

HOSTED BY



Contents lists available at ScienceDirect

International Journal of Nursing Sciences

journal homepage: <http://www.elsevier.com/journals/international-journal-of-nursing-sciences/2352-0132>

Original Article

Development and psychometric assessment of the public health emergency risk perception scale: Under the outbreak of COVID-19

Zhiying Shen ^{a, b}, Zhuqing Zhong ^b, Jianfei Xie ^b, Siqing Ding ^b, Shougen Li ^c, Chengyuan Li ^{a, *}^a Department of Hematology, the Third Xiangya Hospital, Central South University, Changsha, Hunan, China^b Clinical Nursing Safety Management Research Center of Central South University, the Third Xiangya Hospital, Central South University, Changsha, Hunan, China^c Department of Emergency and Critical Care Medicine, the Third Xiangya Hospital, Central South University, Changsha, Hunan, China

ARTICLE INFO

Article history:

Received 6 September 2020

Received in revised form

16 December 2020

Accepted 18 December 2020

Available online 30 December 2020

Keywords:

COVID-19

Emergencies

Pandemics

Public health

Risk perception

Surveys and questionnaires

ABSTRACT

Objective: Correctly understanding and evaluating the level of public risk perception toward public health emergencies not only helps experts and decision-makers understand the public's preventative health behaviors to these emergencies but also enhances their risk information communication with the public. The aim of this study was to develop a risk perception scale for public health emergencies and test its validity and reliability during the coronavirus disease 2019 (COVID-19) pandemic.

Methods: Guided by the theoretical model of risk perception, an initial scale was generated through literature review, group meetings, resident interviews, and expert consultation. A pretest and item screening were then conducted to develop a formal risk perception scale for public health emergencies. Finally, the reliability and validity of the scale were validated through a questionnaire survey of 504 Chinese adults.

Results: The final scale had 9 items. The content validity index of the scale was 0.968, and the content validity index of individual items ranged from 0.83 to 1.00. Three common factors, dread risk perception, severe risk perception, and unknown risk perception, were extracted for exploratory factor analysis, and together they explained 66.26% of the variance in the score. Confirmatory factor analysis showed that the model had a satisfactory fit, where $\chi^2/df = 1.384$, the goodness-of-fit index (GFI) = 0.989, root mean square error of approximation (RMSEA) = 0.028, root mean square residual (RMR) = 0.018, comparative fit index (CFI) = 0.995, normed fit index (NFI) = 0.982, and non-normed fit index (NNFI) = 0.990. The correlations between dimensions ranged from 0.306 to 0.483 ($P < 0.01$). Cronbach's α was 0.793 for the total scale and ranged between 0.687 and 0.801 for the individual dimensions. The split-half coefficient was 0.861 for the total scale and ranged from 0.727 to 0.856 for individual dimensions. The test-retest coefficient was 0.846 for the total scale and ranged from 0.843 to 0.868 for individual dimensions.

Conclusion: The developed scale for the risk perception of public health emergencies showed acceptable levels of reliability and validity, suggesting that it is suitable for evaluating residents' risk perception of public health emergencies.

© 2021 The authors. Published by Elsevier B.V. on behalf of the Chinese Nursing Association. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

What is known?

- Risk perception was correlated significantly with the public's adoption of protective action recommendations, and it was also identified as an important mediating factor between

government intervention and the public's behaviors during public health emergencies.

What is new?

- The Public Health Emergency Risk Perception Scale (PHERPS) constructed in this study has 9 items and has good reliability and validity. It evaluates the public's risk perception level in response to public health emergencies in the three dimensions

* Corresponding author.

E-mail address: lichengyuan_xy3@163.com (C. Li).

Peer review under responsibility of Chinese Nursing Association.

of dread risk perception, severe risk perception, and unknown risk perception.

1. Introduction

At the end of 2019, an outbreak of the coronavirus disease 2019 (COVID-19) caused by the novel coronavirus SARS-CoV-2 was reported in Wuhan, Hubei Province, China, and over 200 countries are facing the challenge against COVID-19 [1,2]. It is one of the emerging infectious diseases in recent years, which pose a serious threat to human health, cause huge economic losses and cause panic. As of 8 November 2020, over 49 million people have been infected, and over 1 million have died from COVID-19 worldwide [3]. In fact, several detrimental infectious diseases have been emerging consecutively globally these years, such as COVID-19, H1N1 and Ebola virus disease, which have caused great harm to human health and slowed economic development in some countries [4–6]. On 30 January 2020, the World Health Organization declared the COVID-19 outbreak a “public health emergency of international concern”. As the epidemic has spread, so has the fear. In the face of public health emergencies, both individuals and organizations may act irrationally [7,8]. By now, most people around the world have been aware of the absolute necessity of maintaining hand hygiene and keeping an appropriate distance away from each other so as to prevent being infected from COVID-19 [9]. Simultaneously, most governments have taken strong measures to prevent the further spread of the epidemic, though some people have low acceptance of vaccinations, medical isolation, and wearing masks [10]. These obstacles not only caused great public panic but also compromised the effectiveness of crucial measures governments have taken to contain the outbreaks of diseases [11–13]. Individuals act discrepantly in response to this epidemic indicates that the risk perception relating to COVID-19 strongly differs between different places and individuals. In addition, public risk perception can potentially be a powerful modifier of the epidemic evolution, as it can influence the number of newly infected cases [9]. To identify the behavior and response pattern of people in a crisis or pandemic, we should start by understanding how people perceive the crisis [14,15]. Therefore, appropriate tools are needed to assess people's risk perception in the face of public health emergencies, which is of great significance for governments or organizations to construct management strategies correctly.

Risk perception refers to an individual's feeling and understanding of objective risks in the outside world. This concept emphasizes the influence on cognition caused by the experience gained from the individual's intuitive judgment and subjective feelings [16]. The assessment of risk perception is influenced by a considerable number of factors pertaining to an individual or society [17]. Previous studies have suggested that risk perception was correlated significantly with the public's adoption of protective action recommendations, and it was also identified as an important mediating factor between government intervention and the public's behaviors during public health emergencies [14,18,19]. In Duan's study, risk perception was considered to be a significant mediator between government intervention and public adoption of protective measures [20]. Liao et al.'s longitudinal survey of Hong Kong residents during the H7N9 outbreak showed that perceived personal infection risks and health effects were associated with protective behavior [21]. In addition, some studies have shown that risk perception plays an important role in affecting mental health during public health crises. In Yue et al.'s study of 308 Chinese pregnant women during COVID-19, perception of risk was a mediating factor between social support and anxiety [22]. The

results of Ding et al. and Zhong et al. also showed that risk perception was related to depression [23,24]. Based on these studies, during the outbreak of public health emergencies, a timely understanding of the public's risk perception might guide the formulation and implementation of epidemic control measures. Therefore, when an unexpected public incident occurs, it is necessary to assess the public's risk perception and analyze its associated factors timely and accurately. It can provide evidence geared to implement targeted risk management strategies. Therefore, the negative impact of the public health incident and a public sentiment disturbance might be avoided. At present, there are no tools to evaluate the risk perception of public health emergencies worldwide.

Many scholars have investigated the risk perception of severe public health emergencies such as COVID-19 [25–27], H1N1 [28–30], and Ebola [31]. These studies all use different risk perception assessment tools, but reviews have pointed out these tools' following defects. For example, the COVID-19 Risk Perception Scale including 6 items was developed mainly aiming to evaluate participants' perceived seriousness of the COVID-19, perceived likelihood that they or their family and friends would be infected with the virus in the next 6 months, and their present level of worry about the virus [19]. However, its development process was based on previous research experience rather than relevant scientific theories. Zanin et al. designed and applied the Public Risk Perception questionnaire to investigate Italians' perception of health risks during COVID-19 [8]. However, the definition of risk perception in this study was not clear, and the reliability and validity of the questionnaire were not reported. In the study of Taghrir et al. only two items “I may be affected with COVID-19 more easily than others” and “I am afraid to be affected with COVID-19” were used to measure the risk perception level of subjects, which was obviously not comprehensive [32]. In addition, the risk perception measurement tools designed by Chan et al. and Olagoke et al. also lack the report on results of tool psychology measurement [12,33].

In Slovic's view, the research of risk perception can be realized by using the psychometric paradigm [34,35]. Risk perception assessment that uses simple, effective scientific tools to assess public health emergencies' risk perception can provide guidance in taking effective measures to maintain and enhance public health and safety. Therefore, this study aims to develop a public health emergency risk perception scale (PHERPS) and validate its reliability and validity under the COVID-19 epidemic as an example and provide a reference for the effective assessment of the public's risk perception of public health emergencies.

2. Methods

2.1. Theoretical framework

This study was guided by a theoretical model of risk perception on the basis of Slovic's research that revealed multidimensional characteristics of risk perception [34,35]. This theoretical model describes risk perception characteristics in the form of a spatial model with two dimensions (unknown and dread dimensions) (Fig. 1). In the model, the degree of risk perception of an emergency is determined by the spatial location of the emergency. The dimensions used to evaluate a risk can be set according to the characteristics of the risk, through which people's attitude toward and perception of the risk are quantified to form a risk cognitive map. The horizontal axis represents the fear risk dimension, which refers to the degree of fear caused by the public health emergency, and the far right side is defined as uncontrollable, dread, global catastrophic, lethal, high risk to future generations, not easily reduced

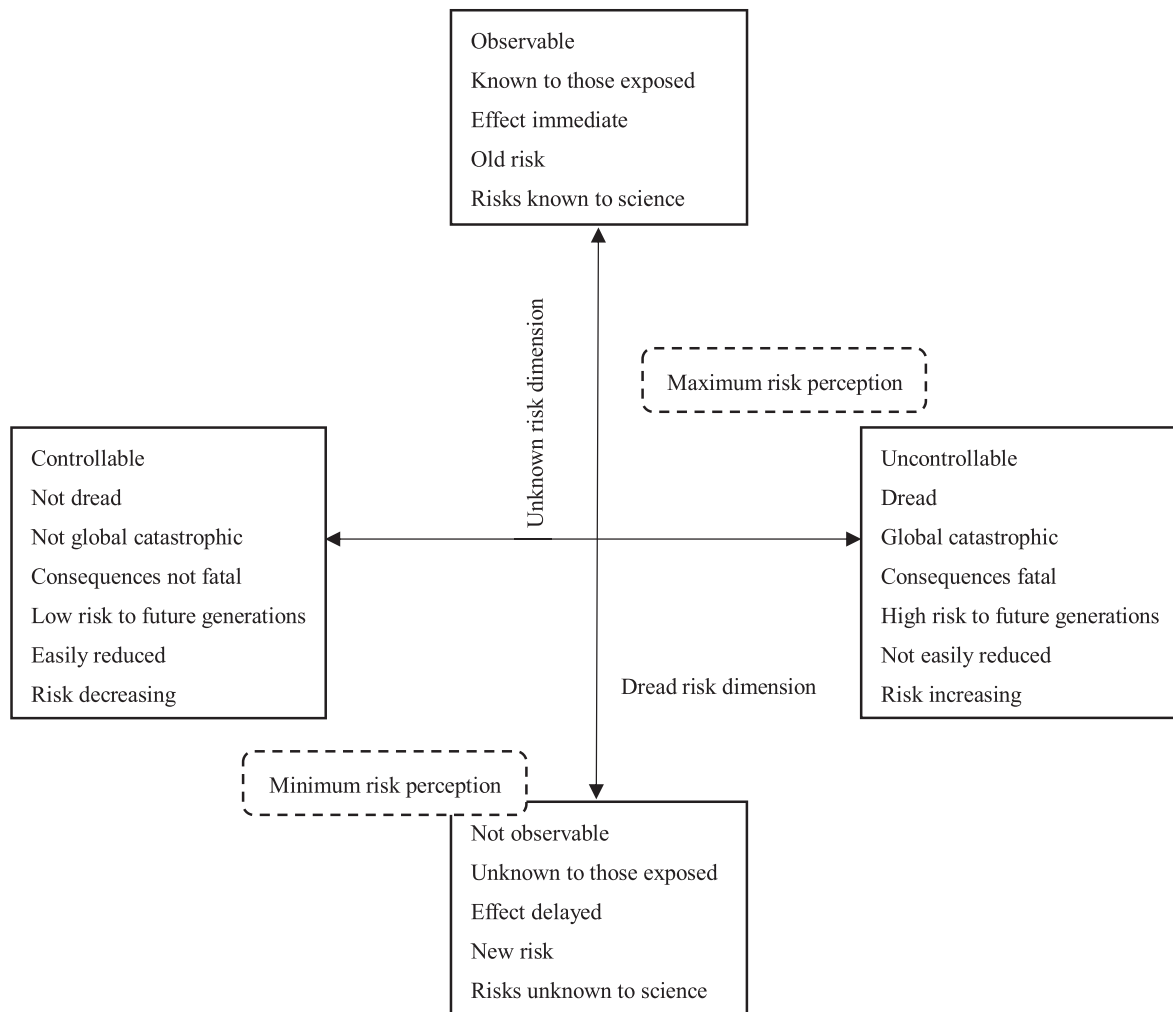


Fig. 1. Theoretical multidimensional model of risk perception.

and risk increasing. The ordinate represents the unknown risk dimension, which refers to the extent to which the public knows about the public health emergency. The top of it is defined as unobservable, unknown, effect delayed, new and unknown to science. Based on the risk perception model, this study proposed to evaluate the public risk perception of public health emergencies from multiple aspects, including the unknown risk dimension and dread risk dimension.

2.2. Phases of development

A first draft of the scale (32 items) was developed through literature review, research group discussion, and resident interviews. Afterward, the first drafted item pool was evaluated in an expert panel meeting, applied in a pretest performed to 10 residents, and the comments were recorded to delete or modify items. After the expert panel meeting and pre-test, 10 items were deleted or merged because of similar meanings. In addition, 6 items were removed according to comments and grades of a two-round expert consultation. Therefore, a primary risk perception scale with 16 items was reached. Then, the 16-item primary scale was used to run a preliminary study with 198 adult Chinese and 7 unqualified items were deleted according to the requirement of item screening. Finally, a formal survey was conducted using a scale that retained 9 items, and the reliability and validity were analyzed.

2.3. Development of a first item pool

Under the guidance of the theoretical risk perception model, the following approaches were used to establish the item pool. 1) Literature review: Previous studies on risk events, including the Wenchuan earthquake [36] and SARS [37], the African swine fever virus [38], and H1N1 [29] were used as references. 2) Research group discussion: Two rounds of research group discussion were held to investigate the consistency of the items in the item pool with the theoretical framework and the logic of each item's wording and to discuss item deletion and addition. 3) Resident interviews: 10 residents were invited to participate in the interview to discuss their self feelings or experience of the epidemic. The interviews were conducted face-to-face in a quiet, private room, and the concerns and opinions of the interviewees were recorded. The duration of each interview was 40–60 min. Finally, an item pool containing 32 items was constructed through the above methods.

2.4. Primary risk perception scale development

Methods for the development of the initial risk perception scale were as follows. 1) Expert panel meetings: An expert group meetings were held, relevant experts specialized in psychology, public health and epidemiological research to review the clarity of drafted items, as well as the relevance and suitability of each item. 2) Pre-

test: after items were modified according to the suggestions in expert consultation, the revised drafted scale was imposed on the interviews performed with 10 community residents. The doubts and advice put forward by interviewed residents on each item of the revised drafted scale were considered, according to which complicated items with specialized words that were hard to understand by residents were modified. 3) Two-round expert consultation: six experts were invited to evaluate the structure and items of the scale and give suggestions for adding, deleting, and modifying items according to their understanding of the evaluation indicators. The expert team included three males and three females aged between 35 and 54 years who had more than 10-year's experience working in the fields of public health, psychology and Epidemiology. All experts had a master's degree or above and had a professional title of associate professor or above. According to the Likert 5-point scoring system, the experts graded the importance of each item, with scores 1 to 5 indicating extremely important, important, somewhat important, unimportant, and very unimportant, respectively. In addition, the experts were encouraged to present their opinions on the items and state their reasons. Two reiterations of feedback and discussion among the experts generated the revised version. The content validity indices of items (I-CVI) and the scale (S-CVI) were calculated. After the random consistency was adjusted using the kappa value (κ) and the items with I-CVI < 0.78 were removed [39].

2.5. Pilot survey

Since people were restricted from going out during the COVID-19 pandemic, a "Questionnaire Star" (Wenjuanxing) online survey was conducted in this study. In March 2020, 210 residents of Changsha, Hunan, China, were surveyed. To ensure that the constructed scale could be generalized, there were no special participant requirements, and all residents aged 18 years or older could voluntarily fill out the questionnaire. In order to ensure the validity of the data, three data screening methods were adopted after the questionnaire collection. 1) If questionnaires were submitted via the same IP address, only the first submitted questionnaire will be retained. 2) Questionnaires with a response time less than 3 min will be deleted. 3) Questionnaires with answers that contained common sense errors, such as "one year of age," were deleted. The screening was carried out by two researchers with a master's degree, and in the case of disagreement, the decision was made by an associate professor of psychology. Finally, 198 effective questionnaires were obtained, with an effective response rate of 94.29%. The items were screened according to the following criteria. 1) Extreme-value comparison analysis: the collected questionnaires with the total score in the top 27% and the bottom 27% were grouped as the high-score group and the low-score group, respectively. Then, the score of each item in the scale was compared between the two groups by using the independent-sample *t*-test, and the items with no statistically significant difference ($P > 0.05$) were removed. 2) Correlation coefficient method: the Pearson's correlation coefficient between each item score and the total score was analyzed, and the items with a Pearson's correlation coefficient $r < 0.3$ were removed. 3) The items that significantly reduced Cronbach's α coefficient were removed. 4) The items with a factor loading coefficient < 0.4 and commonality (common factor variance) < 0.4 were removed. After the procedures above, a formal version of the scale resulted. The scale contained 9 items and was scored according to the Likert 5-point scoring system, with 1–5 representing strongly disapprove, disapprove, neutral, approve, and strongly approve, respectively. The total score could be 9 to 45 points. The higher the score, the higher the risk perception level of public health emergencies.

2.6. Formal investigation

2.6.1. Participants

Using a convenience sampling method, the survey questionnaire was delivered to the residents aged ≥ 18 years old in Hunan on the "Questionnaire Star" platform in April 2020. The research group invited mobile phone users in Hunan Province to fill in the questionnaire through online recruitment by sending a QR code or link of the questionnaire. A total of 550 questionnaires were collected from voluntary participants, and 504 effective questionnaires were obtained after screening, with an effective response rate of 91.6%. The average age of the respondents was 34.46 years ($SD = 9.58$). There were 264 males and 240 females, including 130 unmarriages, 358 married, and 16 divorced or widowed (Table 1). The study was approved by the ethics committee of the Third Xiangya Hospital of Central South University (No. 2020-S028).

2.6.2. Validity test

Content validity and construct validity were tested. Content validity was evaluated by calculating the I-CVI and the S-CVI [40]. The calculations have been figured out according to the feedbacks of the second iteration expert consultation. I-CVI ≥ 0.78 indicates good item-level content validity, and S-CVI ≥ 0.90 means a good scale-level content validity [41]. For construct validity, exploratory factor analysis (EFA) was used to explore the structure of the scale first, and then confirmatory factor analysis (CFA) was conducted by using a structural equation model. Out of the 504 collected questionnaires, we used 252 questionnaires to explore the factor structure of this scale, and the rest 252 responses were used to confirm factor structure with fit indices. The items remaining after item analysis were subjected to EFA through principal component analysis and a varimax rotation, and the factors with an eigenvalue > 1 were extracted as common factors [42]. Maximum-likelihood estimation was used for CFA. The overall fitting performance of the model was evaluated using χ^2/df , goodness-of-fit index (GFI), root mean square error of approximation (RMSEA), root mean square residual (RMR), comparative fit index (CFI), normed fit index (NFI), and non-normed fit index (NNFI) [43].

2.6.3. Reliability test

The Cronbach's α coefficient, split-half reliability coefficient and test-retest reliability coefficient of the overall scale and of each domain were calculated. The value of Cronbach's $\alpha \geq 0.60$ was considered acceptable, and ≥ 0.70 was considered good internal

Table 1
Participant characteristics ($n = 504$).

Characteristic	Group	<i>n</i>	%
Age (years)	18–45	358	71.0
	46–60	106	21.0
	61–90	40	7.9
Gender	Male	264	52.4
	Female	240	47.6
Education level	Junior middle school or below	50	9.9
	High school	109	21.7
	College	282	56
	Master's degree or above	63	12.5
Marital status	Married	358	71.0
	Unmarried	130	25.8
	Divorced or widowed	16	3.2
Annual household income (CNY)	<10,000	86	17.1
	10,000–29,999	128	25.5
	30,000–49,999	130	25.8
	50,000–99,999	85	16.9
	$\geq 100,000$	75	14.9

reliability [44,45]. Spearman-Brown split-half reliability was also measured. A correlation coefficient ≥ 0.70 indicates good internal reliability [46]. The test-retest reliability was measured by Pearson's correlation coefficient between two time-points with a gap of 2 weeks in 40 randomly collected residents. The value of correlation coefficient over time ≥ 0.75 was considered good test-retest reliability [47].

3. Results

3.1. Item analysis

When we analyzed the 16 items of the primary scale, no item was removed through extreme-value comparison analysis, but 4 items were removed based on correlation coefficients: "The pandemic has rapidly affected the society." "Adhering to correct protective measures can prevent infection." "The pandemic is invincible." and "The pandemic will show a downward trend." Three items with commonality < 0.40 or factor loading < 0.40 were removed: "The pandemic can be controlled." "The pandemic will cause other social hazards." and "The pandemic poses a high risk to our future generations." The remaining 9 items did not reduce Cronbach's α coefficient and thus were retained for reliability and validity evaluation. The results of the item analysis are shown in Table 2.

3.2. Validity analysis

3.2.1. Content validity

According to the evaluation by the six experts, the proposed risk perception scale for public health emergencies had an S-CVI of 0.97 and I-CVIs between 0.83 and 1.0. The κ values of all items were higher than 0.74, suggesting that all the items were excellent and none of them should be removed.

3.2.2. Exploratory factor analysis

Totally 252 collected questionnaires were randomly extracted from total questionnaires of 504 to conduct the EFA for the scale. After four iterations, the rotation converged; the Kaiser-Meyer-Olkin (KMO) value was 0.747 and the χ^2 value from Bartlett's spherical test was 1390.014, reaching the significance level of $P < 0.001$. This indicated that the proposed scale was suitable for draw factors [48].

The results of EFA demonstrated that three components with eigenvalues > 1.00 were identified. According to the risk perception theory, risk perception features are expressed as two-dimensional factors, which are unknown dimension and dread dimension, respectively. On a theoretical basis, item 1, "The pandemic is highly contagious.", item 2, "The pandemic is widespread.", item 3, "The health damage caused by the pandemic is fatal." should belong to

the dread risk dimension. However, in the EFA, these three items were assigned to an independent factor. After a panel discussion, we have agreed that these three items represent the level of severity at which a pandemic can have consequences. Therefore, we named this factor "severity risk perception." The factor loading coefficients of all items were between 0.436 and 0.875 (all > 0.4), and the cumulative variance explanation percentage was 66.26%. The factor names and loading levels are given in Table 3.

3.2.3. Confirmatory factor analysis

The results showed that the standardized factor loading coefficients of all items were in the range from 0.533 to 0.828, so all were > 0.400 . All fit indices met the criteria ($\chi^2/df = 1.384$; GFI = 0.989; RMSEA = 0.028; RMR = 0.018; CFI = 0.995; NFI = 0.982; NNFI = 0.990), indicating that the model had a good fit (Table 4). The structure equation modeling was showed in Fig. 2.

3.2.4. Internal correlation

The results of correlation analysis showed that the correlations between the dimensions were between 0.306 and 0.483 ($P < 0.001$), and the correlations between each dimension and the total scale score were between 0.587 and 0.832 ($P < 0.001$) (Table 5).

3.3. Reliability analysis

For all three dimensions (dread risk perception, severe risk perception, and unknown risk perception) and the total scale, the Cronbach's α coefficient was 0.801, 0.687, 0.697, and 0.793, respectively, and the split-half coefficient was 0.865, 0.727, 0.777, and 0.861, respectively. The test-retest Pearson's correlation coefficient was 0.868, 0.855, 0.843, and 0.846, respectively.

4. Discussion

The study has developed a self-reporting scale, the PHERPS, which is also aimed at exploring its psychometric properties in Chinese adults. The quality of items is crucial to the reliability and validity of a scale. In this study, the item pool was established from theoretical research regarding the dimensions of risk perception. By reviewing relevant literature and using research tools reported in China and other countries as references, the item pool was initially chosen through group meetings and interviews with community residents. Next, six experts were invited to analyze and evaluate the indices and items at all levels, and the items were revised according to the experts' suggestions. Finally, the performance of each item in the scale was analyzed based on the test data from 504 questionnaires to yield a formal 9-item scale.

According to the theory on the dimensions of risk perception, the public's dread risk perception of a public health emergency event is

Table 2
Results of item analysis of the PHERPS ($n = 198$).

Item No.	Item	Score of low-score group (Mean \pm SD)	Score of high-score group (Mean \pm SD)	t	P	r ^a
1	The pandemic is highly contagious.	4.28 \pm 0.71	4.96 \pm 0.20	-6.292	< 0.001	0.442
2	The pandemic is widespread.	4.17 \pm 0.73	4.98 \pm 0.15	-7.428	< 0.001	0.386
3	The health damage caused by the pandemic is fatal.	2.94 \pm 1.07	4.47 \pm 0.75	-8.039	< 0.001	0.455
4	I am afraid of being infected.	2.64 \pm 0.82	4.79 \pm 0.55	-14.940	< 0.001	0.710
5	I am afraid the people I care about will be infected.	3.17 \pm 0.70	4.96 \pm 0.29	-16.130	< 0.001	0.698
6	The pandemic is terrible.	3.45 \pm 0.93	4.89 \pm 0.31	-10.130	< 0.001	0.656
7	Not enough is known about the pandemic.	3.38 \pm 0.82	4.72 \pm 0.62	-8.949	< 0.001	0.583
8	It is difficult to predict whether a person is infected or not.	2.85 \pm 0.96	4.64 \pm 0.70	-10.32	< 0.001	0.618
9	Infections that have occurred may not be accurately detected.	2.45 \pm 0.90	4.19 \pm 1.15	-8.158	< 0.001	0.559

Note: ^a Pearson's correlation coefficient between each item score and the total score.

Table 3
Exploratory factor analysis of the PHERPS (n = 252).

Item	Factor loading coefficient		
	Dread risk perception	Severe risk perception	Unknown risk perception
Item 1	0.873	0.065	0.002
Item 2	0.872	0.009	0.079
Item 3	0.436	0.284	0.134
Item 4	0.089	0.875	0.135
Item 5	0.179	0.871	0.164
Item 6	0.303	0.570	0.426
Item 7	0.179	0.346	0.619
Item 8	0.034	0.247	0.812
Item 9	0.021	0.005	0.840
Eigenvalue (rotated)	1.847	2.116	2.000
Variance explanation percentage % (rotated)	20.53	23.51	22.22
Cumulative variance explanation percentage % (rotated)	20.53	44.04	66.26
KMO value	0.747		
Bartlett's sphericity test χ^2	1390.014		
df	36.000		
P	<0.001		

Table 4
Fit indices of the PHERPS.

Fit indices	χ^2/df	GFI	RMSEA	RMR	CFI	NFI	NNFI
Evaluation standard	<3.000	>0.900	<0.100	<0.050	>0.900	>0.900	>0.900
Actual value	1.384	0.989	0.028	0.018	0.995	0.982	0.990

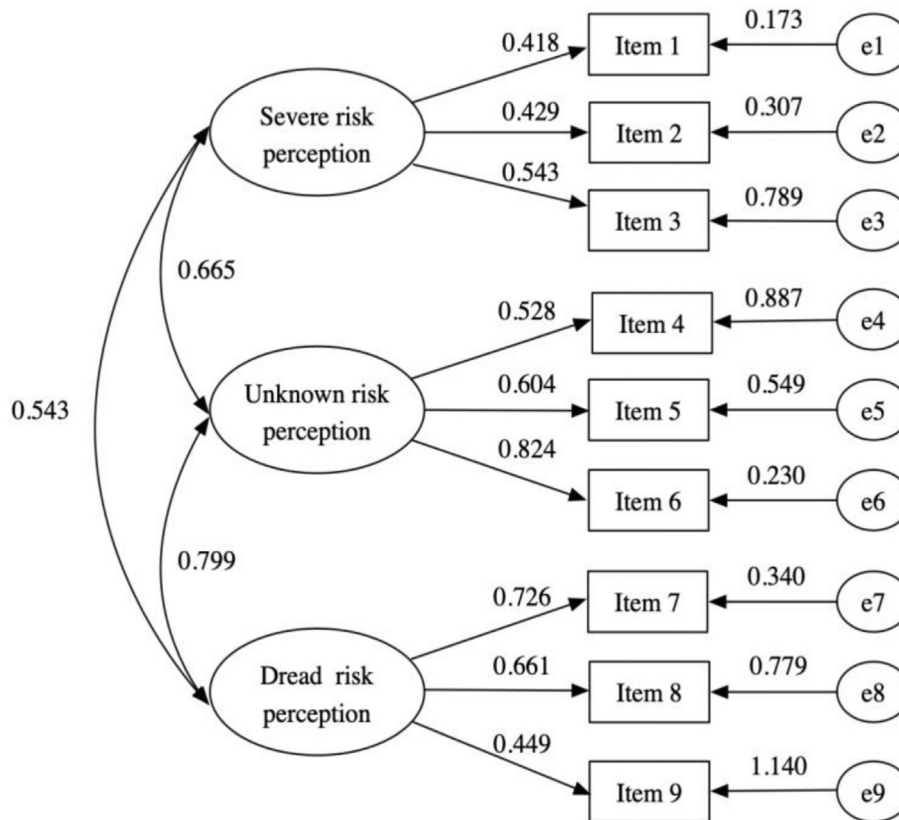


Fig. 2. Structure equation modeling of three-domain with 9 items.

related to various factors, including whether the event is controllable, the severity of the event, how wide it spreads, how fatal it is, whether it is persistent, how fast the risk can be reduced, and whether there is risk accumulation [34,35]. Unknown risk

perception is analyzed from the aspects of whether the virus can be detected, whether it is a known disease, whether its impact is rapid, whether it is known in scientific research, and whether it is familiar to the public [34,35]. Accordingly, the items corresponding to that

Table 5
Correlations among domains and the overall scale of the PHERPS.

Domain	Total scale	Severe risk perception	Unknown risk perception	Dread risk perception
Total Scale	1			
Severe risk perception	0.587 ^a	1		
Unknown risk perception	0.832 ^a	0.306 ^a	1	
Dread risk perception	0.813 ^a	0.323 ^a	0.483 ^a	1

Note: ^a Statistically significant correlation with each other at level of 0.001 (bilateral).

information, including “The pandemic has rapidly affected the society.” “Adhering to correct protective measures can prevent infection.” “The pandemic is invincible.” “The pandemic can be controlled.” “The pandemic will cause other social hazards.” “The pandemic poses a high risk to our future generations.” and “The pandemic will show a downward trend.” were included in the item pool in this study. However, these items did not meet the statistical requirements in the item analysis and were removed from the scale. The reason for this shortcoming may be that the public believes that the epidemic has a downward trend and will eventually pass thanks to the rapid and strict prevention and control actions of the government and social organizations in response to COVID-19 and the public’s experience from similar incidents that have occurred frequently in recent years. Therefore, the abovementioned aspects make a limited contribution to risk perception.

Instead, the public paid more attention to the high contagiousness of the disease, how wide it spreads, how fatal it is, and fear that oneself or relatives/friends will be infected by the virus. The novel coronavirus that causes COVID-19 is a new viral strain that humans had never been exposed to and has multiple transmission routes that are not yet fully understood. Humans are generally susceptible to this disease, which is difficult to detect at the initial stage, and asymptomatic patients may also become infection sources [15]. Therefore, the high-unknowingness nature of the epidemic is also an important contributor to the public perception of risk.

The validity of the proposed risk perception scale for public health emergencies was evaluated mainly from two aspects, content validity and construct validity. In the content validity analysis, the I-cvsi, the κ values, and the S-CVI all met the statistical criteria, indicating that the scale had good content validity [42]. In the EFA of the present study, the factor loadings of all 9 items were >0.4, and the three common extracted factors were consistent with the theoretical concept [43]. “Dread risk perception” is determined using the degree of fear that oneself or relatives/friends will be infected and the overall degree of fear. “Severe risk perception” can be evaluated from the perspectives of the contagiousness of the disease, how wide it spreads, and how fatal it is. “Unknown risk perception” can be evaluated from the perspectives of humans’ understanding of the epidemic in modern medicine, as well as whether the infection can be predicted and accurately detected. In the CFA, the validated factor model was basically in accordance with the assumed dimensions of public health emergency risk perception, and the fit indices of the model met the assessment standards, suggesting that the risk perception scale constructed in this study is in line with the theory [43]. Results demonstrated that good content and face validity of this newly developed PHERPS was satisfactory, indicating that the items of this scale were applicable to its domains as well as to its whole scale, and consensus of experts on items was reached.

In this study, the reliability of the PHERPS and each domain was evaluated by Cronbach’s α coefficient, split-half reliability coefficient, and test-retest reliability coefficient. The split-half reliability and retest reliability all reached a good standard [43]. However, the Cronbach’s α coefficient of two dimensions, unknown risk

perception, and severe risk perception, failed to meet the good standard, meeting only the acceptable standard [44,45]. It might be attributed to the small number of items contained in the two dimensions, so the internal consistency of the two dimensions was compromised. Besides, it may also relate to the limited sample size of the survey. Therefore, although the value is acceptable, further study on this scale is necessary in order to re-confirm the internal consistency of the scale.

Limitations: Our study has some limitations. Due to the strict epidemic management measures, the offline investigation was not feasible, so this study could only adopt online investigation. Depending on the sampling method, the information collected may not be more accurate than offline surveys. In addition, China was the first country to report COVID-19, so Chinese people likely had experienced higher levels of risk perception than other countries’. The test population of this scale is also limited to Chinese adults. Therefore, the generalizability of the scale needs to further verify in other countries or regions.

5. Conclusions

The PHERPS constructed in this study has 9 items. It evaluates the public’s risk perception level in response to public health emergencies in the three dimensions of dread risk perception, severe risk perception, and unknown risk perception. The scale conforms to the theory of risk perception and has good reliability and validity. It contains only a few items and is easy to complete. The proposed scale can serve as an effective tool for evaluating public risk perception in response to COVID-19 and future public health emergency events. It also provides a basis for governments and organizations to observe public opinion, stabilize public sentiment, and implement effective risk management and control measures.

Funding

This research received no external funding.

CRediT authorship contribution statement

Zhiying Shen: Methodology, Writing - original draft. **Zhuqing Zhong:** Conceptualization, Writing - review & editing. **Jianfei Xie:** Methodology, Data curation. **Siqing Ding:** Supervision. **Shougen Li:** Software, Validation. **Chengyuan Li:** Methodology, Writing - review & editing.

Declaration of competing interest

The authors declare no conflict of interest.

Acknowledgements

The authors would like to acknowledge all participants in the study for their support.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ijnss.2020.12.012>.

References

- Chen NS, Zhou M, Dong X, Qu JM, Gong FY, Han Y, et al. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. *Lancet* 2020;395(10223):507–13. [https://doi.org/10.1016/S0140-6736\(20\)30211-7](https://doi.org/10.1016/S0140-6736(20)30211-7).
- Zhu N, Zhang D, Wang W, Li X, Yang B. A novel coronavirus from patients with pneumonia in China, 2019. *N Engl J Med* 2020;382(8):727–33. <https://doi.org/10.1056/NEJMoa2001017>.
- Coronavirus resource center, Johns Hopkins University. COVID-19 Case Tracker. Available online: <https://coronavirus.jhu.edu> (accessed on 08 November 2020).
- Sarkodie SA, Owusu PA. Global assessment of environment, health and economic impact of the novel coronavirus (COVID-19). *Environ Dev Sustain* 2020;6:1–11. <https://doi.org/10.1007/s10668-020-00801-2>.
- Rassy D, Smith RD. The economic impact of H1N1 on Mexico's tourist and pork sectors. *Health Econ* 2013;22(7):824–34. <https://doi.org/10.1002/hec.2862>.
- Kirigia JM, Masiye F, Kirigia DG, Akweongo P. Indirect costs associated with deaths from the Ebola virus disease in West Africa. *Infect Dis Poverty* 2015;4:45. <https://doi.org/10.1186/s40249-015-0079-4>.
- Xie XR, Huang LM, Li JJ, Zhu H. Generational differences in perceptions of food health/risk and attitudes toward organic food and game meat: the case of the COVID-19 crisis in China. *Int J Environ Res Publ Health* 2020;17(9):3148. <https://doi.org/10.3390/ijerph17093148>.
- Motta Zanin G, Gentile E, Parisi A, Spasiano D. A preliminary evaluation of the public risk perception related to the COVID-19 health emergency in Italy. *Int J Environ Res Publ Health* 2020;17(9):3024. <https://doi.org/10.3390/ijerph17093024>.
- Cori L, Bianchi F, Cadum E, et al. Risk perception and COVID-19. *Int J Environ Res Publ Health* 2020;17(9):3114. <https://doi.org/10.3390/ijerph17093114>.
- Cvetković VM, Nikolić N, Radovanović Nenadić U, Ćal A, Nojić EK, Zečević M. Preparedness and preventive behaviors for a pandemic disaster caused by COVID-19 in Serbia. *Int J Environ Res Publ Health* 2020;17(11):4124. <https://doi.org/10.3390/ijerph17114124>.
- Li HQ, Wang SH, Fan CM, Jia JM. Public fear and emergency management in sudden disasters. *East China Economic Management* 2011;25(9):42–6 [in Chinese]. <https://doi.org/10.3969/j.issn.1007-5097.2011.09.007>.
- Olagoke AA, Olagoke OO, Hughes AM. Exposure to coronavirus news on mainstream media: the role of risk perceptions and depression. *Br J Health Psychol* 2020:e12427. <https://doi.org/10.1111/bjhp.12427>.
- Meng B, Liu M, Li QS, Wang L. Theoretical model for risk perception and its factor analysis. *China Saf Sci J* 2010;20(10):61–8 [in Chinese]. <https://doi.org/10.3969/j.issn.1003-3033.2010.10.011>.
- Bish A, Michie S. Demographic and attitudinal determinants of protective behaviours during a pandemic: a review. *Br J Health Psychol* 2010;15(4):797–824. <https://doi.org/10.1348/135910710x485826>.
- Xu H, Gan Y, Zheng D, Wu B, Zhu X, Xu C, et al. Relationship between COVID-19 infection and risk perception, knowledge, attitude, and four non-pharmaceutical interventions during the late period of the COVID-19 epidemic in China: online cross-sectional survey of 8158 adults. *J Med Internet Res* 2020;22(11):e21372. <https://doi.org/10.2196/21372>.
- Sjöberg L. Factors in risk perception. *Risk Anal* 2000;20(1):1–12. <https://doi.org/10.1111/0272-4332.00001>.
- Pidgeon N. Risk assessment, risk values and the social science programme: why we do need risk perception research. *Reliab Eng Syst Saf* 1998;59(1):5–15. [https://doi.org/10.1016/S0951-8320\(97\)00114-2](https://doi.org/10.1016/S0951-8320(97)00114-2).
- Luo Y, Yao L, Zhou L, Yuan F, Zhong X. Factors influencing health behaviours during the coronavirus disease 2019 outbreak in China: an extended information-motivation-behaviour skills model. *Publ Health* 2020;185:298–305. <https://doi.org/10.1016/j.puhe.2020.06.057>.
- Dryhurst S, Schneider CR, Kerr J, Freeman ALJ, Recchia G, van der Bles AM, et al. Risk perceptions of COVID-19 around the world. *J Risk Res* 2020;1–13. <https://doi.org/10.1080/13669877.2020.1758193>.
- Duan TX, Jiang HC, Deng XS, Zhang QW, Wang F. Government intervention, risk perception, and the adoption of protective action recommendations: evidence from the COVID-19 prevention and control experience of China. *Int J Environ Res Publ Health* 2020;17(10):3387. <https://doi.org/10.3390/ijerph17103387>.
- Liao QY, Wu P, Wing Tak Lam W, Cowling BJ, Fielding R. Trajectories of public psycho-behavioural responses relating to influenza A(H7N9) over the winter of 2014–15 in Hong Kong. *Psychol Health* 2019;34(2):162–80. <https://doi.org/10.1080/08870446.2018.1515436>.
- Yue CY, Liu CP, Wang J, Zhang M, Wu HJ, Li CR, et al. Association between social support and anxiety among pregnant women in the third trimester during the coronavirus disease 2019 (COVID-19) epidemic in Qingdao, China: the mediating effect of risk perception. *Int J Soc Psychiatr* 2020;002076402094156. <https://doi.org/10.1177/0020764020941567>.
- Ding YB, Xu JL, Huang SS, Li PP, Lu CZ, Xie SH. Risk perception and depression in public health crises: evidence from the COVID-19 crisis in China. *Int J Environ Res Publ Health* 2020;17(16):5728. <https://doi.org/10.3390/ijerph17165728>.
- Zhong YP, Liu WH, Lee TY, Zhao H, Ji J. Risk perception, knowledge, information sources and emotional states among COVID-19 patients in Wuhan, China. *Nurs Outlook* 2020. <https://doi.org/10.1016/j.outlook.2020.08.005>. published online.
- Lee TY, Zhong YP, Zhou J, He XJ, Kong R, Ji J. The outbreak of coronavirus disease in China: risk perceptions, knowledge, and information sources among prenatal and postnatal women. *Women Birth* 2020. <https://doi.org/10.1016/j.wombi.2020.05.010>.
- Niepel C, Kranz D, Borgonovi F, Emslander V, Greiff S. The coronavirus (COVID-19) fatality risk perception of US adult residents in March and April 2020. *Br J Health Psychol* 2020;25(4):883–8. <https://doi.org/10.1111/bjhp.12438>.
- Peres D, Monteiro J, Almeida MA, Ladeira R. Risk perception of COVID-19 among Portuguese healthcare professionals and the general population. *J Hosp Infect* 2020;105(3):434–7. <https://doi.org/10.1016/j.jhin.2020.05.038>.
- Gidengil CA, Parker AM, Zikmund-Fisher BJ. Trends in risk perceptions and vaccination intentions: a longitudinal study of the first year of the H1N1 pandemic. *Am J Publ Health* 2012;102(4):672–9. <https://doi.org/10.2105/AJPH.2011.300407>.
- Ibukya Y, Chapman GB, Meyers LA, Li M, Galvani AP. The dynamics of risk perceptions and precautionary behavior in response to 2009 (H1N1) pandemic influenza. *BMC Infect Dis* 2010;10:296. <https://doi.org/10.1186/1471-2334-10-296>.
- Rudisill C. How do we handle new health risks? Risk perception, optimism, and behaviors regarding the H1N1 virus. *J Risk Res* 2013;16(8):959–80. <https://doi.org/10.1080/13669877.2012.761271>.
- Rollison JJ, Hanoch Y. Knowledge and risk perceptions of the Ebola virus in the United States. *Prev Med Rep* 2015;2:262–4. <https://doi.org/10.1016/j.pmedr.2015.04.005>.
- Taghrir MH, Borazjani R, Shiraly R. COVID-19 and Iranian medical students: A survey on their related-knowledge, preventive behaviors and risk perception. *Arch Iran Med* 2020;23(4):249–54. <https://doi.org/10.34172/aim.2020.06>.
- Chan EYY, Huang Z, Lo ESK, Hung KKC, Wong ELY, Wong SYS. Sociodemographic predictors of health risk perception, attitude and behavior practices associated with health-emergency disaster risk management for biological hazards: the case of COVID-19 pandemic in Hong Kong, SAR China. *Int J Environ Res Publ Health* 2020;17(11):3869. <https://doi.org/10.3390/ijerph17113869>.
- Slovic P. The Perception of risk. *Risk Society/Policy* 2000;69(3):112. <https://doi.org/10.1126/science.3563507>.
- Slovic P. Perception of risk. *Science* 1987;236(4799):280–5. <https://doi.org/10.1126/science.3563507>.
- Qiang L, Fan C, Jia J, Wang S, Hao L. The public perception of risks and the management of emergency measures taken during unexpected calamities. *Manag World* 2009;6:52–60 [in Chinese]. <https://doi.org/10.19744/j.cnki.11-1235/f.2009.06.006>.
- Wu P, Fang YY, Guan ZQ, Fan B, Kong JH, Yao ZL, et al. The psychological impact of the SARS epidemic on hospital employees in China: exposure, risk perception, and altruistic acceptance of risk. *Can J Psychiatr* 2009;54(5):302–11. <https://doi.org/10.1177/070674370905400504>.
- Miao W. The risk of ASFWeibo's shows the impact on public risk perception. *Guangxi University*; 2019 [in Chinese].
- Jingcheng S, Xiankun M, Zhenqiu S. Content validity index in scale development. *J Cent S Univ* 2012;37(2):152–5. <https://doi.org/10.3969/j.issn.1672-7347.2012.02.007> [in Chinese].
- Hambleton RK, Swaminathan H, Algina J, Coulson DB. Criterion-referenced testing and measurement: a review of technical issues and developments. *Rev Educ Res* 1978;48(1):1–47. <https://doi.org/10.3102/00346543048001001>.
- Waltz CF, Strickland OL, Lenz ER. *Measurement in nursing and health research*. New York, NY: Springer Publishing Company; 2016. <https://doi.org/10.1891/9780826170620>.
- Wu ML. *Practice of questionnaire statistical analysis—operation and application of SPSS*. Chongqing: Chongqing University Press; 2010 [in Chinese].
- Sun ZQ, Xu YY. *Medical statistics*. fourth ed. Beijing: People's Medical Publishing House; 2010 [in Chinese].
- Sushil S, Verma N. Questionnaire validation made easy. *Eur J Sci Res* 2010;46:172–8.
- Liu ZH, Liu P. *PASW/SPSS statistics Chinese edition statistical analysis course*. third ed. Beijing: Publishing House of Electronics Industry; 2010 [in Chinese].
- Karahana Okuroglu G, Karaçanta Atbaş S, Ecevit Alpar Ş. Development, reliability, and validity of the insulin treatment self-management scale. *Int J Nurs Pract* 2020;26(5):e12814. <https://doi.org/10.1111/inj.12814>.
- Develiss R. *Social development theory and applications*. New York, NY: Sage Publications; 2012.
- Cronbach LJ, Meehl PE. Construct validity in psychological tests. *Psychol Bull* 1955;52(4):281–302. <https://doi.org/10.1037/h0040957>.