly affect individuals' willingness to become vaccinated and their subsequent behavior [3, 4].

An increasing number of postpandemic studies have focused on COVID-19 vaccine hesitancy, and this phenomenon is described as people's delay or reluctance to accept recommended and available vaccine services [5]. Studies have shown that COVID-19 vaccine hesitancy is a significant problem that contributes to suboptimal vaccination coverage [6]. The COVID-19 vaccine hesitancy scales in the literature have limitations: (1) The scales measured only one dimension and may not cover the general population's different beliefs about vaccines. (2) Many questionnaires are based on beliefs and attitudes about other vaccines and may not reflect specific beliefs about COVID-19 vaccines. (3) Most of the scales are translated from those used in Western countries. There is no scale grounded in the experiences of Chinese people, and a culturally tailored scale to reflect their experiences with vaccine beliefs is necessary. (4) China is a relationship-oriented society, and attitudes and beliefs toward a new thing are easily influenced by the opinions of others. There is no scale to combine the factors regarding interpersonal influences on individuals' attitudes and beliefs toward vaccines [7].

Failure to consider culturally specific vaccine beliefs and the influences of infodemics may result in an incomplete understanding of these constructs and their impact on vaccine beliefs in China. Existing scales rooted in Western ideologies primarily focus on the cognitive, affective, and behavioral aspects of self-identity, thus inadequately capturing the complexity of vaccine beliefs within collectivist-oriented Chinese and other East Asian populations. This disparity between vaccine beliefs in Western and non-Western cultures emphasizes the necessity for modifications in assessment approaches.

To this end, we developed a questionnaire that is more appropriate for non-Western cultures. We adopted a mixed study design method to develop a scale for the Chinese population. First, the qualitative design of thematic analysis was applied to inductively discover the underlying beliefs or core themes of vaccine beliefs from the Chinese individual's perspective. Second, the factor structure of vaccine beliefs was developed to be consistent within the core themes identified in previous-stage qualitative research. Third, we assessed the scale's reliability, construct validity, and concurrent validity.

Methods

Study design

The current study used mixed methods to obtain a more complete picture of the general public's experience and beliefs toward the COVID-19 vaccine with the following steps and goals: (1) Qualitative research using thematic analysis was conducted to obtain the public's experiences and beliefs toward the COVID-19 vaccine. (2) Based on the themes that emerged, the vaccine belief scale was developed with the aim of satisfactory internal consistency and construct validity. (3) Vaccine beliefs were predicted to be correlated with vaccine-taking behaviors, conspiracy theory and COVID-19 fear.

Item generation and verification

The participants were selected based on purposive sampling. Purposive sampling is used in the process of qualitative research to select respondents most likely to generate appropriate and useful information and is a way of identifying and selecting cases that uses limited research resources effectively. A carefully chosen sample, incorporating a wide range of ages, education levels, and occupations, was purposefully selected for this study. The experiences of 18 individuals hailing from diverse socioeconomic backgrounds were documented. The average age of the participants was 41 years, and 13 participants were female. Prior to the commencement of the interviews, explicit consent was obtained from the participants either in writing or verbally.

First, we interviewed 2 community staff members who had been promoting vaccination work in the community

for a long time to obtain a general understanding of the public's belief in vaccination. To obtain more diversified knowledge, we then interviewed another 9 participants, including a doctor, a nurse, a teacher, a student, a farmer, a retired worker, a driver, a soldier, and one chronic dialysis patient, to better understand the beliefs of these various groups. We also interviewed 4 people in the community who were reluctant to accept vaccination. After the 15 semistructured interviews, data saturation was achieved. To further validate the identified themes, an additional 3 interviews were conducted.

Each interview began with the following prompt: "Please share with us your attitudes toward the COVID-19 vaccine. Are you considering vaccination? Why or why not?" Other probing questions were also asked during the interview process. The interviews were recorded and transcribed verbatim, and the inductive thematic approach was taken, which involves allowing themes to emerge from the data. The first step involves familiarization with the data, which requires researchers to read through the text and take rough notes. The second step is coding, which refers to refining the meaning of the text. The third step is generating themes, which means identifying the patterns from the text by combining the codes into a single theme. The fourth step in the process involves critically evaluating the identified themes to ensure their usefulness and accuracy in representing the data. Following this, the fifth step entails precisely defining and labeling the themes by articulating their respective meanings and determining their explanatory value in relation to the data. Throughout the entire thematic analysis process, five main themes emerged from the data: (1) vaccine benefit (VB), (2) vaccine concern (VC), (3) observing others' reaction to vaccination (VR), (4) influence of authority and others toward vaccination (VI), and (5) common sense about vaccination (VS).

Quantitative phase

The first step involved the creation of a prototype tool, which was facilitated by two experts in scale development. An item pool was derived from the qualitative interviews, yielding a total of 32 items classified into 5 categories. Additionally, 10 items were drawn from the reviewed literature, resulting in a combined total of 42 items. Subsequently, a focus group consisting of 6 interview participants was convened to evaluate and discuss the 42 items. Through this process, 3 items were either merged with existing items or eliminated due to issues of ambiguity or duplication.

The first draft of the prototype tool with 39 items was sent to 9 people, two master's degree psychology students, two psychology professors, two nurses, one physician, a teacher, and a professor of public health. The assessment of this panel of experts was utilized to discern elements that required consolidation, elimination, or alteration, in accordance with the prevailing consensus. To determine the content validity of the scale, we asked a panel of experts to read and critique the newly developed items, particularly the extent to which they effectively measured beliefs toward vaccines, accounting for four main criteria: (i) their willingness to receive vaccination; (ii) the clarity and adequacy of wording; (iii) whether the items were redundant, unclear, or irrelevant; and (iv) their suitability to and significance for the target population. We also asked each panel member to provide recommendations regarding any items that might require changes or modifications. The researchers then convened a meeting to deliberate on these remarks. Consequently, a total of five categories, including 36 items, were deemed suitable and underwent the revisions proposed during the meeting. Step 2 was psychometric testing.

Quantitative research

For these two cross-sectional studies, the participants were invited to complete questionnaires through an online platform called Wenjuanxing. Due to the recruitment methodology, the response rate and missing data were not determined. The scale's development process comprised two significant components: explanatory factor analysis (EFA) and confirmatory factor analysis (CFA). This study adhered to the principles outlined in the Declaration of Helsinki for conducting medical research involving human subjects. Ethical approval was acquired from the Clinical Research Ethics Committee of the Third Affiliated Hospital of Chongqing Medical University. The first page of the questionnaire included information about informed consent. If participants agreed, they could indicate their consent and begin answering the questions.

To commence the pursuit of this objective, the current research endeavor was carried out with the intention of constructing a psychometric assessment of a scale specifically tailored to gauge vaccine beliefs within the context of Chinese culture. The minimum sample size was calculated by using the recommended settings for drawing accurate conclusions and avoiding type II errors [8], and a G*Power calculation (power 0.80, effect size 0.15, and alpha 0.05) for the initial 36 predictor items yielded a minimum sample size of 203 participants. In total, 725 participants in phase 1 and 416 participants in phase 2 of the study showed interest and completed the questionnaire, which was sufficient to proceed.

The first cohort of 725 participants completed the questionnaire in February 2021 before the first vaccine was rolled out nationwide. The data were used for EFA. The first study phase was used to determine the scale items and inquired about the participants' willingness to receive the vaccine.

The second phase of the study included 416 participants who completed the questionnaire from October 2022 to December 2022, when the three-dose vaccine program had basically been completed nationwide. The validation samples were obtained via an anonymous online survey distributed via WeChat groups by staff members who worked in five community centers and two hospitals. This was a cross-sectional study. All of the potential participants were informed that this was a study on attitudes and beliefs toward the COVID-19 vaccine, aiming to enhance the measurement of beliefs toward COVID-19 vaccination in the general population. The participants were also informed that participation was voluntary and that refusal to participate involved no penalties. The inclusion criteria were as follows: (i) aged 18 years or older and (ii) able to read and understand Chinese to a sufficient degree to complete the procedure. The factor structure was cross-validated using the sample in question, employing the CFA method. Drawing on the existing body of literature, the correlation between vaccine beliefs and psychosocial difficulties was investigated within the second sample. We hypothesized that a Chinese version of a vaccine beliefs scale would be a valid scale for testing the Chinese public's beliefs toward vaccines, and we hypothesized that vaccine beliefs, conspiracy theories, and fear of COVID-19 would be associated with the choice to receive the three-dose vaccine.

Potential correlation examination

According to the previous literature, negative beliefs about vaccination are associated with a greater sense of fear of COVID-19, greater acceptance of conspiracy theories and the decision not to undergo vaccination. The associations between negative beliefs about vaccination and these psychosocial problems were examined.

Measures

Intention to be vaccinated

For quantitative sample 1, one item measured the participants' intention to receive the vaccine. One question asked participants about when the vaccine for COVID-19 was available: "What is your intention regarding vaccination?" The participant could answer, "I have already registered to take the vaccine; I have already taken the vaccine; there is a very high probability that I will take the vaccine; not sure, I'm unlikely to do it; no, I will not take the vaccine." This result was coded as a dichotomous variable, where having been vaccinated, registered to be vaccinated, and having a strong likelihood of being vaccinated were coded as having a high intention to be vaccinated, while the other responses were coded as having no strong intention to be vaccinated.

COVID-19 vaccination status

For quantitative sample 2, one item measured the participants' current vaccination status. The response options were denial, one shot, two shots, and three shots. This result was coded as a dichotomous variable. Having had three shots was coded as fully vaccinated, while the other responses were coded as not fully vaccinated.

Fear of COVID-19

The Fear of COVID-19 (FCV-19 S) scale, consisting of 7 items, was initially developed in English by Ahorsu [9] to assess individuals' fear of COVID-19. The Chinese version of the FCV-19 S has been validated and found to be reliable [9, 10]. Participants indicated their level of agreement with fear-related prompts on a 5-point Likert scale ranging from 1 (totally disagree) to 5 (completely agree). Higher scores on the scale indicate greater fear of contracting COVID-19.

Conspiracy belief scale

The validity and reliability of the single-item conspiracy belief scale are commendable, making it a suitable tool for assessing belief in conspiracy theories. Participants are asked to respond to the following prompt: "I think that the official version of the events given by the authorities very often hides the truth." Responses are evaluated on a Likert scale ranging from 1, indicating complete falsehood, to 9, signifying complete truth. Higher scores on this scale indicate a stronger inclination toward embracing conspiracy theories [11].

Statistical analyses

Factor analysis and item trimming

The present investigation employed EFA to ascertain the polychoric correlations of the survey items utilizing the statistical software SPSS 18. The completed questionnaires of Sample 1, a total of 725 participants, were analyzed. The fundamental characteristics of this cohort are outlined in Table 1.

Based on the results of a screening test and parallel analysis, a previous study identified five factors [12]. We selected a 27-item five-factor solution based on specific item selection criteria. These criteria included minimum loadings of 0.40 on at least one factor and cross-loading no more than 0.30 on a second factor. Additionally, each factor required a minimum of three clean items. Following the EFA, we proceeded to test the factor structure found in the first sample, referred to as the tentative model, on a second sample using CFA.

The 27 items obtained from the EFA were analyzed using a five-factor oblique model CFA with the second sample in Mplus, employing robust maximum likelihood estimation methods. The demographic characteristics of the study participants are presented in Table 2. To assess

Table 1 Demographic characteristics of the participants

	N (%)
	725 (100)
Sex	
Male	203 (28.0)
Female	522 (72.0)
Age	
18–20	370 (51.0)
21–25	213 (29.4)
26–30	21 (2.9)
31–35	17 (2.3)
36–40	17 (2.3)
41 above	87 (12.0)
Education	
Middle and middle below	66 (9.1)
Professional school	52 (7.2)
Undergraduate	579 (79.9)
Graduate school	28 (3.9)
Income (CNY)	
1000 below	501 (69.1)
1001–3000	84 (11.6)
3001–5000	57 (7.9)
5001–7000	36 (5.0)
7001–10,000	19 (2.6)
10,001 above	28 (3.9)

Note: *N* = number; CNY = Chinese Yuan

Table 2 Demographic characteristics of the participants

	N (%)
	416 (100)
Sex	
Male	125 (30.0)
Female	291 (70.0)
Age	
18–20	110 (26.4)
21–25	94 (22.6)
26–30	76 (18.3)
31–35	63 (15.1)
36–40	38 (9.1)
41 above	35 (8.4)
Education	
Middle and middle below	25 (6.0)
Professional school	161 (38.7)
Undergraduate	174 (41.8)
Graduate school	56 (13.5)
Income (CNY)	
1000 below	126 (30.3)
1001–3000	57 (13.7)
3001–5000	59 (14.2)
5001–7000	55 (13.2)
7001–10,000	56 (13.5)
10,001 above	63 (15.1)

Note: *N* = number; CNY = Chinese Yuan

the adequacy of the model fit, four fit indices were utilized: (a) the comparative fit index (CFI), where a value of 0.9 or higher indicates a reasonably good fit; (b) the root mean square error of approximation (RMSEA), with a value of 0.10 or lower suggesting a reasonable error of approximation; (c) the standardized root mean square residual (SRMR), where a value of 0.50 or lower indicates an adequate model fit; and (d) the chi square/df ratio, which should ideally be less than 5.

Associations with the hypothesized correlates

The subscale scores and overall scores were derived by summing the items within the scale dimensions, encompassing a total of 416 samples. To explore the associations between continuous variables, the Pearson correlation coefficient was used. Logistic regression was utilized to calculate the adjusted odds ratio (OR) for the binary variable, predicting the connection between the subscale scores and whether the participant would complete the three-shot vaccination series.

Results

Factor analysis and item trimming

The analysis resulted in a five-dimensional scale consisting of perceived benefits, perceived concerns, perceived feedback from others, perceived opinions from experts and others, and perceived general or public opinions toward vaccines. The EFA conducted on the 725 samples revealed the presence of five eigenvalues surpassing the threshold of 1. A notable observation from the scree plot was the significant decline observed between the sixth eigenvalue (1.157) and the seventh eigenvalue (0.802), while the subsequent eigenvalues remained relatively stable, displaying a rather flat trend.

The EFAs were examined through principal axis factorization and the direct oblique method. Throughout the study, the five-factor solution was upheld. To assess the model fit, a CFA was performed based on the EFA in the field sample. The loadings for the first factor, VB (items 1 to 7), ranged from 0.732 to 0.956, while the loadings for the second factor, VC (items 8 to 15), ranged from 0.692 to 0.859. Similarly, the loadings for the third factor, VR (items 16 to 18), ranged from 0.724 to 0.941. For the fourth factor, VI (items 19 to 21), the loadings ranged from 0.599 to 0.863, and for the fifth factor, VS (items 22 to 26), the loadings ranged from 0.832 to 0.903.

The preliminary fit indices indicated an inadequate fit for one of the three indices: CFI, with a value of 0.898; TLI, with a value of 0.888; and RMSEA, with a value of 0.088 (90% confidence interval [CI] = 0.0083, 0.0093). Furthermore, the chi-square statistic (with 319 degrees of freedom) was found to be significant at a *p* value of <0.0001. Consequently, the scale underwent further refinement by sequentially removing one item with a

factor loading below 0.4. As a result, a 26-item five-factor scale was obtained. For this scale, the model fit improved significantly, with CFI=0.937, TLI=0.929, and RMSEA=0.072 (90% CI=0.0067, 0.0078). The revised chi-square statistic remained significant at a *p* value<0.0001.

The scale established from the two cohorts thus included 26 items on five dimensions for the Chinese version of the COVID-19 Vaccine Beliefs Scale. Each of the items representing the five factors and their factor loadings are presented in Table 3.

Multiple-group CFA of invariance across sexes

The configural invariance model fitted the data very well (RMSEA=0.085 [90% CI, 0.080–0.091]; CFI=0.915). Thus, the metric invariance model was tested by constraining the factor loadings across sexes. A constrained metric invariance model showed an acceptable fit (RMSEA=0.084 [90% CI, 0.078–0.086]; CFI=0.915). Moreover, ΔCFI and ΔRMSEA were within recommended guidelines, supporting metric invariance. Given this support, we proceeded to test for scalar invariance. The scalar invariance model fits the data well (RMSEA=0.083 [90% CI, 0.077–0.088]; CFI=0.914). In addition, the ΔCFI and ΔRMSEA values supported the scalar invariance model, which fitted as well as the configural model. The results for the measurement invariance are displayed in Table 4.

Reliability

The subscales showed strong internal consistency, as evidenced by the high alpha coefficients. Specifically, the alpha coefficient for the entire scale was 0.826, while that for the VB subscale was 0.950, that for the VC subscale was 0.931, that for the VR subscale was 0.884, that for the VI subscale was 0.808, and that for the VS subscale was 0.939.

Associations with hypothesized correlates

This research aimed to examine the association between the overall score of the scale and the individual subscale scores in relation to the hypothesized correlates. The hypothesized correlates are shown in Table 4.

Conspiracy belief scale

As hypothesized, the VC (r=.440, p<.01) subscale and VR subscale (r=.174, p<.01) were weakly positively associated with the conspiracy theory score. A greater perceived sense of conspiracy was weakly negatively associated with greater VB (r=-.287, p<.01), VI (r=-.267, p<.01), and VS (r=-.347, p<.01). These results are shown in Table 5.

Fear of COVID-19

This study tested the correlation between the fear of COVID-19 and its subscale scores with the hypothesized correlates. A greater perceived sense of fear of COVID-19 was weakly positively correlated with greater VC (r=.205, p<.01), VR (r=.222, p<.01), and VI (r=.182, p<.01). These results are shown in Table 5.

Intention to receive the vaccine

In the first sample, this research examined the association between beliefs toward the COVID-19 vaccine and the intention to receive the vaccine. Multivariate analysis revealed that VB (OR=1.065, 95% CI 1.035–1.097), VR (OR=0.878, 95% CI 0.832–0.927), and VS (OR=1.076, 95% CI 1.032–1.122) were associated with the intention to receive the vaccine. The regression results of the associations between different demographic data, vaccine beliefs and intention to receive the vaccine are reported in Table 6.

Three doses of vaccine

This research examined the association between beliefs toward the COVID-19 vaccine and the choice of vaccination. The results implied that VC (OR=0.957, 95% CI 0.928–0.987) could predict the choice of taking the recommended three doses of vaccine. The results are shown in Table 7.

Discussion

In this study, we developed a scale that was designed to measure perceptions and beliefs toward vaccines among the Chinese population. The current study revealed a five-factor structure with vaccine beliefs, including perceived benefits, perceived concerns, perceived feedback from others, perceived opinions from experts and others, and perceived general or public opinion toward vaccines. The measure was developed in a multistage procedure from qualitative to quantitative data to form a local scale to evaluate Chinese people's perceptions of and beliefs about the COVID-19 vaccine. The process yielded a conclusive 26-item assessment comprising five distinct dimensions. The assessment displayed commendable psychometric soundness, characterized by a factor arrangement that remained consistent across samples. Additionally, the scores of each dimension displayed an expected correlation with prominent indicators of conspiracy theory beliefs, fear of COVID-19, and behaviors pertaining to receiving all three doses of the COVID-19 vaccine.

When vaccines are not widely available, our results suggest that people may rely on common sense or beliefs about vaccines to guide their vaccination intention [13]. The results of this study suggest that it is very important to strengthen the public's general understanding of

Table 3 Items and factor loadings

Items/Dimensions	Factor loading
VB	
1. I believe that vaccination can help me prevent COVID-19 infection (我相信, 接种疫苗可以帮助我预防新冠感染)	0.733
2. Vaccination makes my daily life more convenient (接种疫苗让我的日常生活更加便捷)	0.732
3. Vaccination makes me feel more secure when I go out (接种疫苗让我外出有更多的安全感)	0.916
4. Vaccination makes me safer in social activities (接种疫苗让我在社交活动中更安全)	0.952
5. Vaccination can protect people around you (接种疫苗可以保护身边人)	0.920
6. Vaccination makes me safer at work (接种疫苗让我在工作中更安全)	0.956
7. Vaccination can allow me to have more intimate behaviors with other people(接种疫苗可以让我与其他人有更亲近的行为)	0.806
VC	
8. I am worried that the side effects of the COVID-19 vaccine will harm my health(我担心接种新冠疫苗带来的副作用危害健康)	0.692
9. I am worried about the unknown risks caused by vaccination (我担心接种疫苗造成的未知风险)	0.758
10. I doubt the effectiveness of the vaccine (我怀疑疫苗的有效性)	0.859
11. I am concerned that the risk of infection remains high after vaccination(我担心接种疫苗后感染风险依然很大)	0.808
12. I am concerned that the vaccination itself carries a risk of contracting COVID-19(我担心接种疫苗本身有感染新冠的风险)	0.702
13. I am concerned that the effective protection period of the existing vaccines is very short(我担心现有疫苗的有效防护时限很短)	0.781
14. I doubt the quality of existing vaccines (我怀疑现有疫苗的质量)	0.832
15. I am concerned about the effectiveness of domestic vaccines (我担心国产疫苗的有效性)	0.857
VR	
16. Regarding whether or not I should get vaccinated, we should see how effective it is for others first (对于是否接种新冠疫苗, 先看看其他人打的效果再说)	0.883
17. Regarding whether or not I should get vaccinated, we should see if other people have any side effects first (对于是否接种新冠疫苗, 先看看其他人有没什么副反应)	0.941
18. I will get vaccinated after reading some of the latest research reports (先看看一些最新的研究报道证实后再打)	0.724
VI	
19. I will get vaccinated if the official media says that I can get vaccinated(官方媒体说可以打就打)	0.825
20. I will get vaccinated if the medical authority says that I can get vaccinated(医学权威说可以打就打)	0.863
21. I will get vaccinated if everyone around me gets vaccinated (我周围的人如果都打了我就去打)	0.599
VS	
22. Vaccination makes society safer(接种疫苗让社会更安全)	0.852
23. Vaccination is a line of defense against disease (打疫苗是对抗疾病的防线)	0.893
24. Vaccination is everyone's responsibility (打疫苗是每个人的责任)	0.832
25. I have had other vaccines in the past and I am confident in the current vaccine (我过去打过其它的疫苗, 我对目前的新冠疫苗还是很有信心的)	0.866
26. Vaccines can protect both oneself and others (疫苗既可以保护自己, 也可以保护他人)	0.903

Note: VB = vaccine benefit; VC = vaccine concern; VR = observing others' reaction to vaccination; VI = influence of authority and others toward vaccination; VS = common sense about vaccination

vaccines in daily life, reduce the influence of misinformation, and improve the public's rational understanding of vaccines, which may positively influence vaccination intention and uptake in the public.

Consistent with other research, the present study confirmed that the perceived benefits of a COVID-19 vaccine were significantly associated with vaccination intention [14]. Interestingly, individuals who cared more

Table 4 Results of tests for invariance across sexes

	χ2	Df	CFI	TLI	RMSEA (90% CI)	ΔCFI	ΔRMSEA
All($n=416$)	916.50	288	0.937	0.929	0.072(0.067 0.078)		
Male($n=125$)	567.01	288	0.920	0.910	0.088(0.077 0.099)		
Female($n=291$)	876.26	288	0.913	0.902	0.084(0.077 0.090)		
M1($n=416$)	1443.27	576	0.915	0.904	0.085(0.080 0.091)	-	-
M2($n=416$)	1467.98	597	0.915	0.907	0.084(0.078 0.086)	0.001	0.001
M3($n=416$)	1497.65	618	0.914	0.910	0.083(0.077 0.088)	0.001	0.001

Note: RMSEA: root mean square error of approximation; CI: confidence interval; CFI: comparative fit index. M1: configural invariance; M2: metric invariance; M3: scalar invariance

Table 5 Associations among COVID-19 vaccine beliefs and hypothesized correlates

Variables	1	2	3	4	5	6	7
1. VB [1]	1						
2. VC [2]	−0.434**	1					
3. VR [3]	−0.034	0.415**	1				
4. VI [4]	0.434**	−0.233**	0.115*	1			
5. VS [5]	0.830**	−0.485**	−0.117*	0.485**	1		
6. Conspiracy Belief	−0.287**	0.440**	0.174**	−0.267**	−0.347**	1	
7. COVID-19 Fear	0.059	0.205**	0.222**	0.182**	0.074	−0.016	1
M[6]	30.96	25.32	11.18	11.43	23.11	4.75	16.20
SD[7]	8.30	9.89	3.91	3.61	5.89	2.66	6.32

Note: * $p<.05$, ** $p<.01$. M=mean; SD=standard deviation; VB=vaccine benefit; VC=vaccine concern

VR=observing others' reactions to vaccination; VI=influence of authority and others toward vaccination; VS=common sense about vaccination

about other people's reactions to vaccination were less likely to have vaccination intentions. This reflects the fact that people who are susceptible to information from others are more susceptible to being influenced by the external environment. Other researchers have confirmed that individuals who are more susceptible to misinformation about COVID-19 vaccines have reduced vaccine intentions [15, 16]. The present investigation indicates that there is a pressing need for interventions that enhance critical thinking and trust in science within these particular populations.

The vaccine concerns subscale was negatively associated with COVID-19 vaccine behaviors. Consistent with a previous study, the current study confirmed that concerns about the side effects, efficacy, and safety of the COVID-19 vaccine are the primary reasons for deferring the three doses of vaccination [17]. One systematic review confirmed that increased COVID-19 vaccine hesitancy was related to concerns about the side effects and safety of the COVID-19 vaccine, which are the primary reasons for deferring vaccination [18]. Our current study revealed that the vaccine concerns subscale included items regarding worries about negative side effects, safety, quality, risk of infection, long-term protective effects of vaccines, and doubts about homegrown vaccines. The concerns regarding the vaccine highlight the ongoing significance of promoting the safety and effectiveness of vaccines. These discoveries can also assist in crafting messages and interventions aimed at encouraging vaccine acceptance. Intervention experts may contemplate creating communications that prioritize the vaccine's safety, efficacy, and reliability, particularly in terms of its ability to prevent severe COVID-19 cases requiring hospitalization and the vaccine's effectiveness in curbing the transmission of infections. The data supporting vaccine safety and the credibility of the pharmaceutical companies responsible for developing the vaccine can also be disseminated [19].

It is remarkable that fear of COVID-19 was associated with concerns about vaccination, others' feedback, and the opinions of experts and others. In previous research, greater COVID-19 vaccine hesitancy or concerns were associated with fear of COVID-19, which implies that those believing that a COVID-19 vaccine would not be effective, safe or trustworthy in preventing COVID-19 infection reported greater fear of COVID-19 [20]. This partially supports the statement that dysfunctional fears and anxiety feed off each other, which may contribute to low vaccination adherence in the pandemic context [21]. Importantly, Chinese society is an other-oriented society, which makes people very concerned about other people's opinions and feedback. Our study further illustrates this phenomenon. This study revealed that people's concerns about experts' opinions on vaccines and other people's feedback are related to greater fear of COVID-19. These results may suggest that the role of social influences is more complex and not always adaptive to vaccine acceptance. However, the challenge of COVID-19 vaccine hesitancy has little to do with the vaccines themselves but is more a problem of the information ecosystems

Table 6 Binary logistic regression model for predicting the intention to receive the vaccine

Variables		Intention to receive the vaccine		
		***P*value**	**Odds ratio (OR)**	**95% Confidence interval (CI)**
Sex	Male	Reference		
	Female	0.047	0.684	(0.471–0.995)
Age	18–20	Reference		
	21–25	0.604	1.109	(0.750–1.639)
	26–30	0.051	3.024	(0.993–9.207)
	31–35	0.898	1.089	(0.293–4.050)
	36–40	0.609	1.400	(0.386–5.069)
	41 above	0.707	1.171	(0.514–2.671)
Education	Middle and middle below	Reference		
	Professional school	0.066	2.280	(0.946–5.494)
	Undergraduate	0.011	2.543	(1.234–5.238)
	Graduate school	0.327	1.757	(0.569–5.427)
Income (CNY)	1000 below	Reference		
	1001–3000	0.124	1.547	(0.887–2.701)
	3001–5000	0.047	2.290	(1.009–5.195)
	5001–7000	0.617	0.778	(0.291–2.079)
	7001–10,000	0.964	1.029	(0.296–3.574)
	10,001 above	0.324	1.671	(0.602-4,638)
VB		0.000	1.065	(1.035–1.097)
VC		0.698	1.004	(0.984–1.024)
VR		0.000	0.878	(0.832–0.927)
VI		0.107	0.957	(0.907–1.010)
VS		0.001	1.076	(1.032–1.122)
Constant		0.000	0.066	

Note: OR=odds ratio; CI=confidence interval; CNY=Chinese Yuan; VB=vaccine benefit; VC=vaccine concern

VR=observing others' reactions to vaccination; VI=influence of authority and others toward vaccination; VS=common sense about vaccination

Table 7 Binary logistic regression model for predicting the need for three doses of COVID-19 vaccination

Variables		Taking three doses vaccination		
		***P*value**	**Odds ratio (OR)**	**95% Confidence interval (CI)**
Sex	Male	Reference		
	Female	0.326	0.763	(0.446–1.308)
Age	18–20	Reference		
	21–25	0.041	2.637	(1.039–6.692)
	26–30	0.433	0.672	(0.249–1.816)
	31–35	0.936	1.046	(0.350–3.121)
	36–40	0.844	1.131	(0.333–3.834)
	41 above	0.953	1.034	(0.340–3.147)
Education	Middle and middle below	Reference		
	Professional school	0.101	2.406	(0.843–6.865)
	Undergraduate	0.134	2.213	(0.782–6.263)
	Graduate school	0.497	1.510	(0.460–4.956)
Income (CNY)	1000 below	Reference		
	1001–3000	0.032	0.417	(0.187–0.928)
	3001–5000	0.725	1.208	(0.422–3.456)
	5001–7000	0.057	0.383	(0.143–1.029)
	7001–10,000	0.836	1.119	(0.387–3.239)
	10,001 above	0.752	0.848	(0.305–2.359)
VB		0.557	1.016	(0.965–1.069)
VC		0.005	0.957	(0.928–0.987)
VR		0.175	0.950	(0.883–1.023)
VI		0.259	1.047	(0.967–1.134)
VS		0.803	1.010	(0.935–1.091)
Constant		0.270	2.955	

Note: OR=odds ratio; CI=confidence interval; CNY=Chinese Yuan; VB=vaccine benefit; VC=vaccine concern

VR=observing others' reactions to vaccination; VI=influence of authority and others toward vaccination; VS=common sense about vaccination

that have magnified widely held social anxieties and fear; these, in turn, have exacerbated skepticism toward vaccines and fears toward COVID-19 [22]. From this perspective, future studies need to leverage the influence of experts and social media to reduce the spread of false and negative information and reduce the public's fear of COVID-19.

A wide body of literature has shown that holding general conspiracy theories or believing COVID-19 misinformation predicts COVID-19 vaccine hesitancy and concerns [23, 24]. The present study revealed that people who believe that vaccines have more benefits are less likely to believe in conspiracy theories, people who are more fearful about vaccines are more likely to believe in conspiracy theories, people who believe more in messages from authorities are less likely to believe in conspiracy theories, people who believe more in feedback from others after they obtain vaccines are more likely to believe in conspiracy theories, and people who have more common sense about vaccines are less likely to believe in conspiracy theories.

In light of the ongoing global pandemic, social media corporations have faced mounting public and political scrutiny regarding their obligation to curtail the dissemination of inaccurate information pertaining to COVID-19 and vaccination on their platforms. The significance of this study is that professional feedback can help the public have a more scientific and clear understanding of vaccines in future epidemics, reducing the influence of conspiracy theories. Previous researchers confirmed that health care authorities' effective maneuvers to increase public awareness of COVID-19 can be effective in fighting conspiracy theories in the community [25]. At the same time, since the internet can amplify vaccine-related adverse reactions, future promotion needs to clearly inform individuals about positive and negative reactions

to reduce the penetration of conspiracy theories. More attention needs to be devoted to helping people understand their own risks and benefits of vaccines and filling knowledge gaps that can reduce belief in conspiracy theories. This requires a scientific understanding and information about vaccine-related side effects to increase transparency and reduce the influence of conspiracy theories.

Compared with other countries, China has a relationally based society. In this relational network, Chinese people are very concerned about the opinions of others. A large amount of false information spreads very quickly in interpersonal networks, and interpersonal influence significantly affects the public's attitudes and beliefs about vaccines. In future public health services, it is necessary to recognize the positive and negative effects of interpersonal influences on vaccination and other public health propaganda policies in the relational society to better carry out public health services. The design of the scale to evaluate beliefs about vaccines can help clinicians, policy makers, and vaccine service providers understand Chinese people's experiences and beliefs about the COVID-19 vaccine. This is a key element in reducing vaccine resistance and ensuring full vaccine coverage.

Strengths and limitations

The current research used a mixed method approach to develop a robust tool to estimate the public's experience and beliefs about vaccination. The current research developed a scale in the local context, and the scale has good reliability, content validity, and structural validity. Despite these advantages, the current study has the following limitations. First, this study did not include participants 9–16 years old or people over 65 years old; vaccine beliefs may differ among teenagers, children and older people. Second, the participants volunteered to complete the online questionnaires; thus, the respondents may be biased toward internet users who are mostly young, high-income, urbanized and highly educated. Third, the current study did not perform a test-retest reliability test and lacked a predictive validity test, which may limit the generalizability of the current research. Further research is warranted to use this measure in different populations to assess its predictive validity and test-retest reliability and to conduct evaluations in other populations. Fourth, belief is a relatively stable attitude that reflects the general attitude of the public toward it. However, perceptions and beliefs concerning vaccines may evolve throughout the pandemic, and the current study may not reflect the evolving beliefs concerning vaccines; we will take time into account in future studies.

Conclusions

The global consensus on the significance of achieving widespread vaccine coverage and addressing COVID-19 vaccine hesitancy is well established. To gain insights into the attitudes and beliefs toward vaccines within specific communities, a comprehensive scale was developed. This five-factor scale has proven to be an effective and efficient tool for assessing vaccine beliefs among the Chinese population. It has exhibited strong internal consistency, as well as construct validity. Notably, the subscales of the scale have demonstrated associations with vaccine conspiracy theories and the fear of contracting COVID-19. The availability of a standardized and validated measurement tool for assessing vaccine beliefs would greatly contribute to the progress of research and the promotion of culturally competent immunization services. Such a tool would be invaluable in designing interventions that effectively promote vaccination within local contexts.

Abbreviations

CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CI	Confidence Interval
CNY	Chinese Yuan
EFA	Explanatory Factor Analysis
FCV-19 S	Fear of COVID-19 Scale
M	Mean
N	Number
OR	Odds Ratio
RMSEA	Root Mean Square Radius of Approximation
SD	Standard Deviation
SRMR	Standardized Root Mean Square Residual
VB	Vaccine Benefit
VC	Vaccine Concerns
VI	Influence of Authority and Others toward Vaccination
VR	Observing Others' Reactions to Vaccination
VS	Common Sense about Vaccination

Author contributions

RZJ and XZY conceived and designed the study, XZY and RZJ conducted data collection, XZY and RZJ conducted the qualitative data analysis, and RZJ and MZJ performed the quantitative statistical analysis and interpreted the data. RZJ wrote the manuscript, and MZJ assisted in writing the results and draw the tables of the manuscript. All authors have read and provided critical feedback on drafts and approved the final manuscript.

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Data availability

The data can be obtained from the corresponding author upon reasonable request.

Code availability

Not applicable.

Declarations

Ethics approval

This study adhered to the Declaration of Helsinki and Resolutions. Ethical approval was acquired from the Clinical Research Ethics Committee of the Third Affiliated Hospital of Chongqing Medical University.

Consent to participate
The participants consented to participate in this study.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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