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What drives the vaccination intention against COVID-19? Application of EPPM, TAM, and theories of risk assessment

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ABSTRACT

Vaccines are widely used to fight against COVID-19. However, COVID-19 vaccine hesitancy appears as some individuals are concerned with COVID-19 vaccines. This study investigates the vaccination intention against COVID-19 in China with the Extended Parallel Process Model (EPPM), Technology Acceptance Model (TAM), and theories of risk information assessment. Results showed that the formation mechanism of vaccination intention could be considered a psychological process, as subjective knowledge was a primary influence on correspondents' weighting of both the potentially positive (usefulness) and negative effects (threat) of vaccination. This unequal consideration then resulted in different levels of fear arousal between subjects. Driven by usefulness/threat perception and fear, people conducted different decision strategies, so-called analytical assessment, and experiential assessment to make vaccination decision. In addition to the direct effects of experiential assessment on vaccination intention, two decision strategies and fear arousal also affected people's vaccination intention through the mediation role of vaccination attitude. For policymakers and stakeholders, this study provides a knowledge base for confidence-building, and emotional guidance concerning against COVID-19 vaccination.

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Introduction

As the novel coronavirus disease (COVID-19) has rapidly instigated a global pandemic since 2019,[1] vaccinations have been widely used to mitigate the losses. A significant amount of resources have been devoted to medical research on the COVID-19 vaccine. By the end of 2020, countries such as China, the USA, and Europe succeeded in rolling out diverse COVID-19 vaccines. There are several COVID-19 vaccines approved by the World Health Organization (WHO) at this writing time. The widespread uptake of safe, effective, and recommended COVID-19 vaccines can reduce the spread of the virus and increase the proportion with immunity to this disease.

However, the success of this strategy relies on people's acceptability to vaccine. Due to misinformation and conspiracy theories, vaccine hesitancy of COVID-19 was widespread in public, which led this vaccination recommendation to fail to obtain high vaccination coverage as expected in many countries.[2–5] A published report by the Pew Research Center stated that four in ten Americans will or probably not take the vaccine and that 21% of American adults are "pretty certain" that they will not take the vaccine.[5] Some surveys conducted in representative countries showed that the vaccine refusal rates exceeded the prediction threshold worryingly. For instance, almost a quarter of French respondents would not have used the available COVID-19 vaccine.[6] Between one-fifth and one-third of American adults planned to refuse a vaccine for COVID-19.[7] Nearly 40% of nurse respondents in Hong Kong indicated that they were likely to opt for the COVID-19 vaccine.[8] Studies in Australia, Italy, and England also suggested high rates of vaccine hesitancy.[9–13] In fact, many experts have warned against a worldwide decline in public trust in immunization over the past decade and predicted that public doubt about vaccines might become an increasingly important global issue. The controversy focused on severe concerns about the safety, efficacy, and affordability of COVID-19 vaccine approved for use. Specifically, the COVID-19 vaccine candidates, which should typically take several years to become commercially available, were developed historically rapidly. This has resulted in a public debate claiming that COVID-19 vaccine had been produced too hastily and had not been tested enough. As a result of professional barriers and information asymmetry, people lack objective knowledge related to COVID-19 vaccine, which means people's attitudes, risk perception, and vaccination intention depend on subjective cognition. In this context, people worry about compromised safety standards for vaccine approvals and doubt that clinical trials may not be able to demonstrate efficacy with the same statistical power usually required for regulatory approval.

Previous literatures have shown that people's view of COVID-19 vaccination was attributed to demographic factors,[13] threat perception of side effects and potential effectiveness,[14–16] political perspectives,[17–19] social norms,[20,21] and 5C (confidence, complacency, constraints, calculation, and collective responsibility) in psychological antecedent model.[22,23] Although those studies found evidence supporting the impact of various factors on risk perceptions and vaccination intentions toward COVID-19 vaccine, most of

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the conclusions were straightforward. Most importantly, the psychological decision processing of vaccination intentions is still unclear, which is a critical premise in policy making related to the COVID-19 vaccine. Thus, we constructed a conceptual model that seeks to better explain the people's intentions toward vaccinating against COVID-19 in China, thus helping public sectors improve vaccination recommendations' effectiveness to establish herd immunity as soon as possible.

Theoretical framework

The Extended Parallel Processing Model (EPPM) is one of the representative models predicting the performance of individual's health behaviors.[24] The EPPM explains people's possible responses to a fear appeal message and places them into three broad categories: non-responses, danger control responses, and fear control responses. The theory predicts behavioral responses individuals may demonstrate depending upon the interaction between their threat perceptions and efficacy perceptions.[25] The EPPM suggests that when people perceive high levels of efficacy, they will engage in danger control responses. On the contrary, high threat/low efficacy conditions may arouse fear and lead to fear control processes enacting the opposite behaviors to avert a given risk, such as defensive avoidance or reactance.[26] Relying on various methods, many studies have empirically supported this theoretical model.[27,28]

Although EPPM was first developed to illustrate people's responses to disease rather than risk issues of vaccines, people's psychological processes are usually similar. In the situation of COVID-19 vaccine, people are faced with the problems of safety and efficacy. Their vaccination intention generally includes three steps: Firstly, people receive comprehensive information through multiple channels and form some degree of understanding regarding COVID-19 vaccines; Secondly, people perceive and assess the risk and benefit of vaccination; Finally, they decide whether to get vaccinated against COVID-19. This multi-stage process is generally consistent with the EPPM model. Thus, we pick three latent variables from the EPPM, namely subjective knowledge (external stimuli), perceived threat, and fear arousal, to put insight into this behavioral intention of vaccinating against COVID-19.

In addition to perceived threats, people's benefit perception of vaccines is also an essential factor affecting willingness to vaccinate. Technology Acceptance Model (TAM) provided a rich theoretical basis for the studies of how benefit perception affects attitudes and intentions and was generally considered to be a universal model for predicting people's acceptance of technology.[29] The TAM explained the mechanism that perceived usefulness, attitude toward using, and perceived ease of use affect behavioral intention to use and actual using behavior. In this model, perceived usefulness is the comprehensive perception of the benefits of technology, attitude toward using refers to the individual's feelings about the target technology, and behavioral intention refers to the intensity of subjective willingness to use a certain technology. For many years, the TAM has provided a framework for effective communication of vaccine-related issues and has been frequently applied in predicting vaccination intention. Therefore, it is suitable for the analysis of vaccination intention toward COVID-19. This is especially needed in China because the Chinese authorities are launching a pressing movement regarding vaccination recommendations to fight against COVID-19, which means people's vaccination attitude is the critical premise for vaccination intention. The TAM has unique advantages in dealing with these issues. Thus, we select three relevant variables (perceived usefulness, vaccination attitude, and vaccination intention) to explore the mechanisms that shape people's vaccination choices.

However, it is important to note that EPPM and TAM focus on the psychological processing of perception and fear. It does not discuss people's decision strategies by which people may show distinguishing behavioral responses. This is of particular importance to vaccination intentions because COVID-19 vaccine is newly developed and not yet fully understood by people. Thus, these decision strategies of vaccination intention should be explained clearly. Some related theories of risk information assessment explained an individual's behavioral decision-making strategy when facing a certain risk situation. According to previous studies,[30] the strategy that people select to process risk information includes a dual-process model of analytical assessment and experiential assessment. The analytical assessment concludes with information integration and logical analysis, while experiential assessment uses simple rules to arrive at a judgment.

People that have more knowledge may be motivated to conduct a vaccination intention with additional efforts of logical evaluation and comprehensive comparison efforts. In contrast, most people may spend less effort presenting willingness to get vaccinated with the simple decision rules of herd mentality and emotionality, and people easily accept the vaccination recommendation they acquire from outside without suspicion. This situation is suitable for theories of risk information assessment. Thus, in this paper, we directly choose analytical assessment and experiential assessment to explain this vaccination intention decision-making mechanism.

As the public's perceived risk, emotional feelings, and psychological decision-making methods are very important to the formation of vaccination intentions based on classical theories, such as the Health Belief Model (HBM), Theory of Planned Behavior (TPB), Social Cognitive Theory, and Social-Ecological Model, the Extended Parallel Processing Model (EPPM), Technology Acceptance Model (TAM), and theories of risk information assessment, this research adapts and synthesizes components from the EPPM, TAM, and risk information assessment theories to develop a model for understanding the driving mechanism of vaccination intention toward COVID-19. This research constructs a conceptual model with the integration, shown in Figure 1. Variables are all directly chosen from the applied models or replaced with relevant variables to fit the situation of the COVID-19 vaccine. The model assumes that subjective knowledge simultaneously triggers perceived threats and perceived usefulness. Subsequently, two decision strategies are stimulated. Finally, people produce a vaccination attitude and vaccination intention.

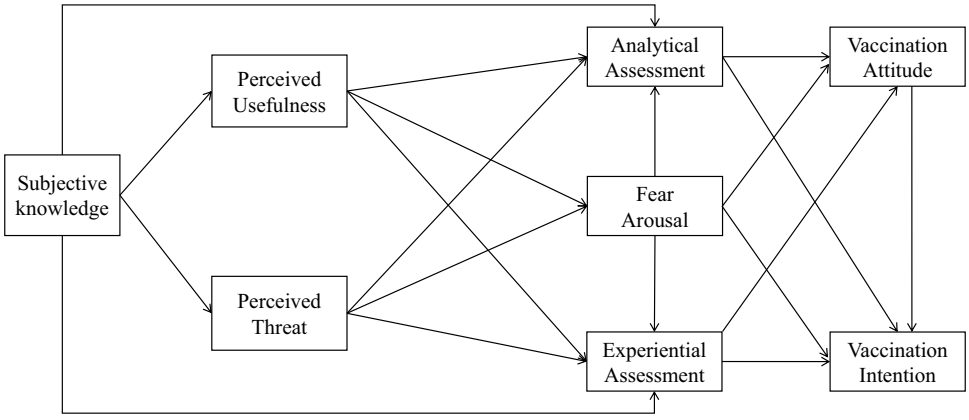

Figure 1. Conceptual model.

Hypotheses development

Subjective knowledge, perceived usefulness, and perceived threat

The multi-attribute model (MAM) is an important framework for explaining people's attitude, emphasizing that attitude is the result of beliefs that people develop on the attributes of a certain issue weighted by evaluation.[31] The MAM indicates that knowledge is the cognitive basis for an individual's attitude. In this study, we used subjective knowledge (the psychological measure of self-reported familiarity with COVID-19 vaccine) instead of objective knowledge to fit our research situation because most people may not have experienced an emergency use of the vaccine before COVID-19 epidemic and also lack factual knowledge of COVID-19 vaccine.

Documents in the field of risk have emphasized risk perception referring to people's expectations of the comprehensive impacts of a risk situation.[30] In the EPPM, perceived threat is a central factor influencing people's responses to threatening situations, this can be seen as the degree to which people believe the risk of COVID-19 vaccine to be serious or significant. These perceived impacts are related to the probability of health risk occurrence and the consequences, including effectiveness of immunity, side effects, long-term safety, etc.[32,33] In addition to risk perception, benefit perception is also an important predictor influencing an individual's attitude. In TAM, perceived usefulness plays a mediator role in providing insights into the formation of individual attitude, which can be considered the comprehensive benefit evaluation of COVID-19 vaccine, including both personal and social aspects.[32] The TAM has been widely verified since it was developed, and some scholars have adapted and revised it appropriately based on research topics.

As shown in a growing body of literature, subjective knowledge is a well-explored factor predicting the cognition of risk and benefit-related issues.[33] But their findings about the relationship between knowledge and risk/benefit perception were not consistent. Many studies supported the negative influence of knowledge on risk perception because knowledge can improve people's cognitive ability and reduce the complexity of cognition, thereby inspiring people to understand the risk with scientific rationality. There were also some studies documenting stark different conclusions in this setting, indicating that knowledge has no significant impact on risk/benefit perception because knowledge is not the priority for risk assessment; people are used to completing this perception process through personal experience and beliefs, especially when facing some risky issues of emerging technology, like genetic engineering, artificial intelligence, and biological medicine.[34,35]

Similarly, COVID-19 vaccines can be regarded as an emerging biomedical technology with uncertainties, and the possible consequences of its application are felt to be unknown due to its rushed development. Furthermore, because of the limited understanding, people's vaccination attitudes are usually related to weighing up the perceived threat and usefulness based on perceived familiarity (subjective knowledge) to COVID-19 vaccine. In fact, COVID-19 vaccines can also cause adverse side effects, just like any other medical product. Most of these reactions are mild and include fever, rash, headache, chest pain, tiredness, soreness, swelling, and redness at the injection site. However, some side effects are serious though rare, such as seizures, difficulty breathing, and other life-threatening allergic reactions.[36] Thus, people always consider the potential side effects when deciding whether to get vaccinated.[37] Some studies showed that knowledge had been identified among the most important determinants that influenced individuals' belief in vaccination issues.[37–40] For instance, Akhmetzhanova et al. (2020) investigated vaccine hesitancy in Kazakhstan and found that more than 30% of the participants consider themselves vaccine-hesitant, primarily due to poor vaccine knowledge.[37] However, few studies have explored this relationship in this COVID-19 crisis. Therefore, we seek to examine whether people's initial subjective knowledge of the COVID-19 vaccine significantly affects the perceived threat and usefulness of vaccinating against COVID-19. Thus, the following hypotheses are proposed.

H1: *People that have more subjective knowledge of COVID-19 vaccine perceive more usefulness toward vaccination.*

H2: *People that have less subjective knowledge of COVID-19 vaccine perceive more threat toward vaccination.*

Fear arousal, analytical assessment, and experiential assessment

The study of fear as an important indicator to influence people to engage in health-protective behaviors has been ongoing for many years. The EPPM postulates that motivation to act in response to fear depends solely on the degree of their perception of a threat.[25] If a threat is perceived, the fear will be successful in motivating people to engage in the recommended protective behaviors. If people do not perceive the threat to be high, they will not experience fear. On the other hand, if people perceive a high threat, they will experience fear. And when people perceive that they have enough efficacy to avert the threat, they will reduce their fear by engaging in danger control responses.[26] So, the EPPM suggests that risk situations could arouse an individual's fear when perceiving high levels of risk and low degree of efficacy.[27] This, especially, has been the case in the position of vaccines; even before the COVID-19 pandemic took hold, vaccination has long been an emotionally charged issue worldwide, and fear was always on the rise coupled with a sense of uncertainty.[41] The COVID-19 vaccine has heightened the public's collective emotions due to its emergency application. Threat perception over vaccine safety, side effects, and the rapid development of the vaccine have been cited as the causal factor to fear.[42] Conversely, constant attention to the benefits of COVID-19 vaccine also contributed to dampening fear responses to vaccination.[43] Thus, the following hypotheses were developed.

H3: *People who perceive more usefulness toward vaccination show lower levels of fear arousal.*

H4: *People who perceive more threat toward vaccination show higher levels of fear arousal.*

The theory of risk information assessment views information processing as an antecedent to attitude formation and behavior change and hypothesizes that people process information using the strategies of analytical (effortful) assessment and experiential (superficial) assessment.[30,44,45] Analytical assessment is the logical evaluation and comprehensive comparison with which individuals make judgments. On the contrary, experiential assessment works when individuals use simple rules to help them arrive at a decision. Many factors affect people's decision strategies, and information (knowledge) sufficiency is considered as the most important determinants.[46] When individuals carry much prior knowledge of the issue, they are more motivated and able to analyze the information related to this issue. ***Trumbo*** viewed knowledge as a vital stimulant to the use of analytical processing and indicated that highly knowledged people are more likely to process information analytically and less likely to rely on emotion and experience cues.[47] So, the improvement of knowledge level helps activate people's "scientific rationality" and reduce "irrational judgment" so that people are more willing to view vaccines from the perspective of logic and reasoning rather than from the standpoint of emotion or experience. However, this relationship has not been confirmed in the risk scenario of the vaccine, and whether or not knowledge of the COVID-19 vaccine affects people's processing strategies is yet to be determined. Therefore, the related hypotheses are developed.

H5: *People that have more subjective knowledge of COVID-19 vaccine are more likely to use analytical assessment to make vaccination decisions.*

H6: *People with less subjective knowledge of COVID-19 vaccine are more likely to use experiential assessment to make vaccination decisions.*

There are few studies on people's risk or benefit perception influencing the decision strategy. Some studies tested the indirect effects of risk perception on systematic processing, linked risk perception with systematic processing in the issue of the Volkswagen crisis, and indicated risk perception increased systematic processing.[48,49] However, in certain matters coupled with both risk and benefit, comprehensive relationships are still not clearly defined. When people are exposed to the situation of the COVID-19 vaccine, the initially perceived threat and perceived usefulness not only motivate them to be involved in different degrees of fear but also affect their intentions to adopt different vaccination decision strategies.[47] Generally, people who perceived more usefulness toward COVID-19 vaccine know more about vaccines and have lower levels of fear toward vaccinating against COVID-19. Hence, people have an advantage in analytical thinking and logical reasoning when making vaccination decisions, while people who perceived more threats know little about vaccines and usually show higher levels of fear.[50] So, it is easier to draw a vaccination decision through personal experience, emotion, and recommendations from others. Higher threat perception and fear arousal related to the COVID-19 vaccine may inspire people's experiential assessment, and the analytical assessment processing will be conserved. Therefore, the following hypotheses are developed.

H7: *People that perceive more usefulness toward vaccination are more likely to use analytical assessment to make vaccination decisions.*

H8: *People that perceive more usefulness toward vaccination are less likely to use experiential assessment to make vaccination decisions*

H9: *People who perceive more threats toward vaccination are more likely to use experiential assessment to make vaccination decisions.*

H10: *People that perceive more threats toward vaccination are less likely to use analytical assessment to make vaccination decisions*

H11: *People with higher levels of fear arousal are more likely to use experiential assessment to make vaccination decisions.*

H12: *People with lower levels of fear arousal are less likely to use analytical assessment to make vaccination decisions.*

Vaccination attitude and vaccination intention

The TAM is considered to be a universal model for individuals' vaccination behavior and has been widely validated by previous researches.[51,52] In TAM, the attitude toward using can affect the behavioral intention to use, and behavioral intention to use determines the actual system use. In this study, to better fit the situation of COVID-19, we used vaccination intention instead of the actual vaccination behavior to describe people's reactions to COVID-19 vaccine because COVID-19 vaccine is a kind of biomedical technology for emergency applications, which cannot be used frequently and is strongly recommended by the government. This makes vaccination attitude and vaccination intentions the key issues for herd immunity. There have been many studies supporting vaccination attitude as a significant indicator of vaccination intention in the framework of TAM.[53] However, there are few studies explaining the impact of decision strategies on vaccination intention. In particular, the effects of analytical assessment and experiential assessment on vaccination intention have not been compared in a certain vaccine situation. **Hovick *et al***. tested the relationship between systematic processing and protective behavior in a health crisis and came to the conclusion that people usually show positive health-protective actions with systematic processing.[48] In many other risk situations, information processing has also been identified in which individuals who process information with logical evaluation exhibit higher intentions to take actions to avoid the risk. By this reasoning, analytical assessment is driven by sufficient information (knowledge) and is conducted by the method of analyzing and comparing, then forming the positive vaccination intention against COVID-19. The experiential assessment with less information (knowledge) is undertaken by experience, emotion, and following, leading to fewer sound judgments and negative vaccination intention when facing the risk situation of the COVID-19 vaccine. Therefore, the following hypotheses are developed.

H13: *People that have more positive vaccination attitudes show more positive vaccination intentions against COVID-19.*

H14: *People who use analytical assessment to make vaccination decisions are likely to have a positive vaccination attitude against COVID-19.*

H15: *People who use analytical assessments to make vaccination decisions are likely to show positive vaccination intention against COVID-19.*

H16: *People who use experiential assessment to make vaccination decisions are likely to have a negative vaccination attitude against COVID-19.*

H17: *People who use experiential assessment to make vaccination decisions are likely to show negative vaccination intention against COVID-19.*

Emotion has played a central role in the research and practice of health behavior change.[54] Emotional responses, such as fear and anxiety, have been found to affect behaviors and outcomes, and heightened or lowered levels of emotions interfere with attitude and intention to engage in preventive health behaviors.[41,55] In the context of the COVID-19 vaccine, fear may be the accentuated emotion affecting vaccine decisions. Coupled with the broader political discord and concerns over the safety or efficacy of the COVID-19 vaccine, the relationship between fear and vaccination intention is complex. There are growing studies revealing fears over vaccine safety, and side effects of the vaccine have been cited as barriers to vaccinating against COVID-19, and this influence is more serious than statistical information ever before.[43] Therefore, the following hypotheses are proposed.

H18: *People that have higher levels of fear arousal show more negative vaccination attitudes against COVID-19.*

H19: *People that have higher levels of fear arousal show more negative vaccination intention against COVID-19.*

Research methodology

Sample and data collection

To explore the formation mechanism of people's vaccination intention, we conducted an immediate online survey through Wenjuanxing, China's most popular online survey platform. Our questionnaire was written in Chinese. Although it was developed in English, we invited four researchers to help us translate it into Chinese and back-translate it into English. By comparing the different versions, we modified and deleted the contents that did not fit Chinese habits and culture to ensure the content validity of our questionnaire. Before the formal investigation, a pre-survey with a convenient sample of 80 students was conducted for further checking and refining the scenario information and measures. We agreed to share the survey data with Wenjuanxing and Cooperative Research Institutions and promised that our study was only for academic research and publication.

The whole investigation process lasted from March 20 to 30, 2021, because this is the window time when the Chinese government began to promote vaccinating against COVID-19 to ensure the reliability and validity of survey data. Wenjuanxing used artificial intelligence algorithm advertisements to promote questionnaires on online platforms, such as WeChat and Weibo, ensuring that we had enough respondents to respond and significantly reduced the cost and difficulty of our investigation. The questionnaire consisted of three parts: an introduction page, a variable page, and a socio-demographic characteristics page. After a brief introduction to thank respondents for their participation, some basic

scenario information introducing the COVID-19 vaccine was presented. Then, a section of items was designed to identify the scales of constructs associated with the conceptual model. Finally, some questions investigating demographics were in the final section. By the way, to eliminate the influence of cognitive bias on the investigation as far as possible, our research team members would provide short explanations to participants before they clicked the survey link and filled in the questionnaire: "We are from independent research institutions, not from vaccine marketer. This is an anonymous survey, the answers are for academic research, and all information will be kept confidential. If interested, we can provide you with the research results." After we ensured that all participants were voluntary and provided their informed consent, they began to fill out the questionnaire in a self-administered manner within 10 min. Finally, these respondents were thanked for participating in a small gift by online lottery.

In total, a random sample of 5011 respondents was interviewed online. However, 103 questionnaires were judged to be invalid because of missing data and outliers; 80 questionnaires were answered in less than 200 s, which can be considered the invalid questionnaire statistically. Finally, a total of 4828 valid questionnaires were included in this study.

Table 1 shows the summary statistics of socio-demographic characteristics, including gender, age, education, registered residence, and income. The gender ratio was almost equal with a proportion, 49.1% ($n = 2392$) percent of the sample were male and 50.9% ($n = 2476$) were female. As for the age distribution, the largest groups were between 31 and 40 (36.6%, $n = 1780$), and 18 and 30 (25.7%, $n = 1252$), followed the group between 31 and 40 (17.0%, $n = 828$), and 51 and 60 (12.6%, $n = 612$).

In terms of education, over half of respondents (676.1%, $n = 3676$) completed their high school, followed by College or University (21.3%, $n = 1028$), and a small portion of the respondents (2.6%, $n = 124$) had master's degree or above. As for registered residence, 66.1% ($n = 3216$) of the respondents were urban residents, and about one-third of respondents were rural residents.

Finally, the income of the majority of the respondents falls into the categories of 10,000–20,000 yuan (46.8%, $n = 2276$) and 5,000–1,0000 yuan (24.8%, $n = 1208$), while small percentage of the respondents were 5,000 yuan or below (14.2%, $n = 692$) and above 20,000 yuan (14.2%, $n = 692$).

Measures

As shown in Table 2, the constructs of the conceptual model were measured with multiple items based on previous studies, and some minor modifications in the wording were made to fit the context of COVID-19 vaccine and Chinese expression culture. All of them were measured on a 7-level Likert scale.

In this study, subjective knowledge was measured by means of a scale that **Ma *et al.,*** has used successfully, the five items focused on classification, scientific mechanism, experimental procedure, benefits, and potential risks of COVID-19 vaccine.[56] Perceived usefulness and perceived threat were measured by a subjectively selected subset of items based on **Chung & Jones-Jang** and **Roberto & Goodall**, the eight items asked people to assess benefits and risks of vaccinating against COVID-19.[57,58] Analytical assessment and experiential assessment were measured through eight items based on the studies of **Slovic & Peters and Moeini**, the measurement of analytical assessment focused on evaluating logic, while experiential assessment pay attention to following strategy.[30,45] Fear arousal was measured by three items modified from the work of **Scharwath**, and the measurement focused on whether people were afraid, anxious, or nervous about vaccination.[59] Vaccination attitude and vaccination intention were measured by six items based on the researches of **Gerend & Shepherd** and **Juraskova *et al.,*** and the measurement focused on people's subjective evaluation of vaccination and the possibility of vaccinating against COVID-19.[60,61]

Descriptive analysis

Before empirically testing the measurement model and structural model, the descriptive statistics and correlations of all our constructs are presented in Table 3, including means (the means of the items), standard deviation, and correlation.

Table 1. Demographic profile of respondents ($N = 4828$).

Variables	Category	Frequency	Percentage(%)
Gender	Male	2392	49.1%
	Female	2476	50.9%
Age	18–30	1252	25.7%
	31–40	1780	36.6%
	41–50	828	17.0%
	51–60	612	12.6%
	61 or above	396	8.1%
Education	Junior high school or below	1872	38.6%
	High school	1804	37.4%
	College or University	1028	21.3%
	Master degree or above	124	2.6%
Registered residence	Rural	1652	34.0%
	urban	3216	66.1%
Income	5000 yuan or below	692	14.2%
	5000–10000 yuan	1208	24.8%
	10000–20000 yuan	2276	46.8%
	20000–30000 yuan	404	8.3%
	30000 yuan or above	288	5.9%

Table 2. Constructs and items included in the questionnaire.

Constructs	Labels	Items	References
Subjective knowledge	SK_1	How much do you know about the main classification of COVID-19 vaccine?	Ma *et al* (2008)
	SK_2	How much do you know about the scientific mechanism of vaccine against COVID-19?	
	SK_3	How much do you know about the procedures for the experiment and development of COVID-19 vaccine?	
	SK_4	How much do you know about benefits of COVID-19 vaccine?	
	SK_5	How much do you know about potential risks of COVID-19 vaccine?	
Perceived Usefulness	PU_1	Vaccination can protect myself from the Corona Virus Disease	Chung&Jones-Jang(2021)
	PU_2	Vaccination can establish herd immunity and maintain social security	
	PU_3	Vaccination can allows individuals to return to normal work, study and daily life	
	PU_4	Vaccination can restore normal and stable order to society	
Perceived Threat	PT_1	COVID-19 vaccine is immature, and vaccination cannot form individual immunity	Roberto&Goodall (2010)
	PT_2	COVID-19 vaccine can cause some side effects, such as headache, cough, diarrhea, nausea, anorexia, allergies, etc.	
	PT_3	COVID-19 vaccine can induce various chronic diseases	
	PT_4	COVID-19 vaccine can cause genetic damage	
Analytical Assessment	AA_1	I make vaccination decision by evaluating the safety of COVID-19 vaccine	Slovic & Peters (2006) and Moeini (2015)
	AA_2	I make vaccination decision by evaluating the cost of COVID-19 vaccine	
	AA_3	I make vaccination decision by evaluating the convenience of vaccination	
	AA_4	I make vaccination decision by evaluating the efficacy of COVID-19 vaccine	
Experiential Assessment	EA_1	I make vaccination decision by following the public opinion about COVID-19 vaccine	Slovic & Peters (2006) and Moeini (2015)
	EA2	I make vaccination decision by following the suggestions of experts, scholars, and opinion leaders	
	EA_3	I make vaccination decision by following the behaviors of friends, colleagues, and classmates	
	EA_4	I make vaccination decision by following the personal mood, emotion, and experience	
Fear Arousal	FA_1	Are you afraid of vaccinating against COVID-19?	Scharwath (2004)
	FA_2	Are you anxious about vaccinating against COVID-19?	
	FA_3	Are you nervous about vaccinating against COVID-19?	
Vaccination Attitude	VA_1	Do you think vaccinating against COVID-19 is wise?	Gerend & Shepherd (2012); Juraskova et al(2012)
	VA_2	Do you think vaccinating against COVID-19 is good?	
	VA_3	Do you think vaccinating against COVID-19 is necessary?	
Vaccination Intention	VI_1	Do you support for vaccinating against COVID-19?	Gerend & Shepherd (2012); Juraskova et al(2012)
	VI_2	Are you willing to be vaccinated against COVID-19?	
	VI_3	Are you sure to be vaccinated against COVID-19?	

Table 3. Means, standard deviation, and correlation.

M	3.76	5.59	4.22	4.92	4.66	4.08	5.21	5.14
SD	1.09	0.97	1.15	1.00	0.92	1.14	1.05	1.21
Correlation	SK	PU	PT	AA	EA	FA	VA	VI
SK	1							
PU	.197***	1						
PT	−.075***	−.008	1					
AA	.023	.189***	−.179***	1				
EA	−.128***	−.277***	.105***	−.629***	1			
FA	−.150***	−.239***	.306***	−.075**	.051*	1		
VA	.183***	.443***	−.144***	.088**	−.190***	−.373***	1	
VI	.218***	.406***	−.190***	.039	−.172***	−.385***	.830***	1

* $p < .1$. ** $p < .05$. *** $p < .001$.

Contrary to previous investigations in the USA and Europe, the results reported that people expressed a relatively positive attitude ($M = 5.21$) and intention ($M = 5.14$) to vaccinate against COVID-19. Meanwhile, fear arousal ($M = 4.08$) related to vaccination was not magnified, revealing that people are not overly emotional when facing COVID-19 vaccine. It is worth noting that people placed a high value on usefulness perception ($M = 5.59$) toward vaccination, significantly higher than perceived threat ($M = 4.22$), indicating that people were usually more sensitive to benefits than to risks associated with COVID-19 vaccine. In terms of decision strategies, statistics suggested that people have more dependence on analytical assessment ($M = 4.92$) compared with experiential assessment ($M = 4.08$). However, the subjective knowledge ($M = 3.76$) did not exceed the threshold of 4, implying the deficiency of current knowledge people held for understanding the COVID-19 vaccine. For the correlations, there were significant associations between each of the constructs, and the results basically verified the relationship assumed by the conceptual model. It is therefore appropriate to conduct further analysis.

Empirical results

As one of the most popular multivariate analysis tools, structural equation modeling (SEM) is often used to test conceptual models. Thus, in this paper, SEM was employed to examine the general fit of the proposed model and hypotheses using the software package AMOS 21. According to the general procedure, the data-analysis consists of two stages. First, a measurement model was created and estimated by confirmatory factor analysis (CFA) to judge whether the questionnaire items measured their intended constructs correctly, namely reliability test and validity test. In the second stage, when

measurement quality was confirmed, a structural model was established and conducted with SEM analysis to verify the hypothesized relationships of the proposed model under the condition of a satisfactory measurement model.

Confirmatory factor analysis (CFA) was implemented to evaluate the adequacy of the measurement model. The adequacy of the measurement model is evaluated in terms of validity and reliability. Reliability refers to the consistency of measurement, while validity refers to the extent to which an instrument measures what it is intended to measure. In this paper, three commonly used fit indices, namely Cronbach's α, Composite Reliability (CR), and Corrected Item-Total Correlation (CITC), were used to assess reliability, and two commonly used fit indices, including standardized loading and average variance extraction (AVE), were used to test the validity of the measurement model.

Measurement model

As shown in Table 4, the composite reliability values of all constructs were over 0.7 (obviously higher than the threshold of 0.5). Cronbach's coefficients of all constructs were in excess of the threshold of 0.70. The CITCs of all items satisfied the general recommended level of 0.70. In conclusion, CFA analysis results demonstrated the acceptable reliability. Moreover, the standardized loading of each measure was greater than 0.7, and the p-value was significantly related to its latent construct ($p < .001$). All AVE was in excess of 0.5, and the square root of the AVE was greater than the cross-correlations between constructs. Thus, the results confirmed the adequate validity of the measurement model.

Structural model

As shown in Table 5, the goodness-of-fit measures indicated a satisfactory fit between the proposed model and the data. Specifically, X^2/df was smaller than 3, and the REMSEA was smaller than 0.08. The GFI, CFI, NFI, TLI, and AGFI were all greater than the suggested criteria of 0.9. The PGFI, PNFI, and PCFI were above the threshold of 0.5.

The structural equation model (SEM) was used to test the proposed model in this study. Because the number of samples was 4828, obviously greater than 500, the study prefers Maximum Likelihood (ML) rather than Generalized Least Squares (GLS) to estimate parameters. As is shown in Table 6 and Figure 2, the influencing paths between constructs were calculated. The results revealed that the model's performance effectively supported the conceptual model; all but three hypotheses (H5, H15, and H19) achieved statistical significance at the level of 0.1 or better.

The overall model showed that subjective knowledge was an antecedent variable. People with higher levels of subjective knowledge usually perceived a lower threat(β=-0.089, $p < .05$) and presented higher levels of perceived usefulness ($\beta = 0.195$, $p < .001$), **H1** and **H2** were confirmed. A higher level of perceived usefulness not only decreased the fear arousal (β=-0.282, $p < .001$) but also promoted people to select analytical assessment ($\beta = 0.104$, $p < .001$) rather than experiential assessment (β=-0.180, $p < .001$) for vaccination decision, **H3**, **H7**, and **H8** were supported as predicted. On the contrary, perceived higher levels of threat could increase the fear arousal ($\beta = 0.245$, $p < .001$) and motivate people to choose experiential assessment ($\beta = 0.049$, $p < .05$) instead of an analytical assessment (β=-0.088, $p < .001$) to make the

Table 4. Confirmatory factor analysis results for measurement model.

Constructs	Labels	Loadings	CITC	CR	Cronbach's *a*	AVE
Subjective knowledge	SK_1	0.831***	0.717	0.850	0.867	0.713
	SK_2	0.849***	0.741			
	SK_3	0.828***	0.713			
	SK_4	0.738***	0.709			
	SK_5	0.795***	0.774			
Perceived Usefulness	PU_1	0.909***	0.840	0.913	0.947	0.820
	PU_2	0.932***	0.875			
	PU_3	0.938***	0.889			
	PU_4	0.936***	0.885			
Perceived Threat	PT_1	0.860***	0.783	0.819	0.835	0.717
	PT_2	0.883***	0.723			
	PT_3	0.858***	0.780			
	PT_4	0.845***	0.772			
Analytical Assessment	AA_1	0.861***	0.780	0.801	0.824	0.715
	AA_2	0.861***	0.721			
	AA_3	0.872***	0.740			
	AA_4	0.835***	0.784			
Experiential Assessment	EA_1	0.838***	0.764	0.775	0.787	0.706
	EA_2	0.795***	0.752			
	EA_3	0.823***	0.757			
	EA_4	0.792***	0.725			
Fear Arousal	FA_1	0.941***	0.872	0.853	0.871	0.768
	FA_2	0.924***	0.856			
	FA_3	0.926***	0.847			
Vaccination Attitude	VA_1	0.885***	0.776	0.847	0.879	0.751
	VA_2	0.877***	0.757			
	VA_3	0.930***	0.830			
Vaccination Intention	VI_1	0.865***	0.754	0.859	0.880	0.762
	VI_2	0.901***	0.805			
	VI_3	0.887***	0.750			

* $p < .1$. ** $p < .05$. *** $p < .001$.

Table 5. Goodness-of-fit statistics for structural model.

Index		Threshold	Acceptance
x^2/df	3.358	<5.0	Passed
RMSEA	0.079	<0.08	Passed
GFI	0.929	>0.9	Passed
PGFI	0.716	>0.5	Passed
AGFI	0.903	>0.9	Passed
TLI	0.946	>0.9	Passed
CFI	0.964	>0.9	Passed
NFI	0.949	>0.9	Passed
PNFI	0.752	>0.5	Passed
PCFI	0.765	>0.5	Passed

vaccination decision, the results confirmed the authenticity of **H4**, **H9**, and **H10**. Although subjective knowledge cannot significantly stimulate analytical assessment ($\beta = 0.005$, $p = .777$), the higher level of subjective knowledge decreased the tendency of experiential assessment (β=-0.027, $p < .05$) in the vaccination decision-making, **H6** were supported, while **H5** were not confirmed. Consistent with the TAM, vaccination attitude was proved to be a motivator to promote vaccination intention ($\beta = 1.167$, $p < .05$), **H13** was confirmed statistically. Meanwhile, both analytical assessment ($\beta = 0.223$, $p < .001$) and experiential assessment (β=-1.075, $p < .001$) were found to significantly influence people's vaccination attitude, and experiential assessment was negatively related to vaccination intention (β=-.253, $p < .05$), whereas analytical assessment failed to predict the vaccination intention ($\beta = 0.017$, $p = .687$). Thus, **H14**, **H16**, and **H17** were supported, **H15** was not confirmed. As for the role of fear arousal, the increase of fear not only inspired the experiential assessment ($\beta = 0.027$, $p = .687$) and inhibited the analytical assessment (β=-.059, $p < .05$) obviously, but also cooled down the willingness to engage in a positive vaccination attitude (β=-.403, $p < .1$), and its direct impact on vaccination intention was not significant (β=-.029, $p = .302$). Therefore, **H11**, **H12**, and **H18** were supported, **H19** was not confirmed.

Discussion

The health problems of residents facing the threat of the virus are becoming more and more urgent, and vaccines, as an effective means to control the new crown epidemic, have also become the focus of global attention. However, after the vaccination agenda began to advance globally, the issue of vaccination acceptance became a common issue for governments across the world. But what factors affect the public's intention to vaccinate against COVID-19? The existing research is

Table 6. Results of structural equation modeling.

Hypothesis	Causal Relationships			Estimate	SE	*P*	Supported
H1	PU	<—	SK	.195	.031	***	YES
H2	PT	<—	SK	−.089	.033	**	YES
H3	FA	<—	PU	−.282	.032	***	YES
H4	FA	<—	PT	.245	.034	***	YES
H5	AA	<—	SK	.005	.018	.777	NO
H6	EA	<—	SK	−.027	.014	**	YES
H7	AA	<—	PU	.104	.019	***	YES
H8	EA	<—	PU	−.180	.024	***	YES
H9	AA	<—	PT	−.088	.019	***	YES
H10	EA	<—	PT	.049	.015	**	YES
H11	AA	<—	FA	−.059	.019	**	YES
H12	EA	<—	FA	.027	.014	*	YES
H13	VI	<—	VA	1.169	.047	***	YES
H14	VA	<—	AA	.223	.059	***	YES
H15	VI	<—	AA	.017	.043	.687	NO
H16	VA	<—	EA	−1.075	.142	***	YES
H17	VI	<—	EA	−.253	.080	**	YES
H18	VA	<—	FA	−.403	.032	***	YES
H19	VI	<—	FA	−.029	.028	.302	NO

* $p < .1$. ** $p < .05$. *** $p < .001$.

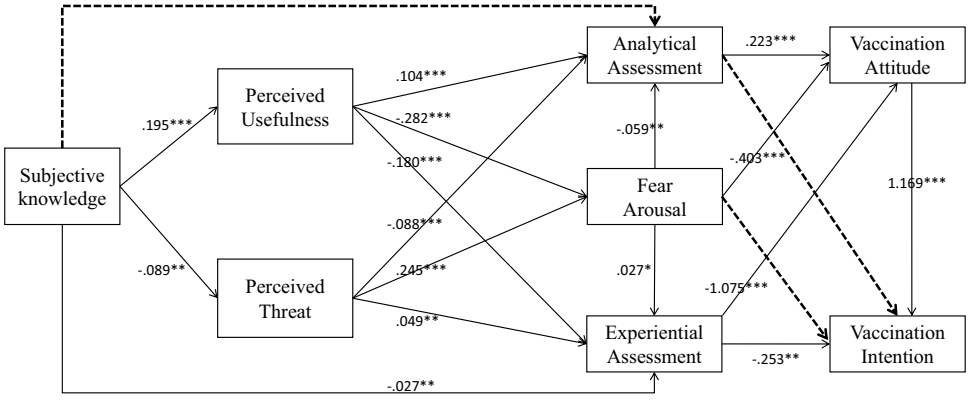

Figure 2. Empirical results of conceptual model.

mainly based on the Health Belief Model (HBM), Theory of Planned Behavior (TPB), Social Cognitive Theory, and Social-Ecological Model.[62–67] From a horizontal and vertical perspective, these studies examined the correlation between attitude and vaccination behavior. Many empirical studies prove that perceived risk and benefit were the critical factors for changing vaccination willingness.[3,5,38] Other scholars have found that the more the public has access to information, the more they have access to vaccine misinformation, which indirectly affects their vaccination behavior decisions.[4,36,39] However, most of these studies have only investigated the link between general cognition and behavior, and few studies have explored the factors that affect the public's intention to vaccinate from cognitive decision-making.

Inconsistent with many studies that focused on objective knowledge and information acquisition, this study pays attention to the initial role that subjective knowledge played in the formation mechanism of vaccination intention against COVID-19.[3,36,39] The findings concluded that subjective knowledge was a significant indicator influencing people's threat and usefulness perception toward vaccination. Specifically, subjective knowledge had a strongly positive effect on perceived usefulness. People with a more subjective understanding of COVID-19 vaccine were likely to show a positive evaluation of vaccinating against COVID-19.

On the other hand, perceived threat was negatively affected by subjective knowledge, people that have little subjective knowledge associated with COVID-19 vaccine were intensively sensitive to the safety and effectiveness of vaccination. It is worth mentioning that fear arousal, as a psychological factor in the EPPM, has been found to be of paramount importance in the conceptual model. The results suggested that perceived threat had a positive effect on fear arousal, while perceived usefulness showed a negative impact. People who perceived more threat toward vaccination showed higher levels of fear, and constant attention to the usefulness of vaccination also contributed to dampening fear responses.

Based on the theory of risk information assessment, this study was the first to examine the influence of decision strategies on the causal chain of vaccination intention, and we divided these decision strategies into analytical assessment and experiential assessment. In this study, both perceived usefulness and perceived threat were confirmed to have significant influences on people's decision strategies. When people perceive more usefulness of vaccination, they prefer to make a vaccination decision with a logical reasoning of analytical assessment, rather than a simple experiential judgment in which people responded to vaccination without additional efforts to evaluate.

On the contrary, perceived threat was the strengthening determinant of experiential assessment. People who perceived more threats toward vaccination usually took less effort and were more likely to use experiential assessment to make vaccination decisions. Interestingly, subjective knowledge failed to predict the analytical assessment significantly, but showed a strongly negative impact on experiential assessment, confirming that the increase of subjective knowledge could reduce the complexity of cognition, thereby decreasing the probability of using experiential strategy to make vaccination decisions. It should also be noted that fear arousal could inspire people to select different decision strategies, the results revealed that people with higher levels of fear arousal were more likely to be interested in experiential assessment, instead of drawing a vaccination decision through analytical assessment.

Theoretically speaking, this study enriches the current research about vaccination intention and provides new insights into the formation mechanism of vaccination intention under the timeliness issues of COVID-19 vaccine in China. This study extends the theoretical model of vaccination intention by integrating EPPM, TAM, and theories of risk information assessment and innovatively explores the specific decision strategies between usefulness/threat perception and vaccination intention. This study explained the initial driving role of subjective knowledge and the effect of fear arousal on the causal chain of vaccination intention. In addition, this study empirically tested the effects of decision strategies and fear arousal on vaccination intention in detail, especially the crucial intermediary role of vaccination attitude.

Practically speaking, this study provides important insights for policy makers in the direction of risk communication and behavior guidance in the issue of COVID-19 vaccine. This study enlightens us: Firstly, knowledge popularization is of crucial importance to vaccination recommendation, the government should establish diversified and institutionalized mechanisms of knowledge disclosure, and proactively release all kinds of scientific information in a timely manner to fill the gap between the sufficiency threshold of knowledge required and the amount currently held for understanding COVID-19 vaccine. Secondly, the government and experts should develop more open ways of public education to guide people to objectively evaluate the risks and benefits of COVID-19 vaccines, and the discourse system should return to scientific rationality for the purpose of preventing the threat of vaccines from being magnified by social rationality. Moreover, the government should pay particular attention to people's emotional response to vaccination, some targeted policies should be adopted to reduce people's fear, anxiety, and tension about vaccinating against COVID-19, thereby inspiring people to use rational assessment rather than simple rules to make a vaccination decision.

Fear arousal is an integral part of the public's vaccination intention formation mechanism. For the media, the objectivity, authenticity, and professionalism of information publicity have an important impact on reducing the public's sense of fear. Therefore, the media's discourse system about vaccines should focus on the construction and return of scientific discourse so that the "authority" of scientific discourse can promote the public's understanding of the vaccine situation from "emotional" to "rational" to help achieve benign risk communication, dissolve the unbalanced tension in the ecology of public opinion, and prevent the occurrence of some negative vaccination behaviors.

Subjective knowledge is the pre-factor for public vaccination intention, especially "vaccine familiarity" is the direct mechanism for the formation of public risk perception and vaccination behavior. Therefore, for the social community, the guidance strategy of vaccination attitude must focus on the situation, and the guidance of the vaccination behavior should be silently guided by the "first perspective" of real-life and use a variety of methods or materials, such as sympathy, empathy,

and resonance to show the public to form a rational choice for vaccination.

Perceived threat is a core element influencing vaccination intent. Therefore, to realize the correct guidance of public vaccination behavior. Hospitals and other professional institutions should adhere to the guidance strategy of issue hedging to reduce people's threat perception and fear. In popularizing vaccine expertise, hospitals must clarify "what to say" and sort out "how to say it." It is necessary to improve the risk information release mechanism, improve the release channels, and enhance the timeliness and objectivity of information release so that the public can fully understand the risk situation.

Finally, this study put insight into people's vaccination attitude and vaccination intention based on the TAM. According to the estimated results, decision strategies and fear arousal were confirmed to be the antecedents predicting people's vaccination intention, whose effects acted in direct or indirect paths. To be more specific, vaccination attitude had an obvious positive influence on vaccination intention as predicted, both vaccination attitude and vaccination intention were negatively influenced by experiential assessment. What is more, analytical assessment and fear arousal failed to predict vaccination intention directly, but vaccination attitude had an important mediating role in these relationships. This implied that people who used analytical assessment along with lower levels of fear arousal tended to show a positive response to vaccinating against COVID-19.

Conclusion

This study shows that subjective knowledge was a primary indicator influencing people's views toward vaccination by using the EPPM, TAM, and theories of risk information assessment.

To sum up, the formation mechanism of vaccination intention against COVID-19 could be considered as a psychological process, in which subjective knowledge is the initial factor leading to a certain degree of perceived usefulness and perceived threat toward vaccination, resulting in different levels of fear arousal. Driven by usefulness/threat perception and fear, people conduct different decision strategies, so-called analytical assessment and experiential assessment, to make vaccination decisions. In addition to existing the direct effects of experiential assessment on vaccination intention, two decision strategies and fear arousal also affect people's vaccination intention through the mediation role of vaccination attitude.

The limitations of this study should be acknowledged. Firstly, the study only focuses on people's vaccination intentions in China, differences may exist in different countries because of cultural differences, and future endeavors should perform some comparative studies. Moreover, there may be some other factors that are not being taken into consideration, such as subjective value and social trust. Further, our use of the Likert scale to assess vaccine intentions could have led to central tendency bias. Hence, the generalization of the results in this study may be constrained, and future studies should consider these matters. Finally, the sample size of this study is small, and a larger sample survey is needed in the future.

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