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ORIGINAL RESEARCH

Direct and Indirect Effects of Risk Perception and Risk Information on PTSD in Frontline Healthcare Workers

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Background: The COVID-19 Delta variant caused an outbreak in Guangdong in mid-May 2021. The risk information and risk perception of COVID-19 have been considered factors associated with mental health statuses, especially posttraumatic stress disorder (PTSD), in frontline healthcare workers.

Objective: The aim of this study is to investigate the interactive relationship in risk information and risk perception of COVID-19 and PTSD in healthcare personnel from the emergency department.

Design: We conducted a survey one month after the outbreak. A cross-sectional survey design is adopted, and 3078 participants are enrolled. The PTSD checklist for DSM-5 (PCL-5), risk information questionnaire, and risk perception questionnaire are utilized to collect data.

Methods: Bivariate correlation analysis and structural equation modelling are performed to analyze the mediating role of risk perception in the relationship between risk information and PTSD.

Results: The estimated prevalence of PTSD among frontline healthcare workers is 28.2%. The risk information for COVID-19, risk perception, and PTSD symptoms are mutually correlated. The specific paths from risk perception to PTSD show significant effects, in which two had negative effects and one had a positive effect. The risk perception feature in 2020 differed from that in 2019, which is largely due to the risk perception of the virus.

Conclusion: The estimated prevalence of PTSD among frontline healthcare workers remains high. Risk information for COVID-19 has dual effects on PTSD through the mediation of risk perceptions. Unfamiliarity with the SAR-COVID-2 Delta variant increased the risk perception of COVID-19. Effective risk communication regarding COVID-19 can have a positive effect on the mental health of frontline healthcare workers.

Keywords: risk perception, posttraumatic stress disorder, risk information, frontline healthcare workers, COVID-19

Introduction

Since the coronavirus disease 2019 (COVID-19) outbreak in December 2019, the associated severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) has continuously evolved and mutated during its spread. The WHO documents that the SARS-CoV-2 Delta lineages (B.1.617.2) have been identified as a variant of concern (VOC).[1] The Delta variant was first detected in India and has been reported to have much higher transmissibility than the wild-type strain.[2] Single-dose vaccination does not sufficiently protect the general population from Delta lineages.[3] From May 21, 2021, the

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COVID-19 outbreak that was caused by the Delta variant emerged in Guangzhou City, with over 160 locally confirmed cases being observed in four cities (Guangzhou, Maoming, Foshan, and Zhanjiang) by June 23.

Posttraumatic stress disorder (PTSD) is considered one of the most common psychological burdens for healthcare workers under the pressure of major public health emergencies[4] and is known as the second tsunami of the COVID-19 pandemic.[5] Individuals with PTSD present symptoms of intrusion, avoidance, negative changes in emotion and cognition, extreme behavior, and hypervigilance. PTSD occurs after experiencing traumatic events such as seeing others suffer and being repeatedly exposed to aversive details.[6] Frontline healthcare workers, such as those who work in emergency departments during the COVID-19 pandemic, have been confronted with enormous pressure, including a high risk of infection, high workload, feelings of incapability when facing critically ill patients, and exhaustion,[7] which has raised their risk of developing PTSD or showing prominent PTSD-related symptoms. Previous investigations have supported that the estimated prevalence rate of PTSD among frontline healthcare workers was relatively high during the COVID-19 pandemic,[8,9] with being female, having poor sleep quality, and less time for leisure being risk factors for PTSD.[8,10]

Risk perception refers to the intuitive evaluation of the probability and consequences of a certain hazard. Slovic et al developed a cognitive map to measure risk perception using a psychometric paradigm.[11] The two dimensions were dread and unknown risks. One study parsimoniously applied this paradigm to measure the risk perception of the SARS epidemic and found that risk perception is an effective indicator of the psychological consequences of the general public.[12] Furthermore, Geng et al developed a simple measurement of risk perception of the COVID-19 pandemic in frontline healthcare workers based on a two-dimensional Slovic model and confirmed its validation by factor analysis. The distributions of COVID-19 related hazards differed significantly between healthcare workers with and without high PTSD scores.[8] There is other evidence supporting the close relationship between the risk perception of SARS or COVID-19 and PTSD in healthcare workers, but other psychometric methods are used to measure risk perception.[13,14]

Risk information is a critical mediator of risk communication and is defined as the exchange of information on hazards between official departments and individuals or communities.[15] Risk information that contains the information related to oneself and government measures to control risk have a direct effect on risk perception.[16] For instance, dread factors, including the high probability of getting infected, outcomes of getting infected, lack of protective and preventive measures, rapid increase in cases or case-fatality rates, and uncertainty about the disease, heightened the risk perception of SARS in 2003.[17] Shi et al found that the risk information of SARS could be divided into four parts (information about the disease, information about the cure, information related to oneself, and information about government control) and built a predictive model showing significant associations between risk information and the level of risk perception.[12] Poor risk information management can result in negative socioeconomic effects and negative public psychological responses.[18] Thus, people should be warned about the consequences of uncontrolled risk communication and heightened risk perceptions caused by COVID-19.

According to slovic's risk perception theory, dread risk is characterized by a perceived lack of control, catastrophic potential, fatal consequences, and an inequitable distribution of risks and benefits. A higher fear risk score indicates a greater perceived level of risk. Studies have demonstrated that while people acquire more information about risks, their perception of fear may not diminish; instead, it might intensify due to heightened attention to potential dangers. Second, the perception of unknown risks is associated with hazards that are unobserved, unfamiliar, novel, and whose adverse effects manifest with delay. As individuals gain more knowledge about these risks, they may develop a deeper understanding of their nature and potential consequences, thereby mitigating the perception of such risks. For instance, comprehending the specific risks and management strategies associated with vaccine technology can reduce the public's perception of "unknown risks". Thus, based on existing theoretical frameworks and empirical evidence from prior studies, it is evident that individuals' comprehension of risk information exerts differential impacts on the two dimensions of risk perception.

Previous evidence has highlighted the relationship between risk perception and PTSD. Jalloh et al conducted a cross-sectional survey of a national sample in areas affected by Ebola, revealing that the perceived threat of Ebola was independently linked to PTSD.[19] Another study found that perceptions of SARS-related risks were significantly and positively correlated with PTSD symptom scores in healthcare workers three years after the outbreak.[13] Research during

the COVID-19 pandemic has explored the connection between pandemic-related information—such as risk communication and knowledge about COVID-19—and preventive behaviors.[18,20]

In summary, the associations between risk perception of the COVID-19 pandemic and PTSD in frontline healthcare workers and risk information provided strong evidence. However, some gaps remain to be addressed. The correlation between the risk information of COVID-19, risk perception, and its pre-existing factors has not yet been examined. Moreover, the difference between the two dimensions of risk perception in Slovic's model has not yet been studied. The risk information of pandemics might add to the knowledge to reduce unknown risks but exacerbate dread risk through the unmeasurable effects of negative news. Furthermore, the difference in the cognitive map of risk perception between epidemics caused by SAR-COV-2 wild-type (2019) and SAR-COV-2 Delta lineages (2020) is unknown. Since frontline workers have been facing continuous pressure from pandemics, research on the above questions could provide more accurate advice for the management of risk communication and the psychological state of frontline healthcare workers. Therefore, the current study aimed to investigate the risk information and perception of COVID-19 and PTSD among healthcare workers from emergency departments in a national sample. The hypotheses were as follows: (1) Risk information of COVID-19 positively correlated with dread risk (measured by the level of dread) of COVD-19. (2) The risk information for COVID-19 was negatively correlated with unknown risk (measured by the level of unfamiliarity) of COVID-19. (3) Risk perception was positively correlated with PTSD. (4) The cognitive maps of risk perception of COIVD-19 were significantly different between epidemics caused by the SAR-COV-2 wild-type (2019) and SAR-COV-2 Delta lineages (2020).

Methods

Setting and Sample

A cross-sectional survey design was adopted, and topic-related psychological variables were assessed by healthcare workers in the emergency department of a hospital. Minimum sample size was calculated as 3206 with $\alpha = 0.05$, relative error = 10% and prevalence rate expected as 10.7% based on our preliminary research.[8] Overall, there were 3541 respondents. A total of 463 participants were excluded based on the following exclusion criteria: a) response time < 200s (N = 23), b) response time > 3600s (N = 53), and c) failure to pass the attentional check items (N = 387). There were two attentional check items: "Please select '2021' for the following numbers" and "Please select 'Yes' to the following answers". The sampling process is illustrated in Figure 1. During recruitment, demographic information was collected (including sex, age, marital status, nationality, education level, medical profession, province, and hospital level).

Procedure and Data Collection

The survey was conducted from June 17 to 23, 2021, approximately one month after the outbreak of the COVID-19 Delta variant in Guangdong Province. The online questionnaire was designed by one of our authors (YZ) in advance and could be accessed by a link generated by Wenjuanxing. One of our corresponding authors (XL) distributed an online questionnaire to managers and administrative staff in emergency departments of several hospitals located in Guangdong, Xinjiang, Fujian, Hainan, and Huanan provinces. They subsequently sent this link to the online groups in their departments so that the HCWs could complete the questionnaire by clicking on it on their mobile phone or computer. After entering the online survey, the questionnaire could only be submitted when all the items were answered. Data were automatically stored in the Wenjuanxing online system (https://www.wjx.cn/), and downloaded after the survey was completed. Informed consent was obtained from all participants before their participation in the study. This study was approved by the Ethics Committee of the Southern Medical University.

Measures

PTSD Symptom Severity

The PTSD checklist for DSM-5 (PCL-5) was utilized to assess PTSD symptom severity. The PCL-5 is a self-reported scale consisting of 20 items that directly correspond to the DSM-5.[21] There were four clusters of core symptoms: intrusive symptoms (Criterion B: questions 1–5), avoidance symptoms (Criterion C: questions 6 and 7), negative

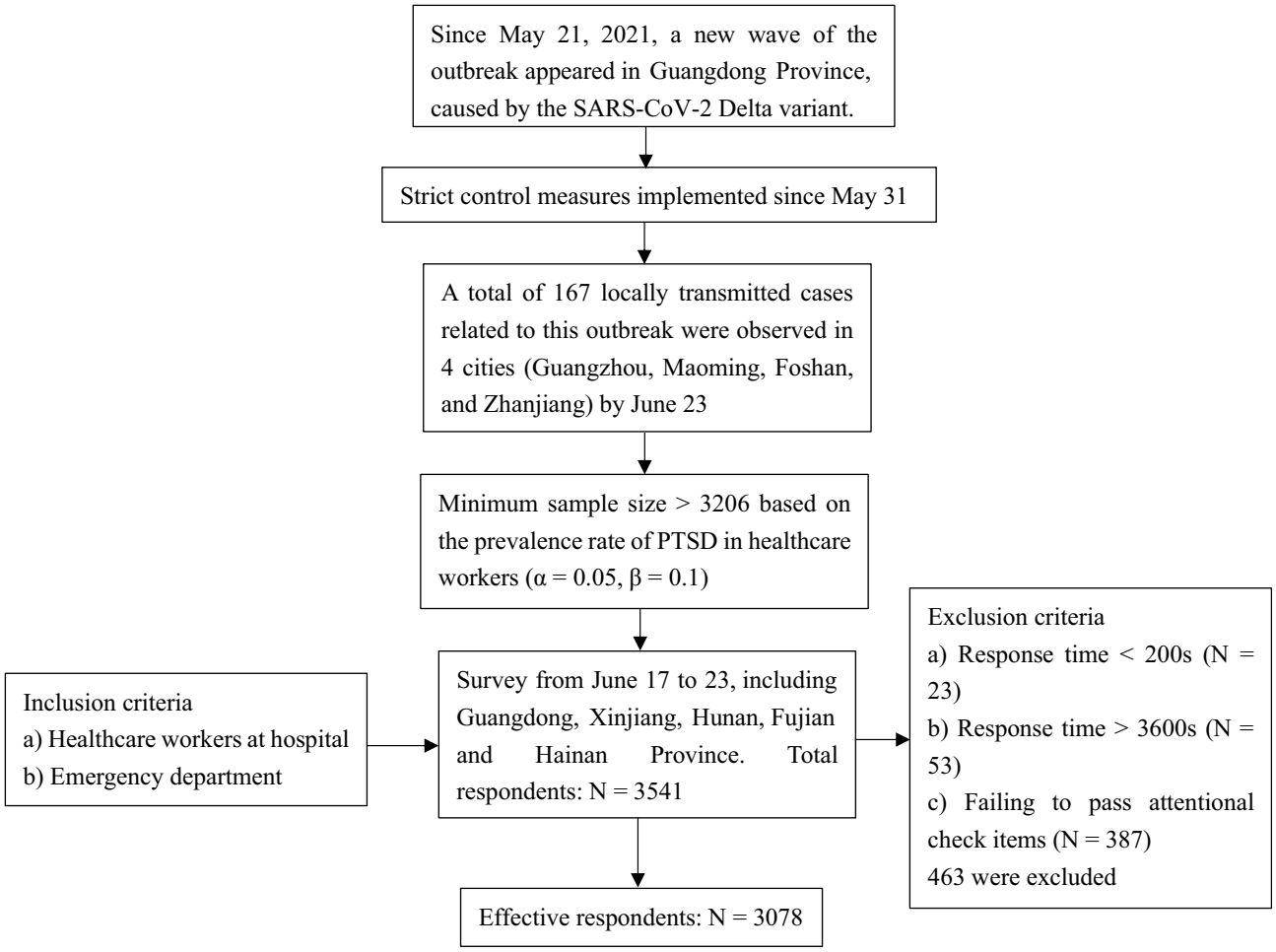

Figure 1 Sampling process.

alterations in cognition and mood (Criterion D: questions 8–14), and hyperarousal symptoms (Criterion E: questions 15–20). Each item was rated on a five-point Likert scale ranging from 0 (not at all) to 4 (extremely) during the previous month. The sum of the scores of all PCL-5 symptom clusters was an indicator of PTSD symptom severity, and a cutoff score of over 33 points suggested a probable diagnosis of PTSD or significant symptom presentation. The Chinese version of the original PCL-5 has good psychometric quality and has been widely used in trauma-related research and practice.[22] Cronbach's alpha of the PCL-5 in the current study was 0.969, suggesting a relatively high internal consistency.

Risk Information Questionnaire

It was found that risk information in the SARS epidemic in 2003 had a four-factor structure: information about disease (eg, new and cumulative confirmed/suspected cases, or deaths), information about a cure (eg, new and cumulative cured cases), information related to oneself (eg, whether there were confirmed cases at a nearby place), and information about government control (eg, lockdown measures, water and electricity supply).[12] Thus, a custom-made simplified questionnaire of risk information was conducted with six items about the COVID-19 pandemic: 1) new confirmed/suspected and cumulative cases; 2) new/cumulative deaths; 3) new/cumulative cured cases; 4) new confirmed cases near workplaces/homes; and 5) government measures (eg, lockdown measures and support for necessities) to hardest-hit areas; 6) nucleic acid testing and vaccination. Each item was rated on a five-point Likert scale ranging from 0 (not concerned) to 4 (extremely concerned). The score indicated the degree of concern about risk information.

Risk Perception Questionnaire

According to the psychometric model postulated by Slovic, dread and unfamiliarity were adopted to measure two-dimensional risk perception.[11] Each dimension contained the same four items as the four hazards that were rated on a five-point Likert scale ranging from 1 (not dreadful at all or very familiar) to 5 (extremely dreadful or not familiar at all). These four hazards were as follows: a) Virus: SAR-COV-2 Delta variant; H2. Disease: COVID-19; H3. COVID-19 patients or viral carriers; H4. Treatment and prevention of COVID-19. Thus, there were eight items in this section (two dimensions × four hazards). Our previous study confirmed that the above items fit Slovic's two-dimensional theory, and these four hazards could better represent the overall risk perception of the COVID-19 pandemic.[8]

Data Analysis

The kurtosis and skewness in the total scores of risk information, dread of risk perception, unfamiliarity of risk perception, and each cluster of PTSD symptoms were all between −1 and 1, suggesting compliance with normality. Descriptive analyses were used to examine the sample characteristics. Bivariate analyses (*t*-test and one-way analysis of variance (ANOVA)) were then carried out to compare the PCL-5 scores among different demographic subgroups and PTSD severity groups (divided by the cutoff point of 33). Correlations among risk information, risk perception, and PTSD were analyzed using Pearson's correlation coefficients. In addition, Bayesian factors were calculated using JASP to compare the probability of significance of statistical hypotheses. A Bayes Factor (BF) ranging from 1 to 3 indicated weak evidence, while a BF of 3 to 10 indicated moderate evidence, and a BF of 10 or higher indicated strong evidence. A structural equation model (SEM) was used to analyze the mediating role of risk perception between risk information and PTSD. Because the current study had a large sample, the chi-square test could be large and significant, even with small discrepancies between the implied and obtained covariance matrices. Multivariate normality was not possible in the current study (Mardia's coefficient for multivariate kurtosis was > 3), indicating significant multivariate nonnormality. Consequently, the Bollen–Stine bootstrap p (k = 2000) procedure was used to adjust the model fit and parameter estimates.[23] Bias-corrected and percentile-based bootstrap confidence intervals (k = 2000) were used to examine the mediation effects in the model. Simulation research shows that bootstrapping is more powerful than the Sobel test and causal steps approach for testing intervening variable effects.[24]

Results

The Prevalence, Demographic Characteristics, and Differences in PCL-5 Scores for Various Subgroups

There were 3078 valid respondents, among whom 72.3% were female and 35 years old or younger. Of the participants, 68% were married, 29.2% were unmarried, 2.3% were divorced, and 0.2% were widowed. Most respondents (68.6%) were of Han nationality, and 31.4% belonged to minorities. Regarding education levels, about 90% of the sample had junior college or bachelor's degrees, 3.6% had high school qualifications or below, 5.7% had master's degrees, and 0.8% had doctorates or above. The percentages of physicians, nurses, and other professionals were 28.7%, 68.4%, and 2.9%, respectively. Nearly, 52% of the HCWs were from Guangdong Province, 44% from Xinjiang Province, and 4.2% from other provinces, such as Fujian, Hunan, and Hainan. Approximately 70% of the samples were from Class 3 hospital, whereas those from Class 2 and Class 1 were 25.5% and 5.2%, respectively. Considering that those with a PCL-5 total score of 33 or higher for a probable PTSD diagnose, the prevalence of probable PTSD in the investigated population was 28.2% (see Table 1).

A comparison of PTSD severity scores among the different demographic subgroups is presented in Table 1. Women had more severe PTSD symptoms than men ($t = 4.976$, $p < 0.001$). No significant difference was found between those who were 35 years or younger and 36 years or older ($t = 1.634$, $p = 0.103$). There were significant between-group differences among the marital status subgroups ($F = 10.781$, $p < 0.001$). The Han nationality group had significantly lower PTSD scores than the minority group ($t = 6.676$, $p < 0.001$). There was no significant difference in the PCL-5 scores among the four education levels ($F = 2.133$, $p < 0.094$). With respect to the medical profession, nurses had the highest PTSD severity, followed by doctors and other professionals ($F = 12.629$, $p < 0.001$). There were significant

Table 1 Demographic Information and Group Differences of PCL-5 Scores

		Respondents		PCL-5				
		N	%	Mean	SD	F/t	p	BF_{10}
Gender								
	Female	2225	72.3	24.22	16.24	4.976	<0.001	5107.693
	Male	853	27.7	21.10	15.31			
Age								
	≤35	2226	72.3	23.64	16.33	1.634	0.103	0.158
	≥36	852	27.7	22.62	15.25			
Marital status								
	Unmarried	899	29.2	20.84	15.24	10.781	<0.001	49,328.162
	Married	2104	68.4	24.33	16.23			
	Divorced	70	2.3	25.87	17.34			
	Widowed	5	0.2	28.40	16.35			
Ethnic group								
	Han	2110	68.6	22.00	15.26	6.676	<0.001	1.290×10^{9}
	Minorities	968	31.4	26.32	17.28			
Education level								
	High school or below	111	3.6	21.87	16.52	2.133	0.094	0.132
	Junior college or bachelor	2766	89.9	23.57	16.04			
	Masters	176	5.7	21.70	16.19			
	Doctorate or above	25	0.8	17.72	12.20			
Medical profession								
	Physician	883	28.7	22.05	15.69	12.629	<0.001	725.092
	Nurse	2104	68.4	24.17	16.14			
	Other	91	2.9	17.11	15.27			
Area								
	Guangdong	1597	51.9	21.00	14.42	41.921	<0.001	4.928×10^{15}
	Xinjiang	1351	43.9	26.31	17.48			
	Other	130	4.2	21.56	14.44			
Hospital level								
	Class-1	161	5.2	21.09	15.18	5.558	0.004	1.783
	Class-2	784	25.5	22.12	15.95			
	Class-3	2133	69.3	23.98	16.11			
PTSD severity								
	PCL-5<33	2211	71.8	15.26	9.32	75.350	<0.001	∞
	PCL-5≥33	867	28.2	43.99	9.99			

Notes: The PCL-5 is a checklist used for assessing PTSD based on the DSM-5 criteria. A Bayes Factor (BF)ranging from 1 to 3 indicates weak evidence, while a BF of 3 to 10 suggests moderate evidence, and a BF of 10 or higher indicates strong evidence.

differences in PTSD scores among the provinces ($F = 41.926$, $p < 0.001$). HCWs from higher-class hospitals had higher PTSD scores ($F = 5.558$, $p = 0.004$). The results of Bayesian factor analysis were consistent with the above results.

Risk Information and Perception of COVID-19 Pandemic

The overall degree of concern for each item of risk information and the level of dread and unfamiliarity are presented in Table 2. For risk information, only "new confirmed cases near the workplace/home" had an overall level of concern over 3, while other items were all close to and below 3. On the dimension of dread of risk perception, only the "virus: SAR-COV-2 Delta variant" had ratings over 3 and the "COVID-19 treatment and prevention" had the lowest ratings (2.16). On the dimension of unfamiliarity, "virus: SAR-COV-2 Delta variant" also had the highest rating (2.83), and other items were close to each other (near 2.33). According to a median score of 3, the "virus: SAR-COV-2 Delta variant" had left the "minimum risk" quadrant.

Table 2 Risk Information and Risk Perception of COVID-19 Pandemic (N = 3078)

Risk information	Level of concern		Risk perception	Dread		Unfamiliarity	
	Mean	SD		Mean	SD	Mean	SD
New confirmed (suspected) cases, cumulative cases	2.98	0.92	Virus: SAR-COV-2 Delta variant	3.01	1.25	2.83	0.84
New death, cumulative death	2.82	1.01	Disease: COVID-19	2.95	1.24	2.29	0.84
New/cumulative cured cases	2.78	1.01	COVID-19 patient or virus carrier	2.97	1.24	2.37	0.86
New confirmed cases near working place/home	3.18	0.92	COVID-19 treatment and prevention	2.16	1.22	2.28	0.87
Government measures to hardest-hit areas	2.92	0.95					
Information about nucleic acid test and vaccination	3.09	0.88					

Analysis of the Mediating Role of Risk Perception of the COVID-19 Pandemic Between Risk Information and PTSD

Correlation analysis was conducted on risk information, risk perception of the COVID-19 pandemic, and clusters of PTSD symptoms. The results are summarized in Table 3. Except for the correlation of concern for risk information and Cluster D of PTSD and risk information and Cluster E of PTSD, all other correlations were significant ($p < 0.001$). Bayesian factor analysis was supplemented and consistent with the above results.

These two dimensions of risk perception were used as mediators in the model connecting risk information and PTSD. To examine the effects and model fit, all participants' data were entered into the model, and the final model is shown in Figure 2. Bollen–Stine bootstrap was $p < 0.001$, indicating the necessity of adjusting the model to handle multivariate non-normality and a large sample. The adjusted chi-square was 168.383, standardized RMR = 0.054, goodness of fit (GFI) = 0.996, and adjusted goodness of fit (AGFI) = 0.994, RMSEA=0.084, suggesting a good model fit after adjustments. The results of the path coefficients are presented in Table 4. However, the total and direct effects of RI on PTSD were not significant according to the 95% CI. The specific paths from RI to PTSD all showed significant effects, in which two had negative effects (RI > Unfamiliarity > PTSD, B = −0.273, 95CI%: −0.362 to −0.205; RI > Unfamiliarity > Dread > PTSD, B = −0.092, 95CI%: −0.123 to −0.068), and one had positive effects (RI > Dread >

Table 3 Bayesian Pearson Correlations Between Risk Information and Risk Perception of COVID-19 Pandemic, and PTSD

Variable		1	2	3	4	5	6	7
1. Concern of risk information	Pearson's r	—						
	BF_{10}	—						
2. Dread of risk perception	Pearson's r	0.202	—					
	BF_{10}	$1.318\times10^{+26}$	—					
3. Unfamiliarity of risk	Pearson's r	−0.249	0.183	—				
	BF_{10}	$1.708\times10^{+41}$	$1.098\times10^{+21}$	—				
4. B Cluster of PTSD	Pearson's r	0.092	0.408	0.210	—			
	BF_{10}	11,578.051	$1.266\times10^{+120}$	$3.773\times10^{+28}$	—			
5. C Cluster of PTSD	Pearson's r	0.089	0.336	0.153	0.767[a]	—		
	BF_{10}	4178.160	$3.132\times10^{+78}$	$1.464\times10^{+14}$	∞	—		
6. D Cluster of PTSD	Pearson's r	0.010	0.341	0.227	0.770[a]	0.722[a]	—	
	BF_{10}	0.027	$6.203\times10^{+80}$	$5.567\times10^{+33}$	∞	∞	—	
7. E Cluster of PTSD	Pearson's r	0.032	0.353	0.204	0.739[a]	0.662[a]	0.864[a]	—
	BF_{10}	0.109	$1.192\times10^{+87}$	$4.381\times10^{+26}$	∞	∞	∞	—

Notes: [a]Posterior is too peaked. A Bayes Factor (BF)ranging from 1 to 3 indicates weak evidence, while a BF of 3 to 10 suggests moderate evidence, and a BF of 10 or higher indicates strong evidence.

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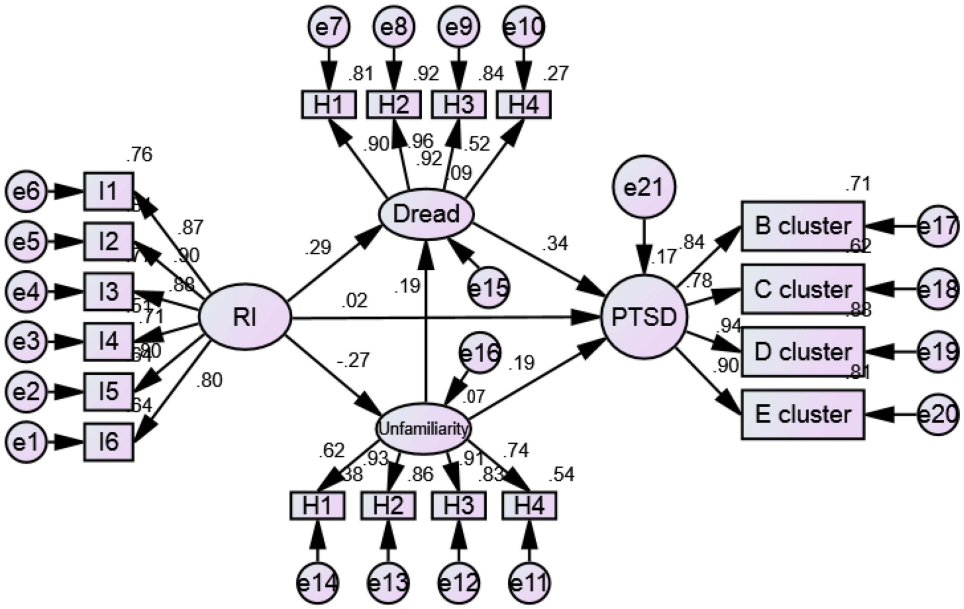

Figure 2 Mediating role of risk perception in two dimensions between risk information and PTSD.
Notes: I1: New confirmed (suspected) cases, cumulative cases; I2: New deaths, cumulative deaths; I3: New/cumulative cured cases; I4: New confirmed cases near the workplace/home; I5: Government measures to hardest-hit areas; I6: Information about nucleic acid testing and vaccinations; H1: Virus: SAR-COV-2; H2: Disease: COVID-19; H3: COVID-19 patient or virus carrier; H4: COVID-19 treatment and prevention; RI: Risk information. Index of model fit: Bollen-Stine bootstrap N = 2000, Bollen-Stine bootstrap $p < 0.001$, adjusted chi-square = 168.383, goodness of fit (GFI) = 0.996, adjusted goodness of fit (AGFI) = 0.994, standardized RMR = 0.0541, and RMSEA=0.084.

PTSD, B = 0.524, 95CI%: 0.432 to 0.631). Hence, the overall effects of RI on PTSD were confounded by these two opposite directions. All other paths showed significant effects.

Table 4 Path Coefficients (Unstandardized) and Confidence Intervals

Relationships	Estimates (unstandardized)	Product of Coefficients		Bootstrapping			
				Bia-Corrected 95% CI		Percentile 95% CI	
		SE	Z	Lower	Upper	Lower	Upper
Total effect							
RI->PTSD	0.078	0.070	1.114	−0.063	0.209	−0.060	0.211
RI->Dread	0.377	0.032	11.781	0.314	0.440	0.314	0.440
Unfamiliarity->PTSD	1.518	0.141	10.766	1.254	1.832	1.242	1.804
Direct effect							
RI->Dread	0.457	0.032	14.281	0.392	0.521	0.395	0.523
RI->Unfamiliarity	−0.241	0.022	−10.955	−0.286	−0.198	−0.286	−0.198
Dread->PTSD	1.146	0.072	15.917	1.007	1.281	1.007	1.282
Unfamiliarity->PTSD	1.135	0.132	8.598	0.877	1.402	0.872	1.397
RI->PTSD	0.083	0.108	0.769	−0.128	0.297	−0.135	0.294
Unfamiliarity->Dread	0.334	0.039	8.564	0.259	0.414	0.257	0.410
Specific indirect effect							
RI->Dread->PTSD	0.524	0.051	10.275	0.432	0.631	0.429	0.629
RI->Unfamiliarity->PTSD	−0.273	0.039	−7.000	−0.362	−0.205	−0.357	−0.201
RI->Unfamiliarity->Dread	−0.08	0.011	−7.273	−0.106	−0.060	−0.104	−0.059
RI->Unfamiliarity->Dread->PTSD	−0.092	0.014	−6.571	−0.123	−0.068	−0.122	−0.066
Unfamiliarity->Dread->PTSD	0.383	0.050	7.660	0.294	0.488	0.289	0.480

Abbreviation: RI, Risk Information.

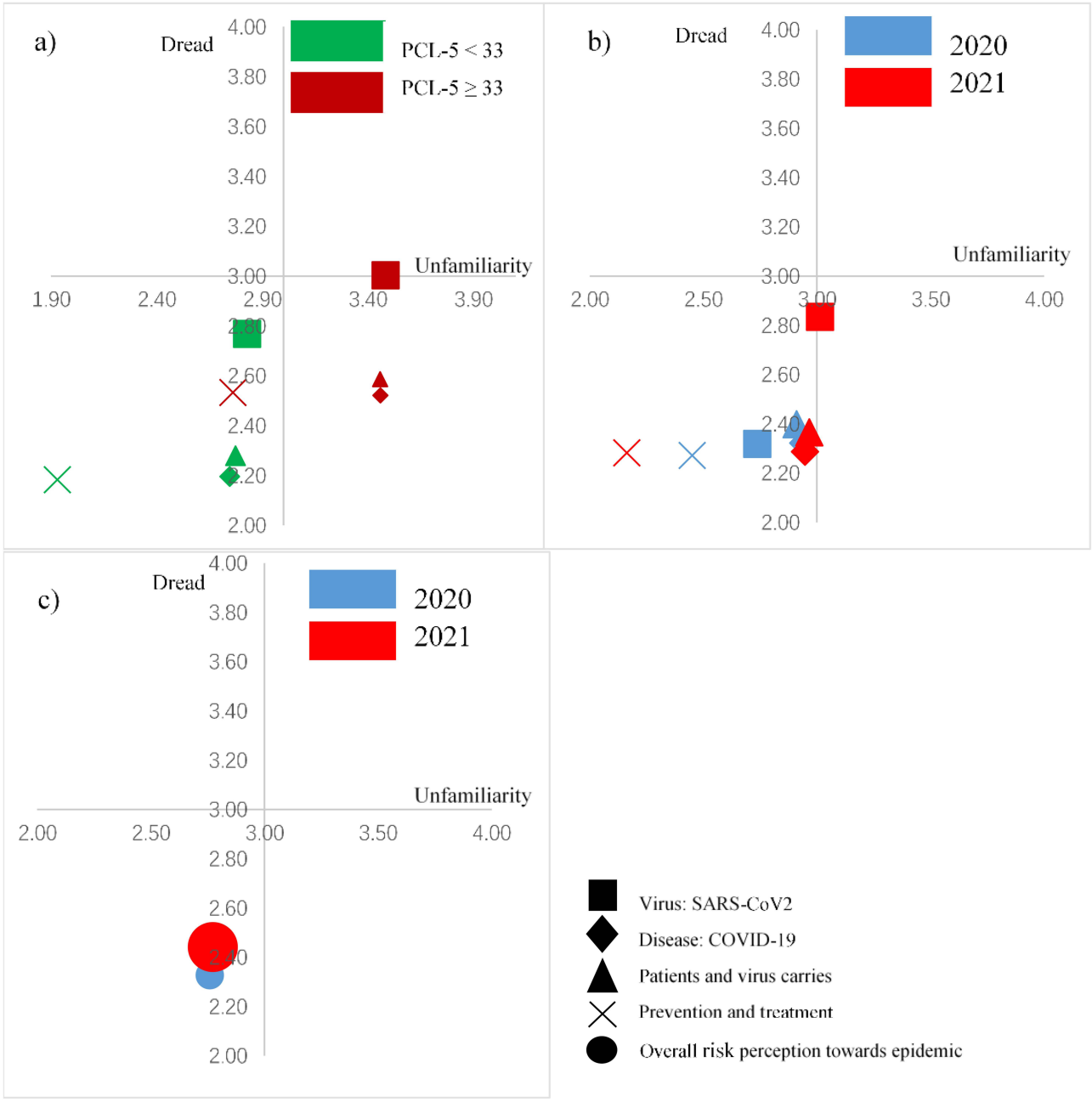

Figure 3 Map of risk perception in different populations divided by PCL-5 (**a**), and comparison of risk perception between 2020 (N = 317) and 2021 (N = 3078) (**b** and **c**).
Notes: Each dimension of the overall risk perception of the epidemic was calculated using the mean value of the four hazards. In 3c, the diameter of the dot reflects the prevalence rate of probable PTSD for that year. Differences in 3a: Virus: SARS-CoV2: Dread: $t = -14.236$, $p < 0.001$; Unfamiliarity: $t = -7.130$, $p < 0.001$. Disease: COVID-19 Dread: $t = -15.738$, $p < 0.001$; Unfamiliarity: $t = -9.516$, $p < 0.001$. Patients and virus carries: Dread: $t = -15.006$, $p = p < 0.001$; Unfamiliarity: $t = -9.028$, $p < 0.001$. Prevention and treatment: Dread: $t = -17.927$, $p < 0.001$; Unfamiliarity: $t = -10.249$, $p < 0.001$. Differences in 3b and 3c: Virus: SARS-CoV2: Dread: $t = -4.327$, $p < 0.001$; Unfamiliarity: $t = -10.580$, $p < 0.001$. Disease: COVID-19 Dread: $t = -0.119$, $p = 0.905$; Unfamiliarity: $t = 0.710$, $p = 0.478$. Patients and virus carries: Dread: $t = -0.866$, $p = 0.387$; Unfamiliarity: $t = 0.635$, $p = 0.525$. Prevention and treatment: Dread: $t = 4.472$, $p < 0.001$; Unfamiliarity: $t = -0.216$, $p = 0.829$. Differences of mean value of dread: $t = -0.222$, $p = 0.824$. Differences of mean value of unfamiliarity: $t = -2.678$, $p = 0.007$. Each dimension of overall risk perception towards the epidemic was calculated using the mean value of four hazards: virus (SARS-CoV2), disease (COVID-19), patients and virus carriers, prevention, and treatment. These four items were investigated in 2020 and 2021.

Difference in Risk Perception Divided by the PCL-5 Score and Comparison of Risk Perception Between 2020 and 2021

A map of the risk perception for the COVID-19 pandemic in different populations divided by PCL-5 is shown in Figure 3a. The distribution of hazards in high PCL-5 score group deviated significantly from that in the low PCL-5 score

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group, with the risk perception of the "virus: SAR-COV-2 Delta variant" being in the "maximum risk" quadrant. The data from our previous research, which was conducted to investigate the risk perception and PTSD in designated hospitals in Guangdong six months after the COVID-19 outbreak in 2020 (N = 317), were used to compare the risk perception of the COVID-19 pandemic between 2020 and 2021.[8] The results are shown in Figure 3b and 3c. The most distinct difference was found in the risk perception of the "virus: SAR-COV-2", which was defined as a Delta variant in 2021 (Dread: $t = -14.236$, $p < 0.001$; Unfamiliarity: $t = -7.130$, $p < 0.001$). Dread regarding the prevention and treatment of COVID-19 was lower in 2021 ($t = 4.472$, $p < 0.001$). Concerning overall risk perception, unfamiliarity was significantly higher in 2021 ($t = -2.678$, $p = 0.007$).

Discussion

After the outbreak of COVID-19 pandemic caused by SARS-COV-2 Delta, this study investigated the PTSD, risk information, and risk perception of COVID-19 in healthcare workers from the emergency department. The sample covered several provinces, including the hardest-hit area of Guangdong. The estimated prevalence of PTSD in this study was 28.2%. The findings of this study lend support to Slovic's two-dimensional theory of risk perception. Risk information influences risk perception via two distinct pathways, ultimately affecting the symptoms of PTSD. As hypothesized, COVID-19 risk information was positively correlated with perceived fear of COVID-19, as quantified by fear levels. Additionally, COVID-19 risk information exhibited an inverse relationship with the perception of unknown risks associated with COVID-19, as measured by unfamiliarity. Correlation analysis and a cognitive map of risk perception revealed that PTSD was associated with risk perception. The hypothesis that the distributions of COVID-19 related hazards differed significantly between 2019 and 2020 was only partly supported. Furthermore, we found that the risk information of COVD-19 had a dual influence on PTSD through the two dimensions of risk perception, and the total effect was suppressed.

The sample in the current study was expanded from our preliminary investigation, and it was found that the prevalence rate of PTSD was higher than it was the year before. One's sex, ethnic group, medical profession, and area of province were identified as factors associated with PTSD severity, consistent with previous surveys on SARS or COVID-19.[8,25,26] Hospital level was also related to PTSD scores, as healthcare workers in higher classes of hospitals could have endured more stress from patients and their families in China.[27] Meanwhile, healthcare personnel in emergency care settings not only face traumatic situations, such as treatment of critical patients or frequently witnessing death and severe trauma, but also regularly face high-pressure scenes, which increase the risk of developing PTSD-related symptoms, including fear of contagion, unpredicted caseloads, limited availability of personal protective equipment, and stigmatization and rejection by neighborhoods.[28,29] During the fight against COVID-19, the workload for emergency department personnel was continuously heavy owing to more responsibility for the control and prevention of the pandemic. Burnout, a possible contributing factor to the increase in the prevalence of PTSD, was common.[30] Although other reports showed that first-line exposure to epidemics had a protective effect, these results should be interpreted cautiously based on the individuality of the sample.[31] Therefore, PTSD remains a non-negligible mental health burden for frontline healthcare workers.

Our study preliminarily demonstrated that the connection between risk information and perception of COVID-19 in frontline healthcare workers was a two-way relationship based on quantitative data. The dual effects could verify our inference that risk information of the pandemic contains basic knowledge of COVID-19 and reduces the unknown risk, but negative information could induce fear to increase the dread risk. The relationship between information and risk perception is complex under the risk communication of COVID-19. With the background of the medical profession, frontline healthcare workers tend to have a more rational perception of COVID-19 than the general public.[32] Effective risk communication with useful hazard information can help people take action to mitigate risks. However, without formal training in risk communication or proper guidance from authoritative organizations or experts, information from pandemics can also lead to emotional responses in this population.[11] The uncertainty and unacceptability of the COVID-19 risk and outrage response can be accelerated by the rapid spread of misinformation.[33]

Our results further confirm the close relationship between risk perception of COVID-19 and PTSD among healthcare workers.[8,14] Consistent with previous findings, the distributions of COVID-19-related hazards were significantly different

in the cognitive map between groups with high and low levels of PTSD severity.[8] Both the development of PTSD and risk perception showed individual differences.[34,35] Those with high levels of PTSD were prone to negative cognitive beliefs (eg, "Now the world is even more dangerous") that also functioned in the process of evaluating the risk of COVID-19 at a high level. However, causality between risk perception and PTSD remains unclear. Our unpublished parallel study with a one-year follow-up sample found that current PTSD severity was positively correlated with PTSD severity the year before, and this relationship was mediated by the current risk perception of COVID-19.[36] Deeper research into this phenomenon requires a large longitudinal program (eg, the National Psychological Trauma Recovery Plan) to comprehensively analyze the variables of personality, cognition, occurrence of trauma, and consistence of PTSD.[37]

The total effects of risk information of COVID-19 on PTSD were not statistically significant. This is because the risk information included in this study was objective and relatively neutral. Meaningful inferences can be drawn from these findings. On one hand, risk information affects PTSD on the "negative path" through increasing the dread risk. Irrational negative information about COVID-19, such as untruthful scandals, rapidly spreading rumors, or overstated fear, would have a greater effect on raising dread than reducing unfamiliarity and worsening the psychological health represented by PTSD in healthcare workers.[38] On the other hand, the "positive path" is achieved through reducing the unknown risk. Rational information about the pandemic is necessary, such as comprehensive interpretations and authoritative advice from experts and official departments; these would have a greater effect on reducing unfamiliarity rather than on inducing fear. For example, expert information is an important source of trust in and acceptance of COVID-19 vaccines.[39] One important way to balance the effect of multiple types of risk information is through the use of social media to ensure appropriate risk communication: the "positive path" should be strengthened and the "negative path" should be weakened.[40]

According to the cognitive map, the overall risk perception of COVID-19 in 2020 (caused by SARS-COV-2 Delta) differed from that of COVID-19 in 2019, based on an investigation into frontline healthcare workers. The difference was mainly presented in the dimension of unfamiliarity and was largely caused by the difference in the risk perception of the virus. The risk perception of SARS-COV-2 Delta significantly deviated from other hazard items both in 2020 and 2021, being extremely close to the "maximum risk" quadrant. In those frontline healthcare workers with high PTSD symptom severity, the risk perception of SARS-COV-2 Delta was even distributed in the "maximum risk" quadrant. Delta VOC were found to yield a shorter incubation period, higher viral load, and longer duration of viral shedding than the wild-type strain.[41,42] The unknown nature of the emerging mutant lineage was a critical factor that increased risk perception of COVID-19. Because the virus had been mutating over time,[43,44] the management of risk information of the virus is important and should be considered a special target for risk-communication strategies.

Our study contributes valuable insights by examining PTSD and risk perception among healthcare workers during the COVID-19 pandemic. First, our study provides a comprehensive analysis of PTSD prevalence and risk perception during the pandemic, focusing on emergency department staff in multiple provinces. Second, by demonstrating the dual impact of risk information on dread and unfamiliarity, our study empirically supports Slovic's two-dimensional theory of risk perception, providing new insights into the complex dynamics of risk communication during public health crises. Third, we identified key demographic and occupational factors associated with PTSD severity, which are consistent with and extend previous studies on SARS and COVID-19.

Limitations

Although this study demonstrates meaningful outcomes, it has several limitations. First, a stratified sampling method was not used. To make our sample representative, we contacted managers of several emergency departments in hospitals to ensure full staff enrollment. However, comparative samples from other departments and the public are lacking. Second, there were no longitudinal data, and the comparison between risk perceptions among samples from 2020 to 2019 had confounding factors. Our unpublished study (accepted by the journal) fills this gap.[36] Third, the risk information for COVID-19 in the current study contained only objective and neutral items. The effects of rational and irrational pandemic information on risk perception and PTSD cannot be accurately examined using quantitative evidence.

Conclusion

One month after the COVID-19 Delta-variant outbreak, the estimated prevalence of PTSD among frontline healthcare workers was relatively high (28%). Risk information for COVID-19 had dual effects on PTSD through the mediation of risk perceptions, risk information about COVID-19 reduces unknown risks, but negative information arouses fear and increases dread risk. One potential strategy to control the effect of COVID-19-related information on the mental health of frontline medical personnel was to strengthen the "positive path" and weaken the "negative path". The unfamiliarity with the SAR-COVID-2 Delta variant caused an increase in the risk perception of COVID-19 in 2020 compared to 2019, suggesting that information about the virus is an important target for the management of risk perception. Effective risk communication regarding COVID-19 can have a positive effect on the mental health of frontline healthcare workers.

Ethics Approval and Consent to Participate

Informed consent was obtained from all participants before their participation in the study. This study was approved by the Ethics Committee of the Southern Medical University.

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Author Contributions

All authors made a significant contribution to the work reported. LW, SG, YZ and RJ contributed to the conception and design of the study, as well as the acquisition and interpretation of data. They also participated in drafting the manuscript and are the co-first authors. HO, SC, ZS, WY, JW, and YJ contributed to the statistical analysis and critically revised the manuscript. XL and WL led the entire study, including its conception, execution, and supervision. They also participated in the critical review of the manuscript and are the co-corresponding authors. All authors gave final approval of the version to be published, agreed on the journal to which the article has been submitted, and agree to be accountable for all aspects of the work.

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References

1. WHO. Update 60 nomenclature variants. 2021. Available from: https://www.who.int/docs/default-source/coronaviruse/risk-comms-updates/update60_nomenclature-variants.pdf?sfvrsn=27fc6fa_4&download=true. Accessed March 17, 2025.
2. Campbell F, Archer B, Laurenson-Schafer H, et al. Increased transmissibility and global spread of SARS-CoV-2 variants of concern as at June 2021. *Euro Surveillance*. 2021;26. doi:10.2807/1560-7917.Es.2021.26.24.2100509
3. Chew NWS, Lee GKH, Tan BYQ, et al. A multinational, multicentre study on the psychological outcomes and associated physical symptoms amongst healthcare workers during COVID-19 outbreak. *Brain Behav Immun*. 2020;88:559–565. doi:10.1016/j.bbi.2020.04.049
4. Zhou Y, Sun Z, Wang Y, et al. The prevalence of PTSS under the influence of public health emergencies in last two decades: a systematic review and meta-analysis. *Clin Psychol Rev*. 2021;83:101938. doi:10.1016/j.cpr.2020.101938
5. Dutheil F, Mondillon L, Navel V. PTSD as the second tsunami of the SARS-Cov-2 pandemic. *Psychol Med*. 2020;1–2. doi:10.1017/S0033291720001336
6. Shalev A, Liberzon I, Marmar C. Post-traumatic stress disorder. *N Engl J Med*. 2017;376(25):2459–2469. doi:10.1056/NEJMra1612499
7. Kang L, Li Y, Hu S, et al. The mental health of medical workers in Wuhan, China dealing with the 2019 novel coronavirus. *Lancet Psychiatry*. 2020;7(3):e14. doi:10.1016/s2215-0366(20)30047-x
8. Geng S, Zhou Y, Zhang W, et al. The influence of risk perception for COVID-19 pandemic on posttraumatic stress disorder in healthcare workers: a survey from four designated hospitals. *Clin Psychol Psychother*. 2021;28(5):1146–1159. doi:10.1002/cpp.2564
9. Rodriguez RM, Montoy JCC, Hoth KF, et al. Symptoms of anxiety, burnout, and PTSD and the mitigation effect of serologic testing in emergency department personnel during the COVID-19 pandemic. *Ann Emerg Med*. 2021;78(1):35–43e32. doi:10.1016/j.annemergmed.2021.01.028

10. Yin Q, Sun Z, Liu T, et al. Posttraumatic stress symptoms of health care workers during the Corona virus disease 2019. *Clin Psychol Psychother*. 2020;27(3):384–395. doi:10.1002/cpp.2477
11. Slovic P. Slovic P.Perception of risk. *Science*. 1987;236(4799):280–285. doi:10.1126/science.3563507
12. Shi K, Fan H, Jia J, et al. The risk perceptions of SARS and scio-psychological behaviors of urban people in China. *Acta Psychologica Sinica*. 2003;35:546–554.
13. Wu P, Fang Y, Guan Z, et al. The psychological impact of the SARS epidemic on hospital employees in China: exposure, risk perception, and altruistic acceptance of risk. *Revue Canadienne de Psychiatrie [Canadian Journal of Psychiatry]*. 2009;54:302–311. doi:10.1177/070674370905400504
14. Yin Q, Chen A, Song X, et al. Risk perception and PTSD symptoms of medical staff combating against COVID-19: a PLS structural equation model. *Front Psychiatry*. 2021;12:607612. doi:10.3389/fpsyt.2021.607612
15. Covello VT, Merkhofer MW. *Risk Assessment Methods*. Springer; 1993.
16. Powell D. *An Introduction to Risk Communication and the Perception of Risk*. University of Guelph; 1996.
17. Smith RD. Responding to global infectious disease outbreaks: lessons from SARS on the role of risk perception, communication and management. *Soc Sci Med*. 2006;63(12):3113–3123. doi:10.1016/j.socscimed.2006.08.004
18. Abrams EM, Greenhawt M. Risk communication during COVID-19. *J Allergy Clin Immunol Pract*. 2020;8(6):1791–1794. doi:10.1016/j.jaip.2020.04.012
19. Jalloh MF, Li W, Bunnell RE, et al. Impact of Ebola experiences and risk perceptions on mental health in Sierra Leone, July 2015. *BMJ Global Health*. 2018;3(2):e000471. doi:10.1136/bmjgh-2017-000471
20. 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):249–254. doi:10.34172/aim.2020.06
21. Blevins CA, Weathers FW, Davis MT, et al. The posttraumatic stress disorder checklist for DSM-5 (PCL-5): development and initial psychometric evaluation. *J Trauma Stress*. 2015;28(6):489–498. doi:10.1002/jts.22059
22. Wang L, Zhang L, Armour C, et al. Assessing the underlying dimensionality of DSM-5 PTSD symptoms in Chinese adolescents surviving the 2008 Wenchuan earthquake. *J Anxiety Disord*. 2015;31:90–97. doi:10.1016/j.janxdis.2015.02.006
23. Enders CK. Applying the Bollen-Stine bootstrap for goodness-of-fit measures to structural equation models with missing data. *Multivariate Behav Res*. 2002;37(3):359–377. doi:10.1207/S15327906MBR3703_3
24. Hayes AF. Beyond Baron and Kenny: statistical mediation analysis in the new millennium. *Commun Monogr*. 2009;76(4):408–420. doi:10.1080/03637750903310360
25. Liu N, Zhang F, Wei C, et al. Prevalence and predictors of PTSS during COVID-19 outbreak in China hardest-hit areas: gender differences matter. *Psychiatry Res*. 2020;287:112921. doi:10.1016/j.psychres.2020.112921
26. Maunder RG, Lancee WJ, Rourke S, et al. Factors associated with the psychological impact of severe acute respiratory syndrome on nurses and other hospital workers in Toronto. *Psychosom Med*. 2004;66(6):938–942. doi:10.1097/01.psy.0000145673.84698.18
27. Xu Y, Chen G, Han X, et al. Overwork death of Chinese physicians under high-intensity pressure, 2007-2018. *Iran J Public Health*. 2020;49:2251–2255. doi:10.18502/ijph.v49i12.4804
28. Carmassi C, Foghi C, Dell'Oste V, et al. PTSD symptoms in healthcare workers facing the three coronavirus outbreaks: what can we expect after the COVID-19 pandemic. *Psychiatry Res*. 2020;292:113312. doi:10.1016/j.psychres.2020.113312
29. Rodriguez RM, Medak AJ, Baumann BM, et al. Academic emergency medicine physicians' anxiety levels, stressors, and potential stress mitigation measures during the acceleration phase of the COVID-19 pandemic. *Acad Emerg Med*. 2020;27(8):700–707. doi:10.1111/acem.14065
30. Raudenská J, Steinerová V, Javůrková A, et al. Occupational burnout syndrome and post-traumatic stress among healthcare professionals during the novel coronavirus disease 2019 (COVID-19) pandemic. *Best Pract Res Clin Anaesthesiol*. 2020;34(3):553–560. doi:10.1016/j.bpa.2020.07.008
31. Li Z, Ge J, Yang M, et al. Vicarious traumatization in the general public, members, and non-members of medical teams aiding in COVID-19 control. *Brain Behav Immun*. 2020;88:916–919. doi:10.1016/j.bbi.2020.03.007
32. Fischhoff B. The realities of risk-cost-benefit analysis. *Science*. 2015;350(6260):aaa6516. doi:10.1126/science.aaa6516
33. Malecki K, Keating JA, Safdar N. Crisis communication and public perception of COVID-19 risk in the era of social media. *Clin Infect Dis*. 2020. doi:10.1093/cid/ciaa758
34. Holmes A, Singewald N. Individual differences in recovery from traumatic fear. *Trends Neurosci*. 2013;36(1):23–31. doi:10.1016/j.tins.2012.11.003
35. Barnett J, Breakwell GM. Risk perception and experience: hazard personality profiles and individual differences. *Risk Anal*. 2001;21(1):171–177. doi:10.1111/0272-4332.211099
36. Ouyang H, Geng S, Zhou Y, et al. The increase of PTSD in front-line health care workers during the COVID-19 pandemic and the mediating role of risk perception: a one-year follow-up study. *Transl Psychiatry*. 2022;12(1):180. doi:10.1038/s41398-022-01953-7
37. Zhou Y-G, Shang Z-L, Zhang F, et al. PTSD: past, present and future implications for China. *Chin J Traumatol*. 2021;24(4):187–208. doi:10.1016/j.cjtee.2021.04.011
38. Tasnim S, Hossain MM, Mazumder H. Impact of rumors and misinformation on COVID-19 in social media. *Yebang Uihakhoe Chi [Journal of Preventive Medicine and Public Health]*. 2020;53(3):171–174. doi:10.3961/jpmph.20.094
39. Rzymski P, Zeyland J, Poniedziałek B, et al. The perception and attitudes toward COVID-19 vaccines: a cross-sectional study in Poland. *Vaccines*. 2021;9(4):382. doi:10.3390/vaccines9040382
40. Chipidza W, Akbaripourdibazar E, Gwanzura T, et al. Topic analysis of traditional and social media news coverage of the early COVID-19 pandemic and implications for public health communication. *Disaster Med Public Health Prep*. 2021:1–8. doi:10.1017/dmp.2021.65
41. Wang Y, Chen R, Hu F, et al. Transmission, viral kinetics and clinical characteristics of the emergent SARS-CoV-2 Delta VOC in Guangzhou, China. *EClinicalMedicine*. 2021;40:101129. doi:10.1016/j.eclinm.2021.101129
42. Zhang M, Xiao J, Deng A, et al. Transmission dynamics of an outbreak of the COVID-19 Delta variant B.1.617.2 - Guangdong Province, China, May-June 2021. *China CDC Wkly*. 2021;3(27):584–586. doi:10.46234/ccdcw2021.148
43. Karim SSA, Karim QA. Omicron SARS-CoV-2 variant: a new chapter in the COVID-19 pandemic. *Lancet*. 2021;398(10317):2126–2128. doi:10.1016/s0140-6736(21)02758-6
44. Tao K, Tzou PL, Nouhin J, et al. The biological and clinical significance of emerging SARS-CoV-2 variants. *Nat Rev Genet*. 2021;22(12):757–773. doi:10.1038/s41576-021-00408-x