The Roles of Risk Perception, Negative Emotions and Perceived Efficacy in the Association Between COVID-19 Infection Cues and Preventive Behaviors: A Moderated Mediation Model

Guangteng Meng, Xiaoyan Yuan, Ya Zheng, Kesong Hu, Qi Li, Bibing Dai, Xun Liu

Submitted to: JMIR Public Health and Surveillance
on: August 15, 2021

Table of Contents

The Roles of Risk Perception, Negative Emotions and Perceived Efficacy in the Association Between COVID-19 Infection Cues and Preventive Behaviors: A Moderated Mediation Model

Guangteng Meng[1, 2] BSc; Xiaoyan Yuan[3] MSc; Ya Zheng[4] PhD; Kesong Hu[5] PhD; Qi Li[6] PhD; Bibing Dai[7] PhD; Xun Liu[1, 2] PhD

[1]CAS Key Laboratory of Behavioral Science Institute of Psychology Chinese Academy of Sciences Beijing CN
[2]Department of Psychology University of Chinese Academy of Sciences Beijing CN
[3]Big Data Group Smart Platform R&D Department Tianjin Meiteng Technology Co., Ltd Tianjin CN
[4]Department of Psychology Dalian Medical University Dalian CN
[5]Department of Psychology Lake Superior State University Sault St. Marie US
[6]Beijing Key Laboratory of Learning and Cognition School of Psychology Capital Normal University Beijing CN
[7]Department of Psychiatry and Psychology School of Basic Medical Sciences Tianjin Medical University Tianjin CN

Corresponding Author:
Guangteng Meng BSc
CAS Key Laboratory of Behavioral Science
Institute of Psychology
Chinese Academy of Sciences
Lincui Road 16
Chaoyang District
Beijing
CN

Abstract

Background: The coronavirus disease 2019 (COVID-19) pandemic has disrupted the lives of everyone worldwide. Preventive behaviors are especially critical to the protection of individuals whose family members or acquaintances have been infected. However, limited research has explored the influence of infection cues on preventive behaviors.

Objective: This study proposed the information-perception/emotion-action model (IPEAM) to elucidate the mechanism by which infection cues influence preventive behaviors and the roles of risk perception, negative emotions, and perceived efficacy in that influence.

Methods: A cross-sectional online survey was conducted in 34 provinces in China during the first wave of the COVID-19 pandemic. A moderated mediation analysis was conducted to examine whether risk perception and negative emotions mediated and perceived efficacy moderated the relationship between infection cues and preventive behaviors.

Results: A total of 26511 participants responded to the survey and 20205 valid responses (76.2%) were obtained for further analysis. The moderated mediation results show that infection cues positively predicted preventive behaviors in a manner mediated by risk perception (Bindirect=0.135, 95% CI 0.118 to 0.153) and negative emotions (Bindirect=0.140, 95% CI 0.122 to 0.159). Moreover, perceived efficacy moderated the influence of infection cues not only on preventive behaviors (B=0.013, P=.01) but also on risk perception (B=0.130, P<.001) and negative emotions (B=0.232, P<.001). The higher the perceived efficacy, the stronger these influences were.

Conclusions: These findings validated our IPEAM, which elucidates the mechanisms underlying the promoting effect of infection cues on preventive behaviors during the initial stage of the COVID-19 pandemic. This study suggests that governments should establish early warning and support systems based on the dynamic surveillance of infection cues.

(JMIR Preprints 15/08/2021:32930)
DOI: https://doi.org/10.2196/preprints.32930

Preprint Settings

1) Would you like to publish your submitted manuscript as preprint?

Please make my preprint PDF available to anyone at any time (recommended).

✓ **Please make my preprint PDF available only to logged-in users; I understand that my title and abstract will remain visible to all u**

Only make the preprint title and abstract visible.

No, I do not wish to publish my submitted manuscript as a preprint.

2) If accepted for publication in a JMIR journal, would you like the PDF to be visible to the public?

✓ **Yes, please make my accepted manuscript PDF available to anyone at any time (Recommended).**

Yes, but please make my accepted manuscript PDF available only to logged-in users; I understand that the title and abstract will remain v

Yes, but only make the title and abstract visible (see Important note, above). I understand that if I later pay to participate in <a href="http

Original Manuscript

Original Paper

Guangteng Meng[1,2], PhD candidate; Xiaoyan Yuan[3], MSc; Ya Zheng[4], PhD; Kesong Hu[5], PhD; Qi Li[6*], PhD; Bibing Dai[7*], PhD; Xun Liu[1,2], PhD.

[1]CAS Key Laboratory of Behavioral Science, Institute of Psychology, Chinese Academy of Sciences, Beijing 100101, China
[2]Department of Psychology, University of Chinese Academy of Sciences, Beijing 100049, China
[3]Big Data Group, Smart Platform R&D Department, Tianjin Meiteng Technology Co., Ltd, Tianjin 300381, China
[4]Department of Psychology, Dalian Medical University, Dalian 116044, China
[5]Department of Psychology, Lake Superior State University, Sault St. Marie, MI, USA
[6]Beijing Key Laboratory of Learning and Cognition, School of Psychology, Capital Normal University, Beijing 100048, China
[7]Department of Psychiatry and Psychology, School of Basic Medical Sciences, Tianjin Medical University, Tianjin 300070, China

Corresponding Author:
Qi Li, PhD
Beijing Key Laboratory of Learning and Cognition, School of Psychology, Capital Normal University
105 West North Ring Road, North Street Haidian District, Beijing, 100048, China
Phone: +86 15801360869
Email: 6893@cnu.edu.cn

Bibing Dai, PhD
Department of Psychiatry and Psychology, School of Basic Medical Sciences, Tianjin Medical University
22 Qixiangtai Road, Heping District, Tianjin, 300070, China
Phone: +86 18722051910
Email: daibibing@tmu.edu.cn

The Roles of Risk Perception, Negative Emotions and Perceived Efficacy in the Association Between COVID-19 Infection Cues and Preventive Behaviors: A Moderated Mediation Model

Abstract

Background: The coronavirus disease 2019 (COVID-19) pandemic has disrupted the lives of everyone worldwide. Preventive behaviors are especially critical to the protection of individuals whose family members or acquaintances have been infected. However, limited research has explored the influence of infection cues on preventive behaviors.
Objective: This study proposed the information-perception/emotion-action model (IPEAM) to elucidate the mechanism by which infection cues influence preventive behaviors and the roles of risk perception, negative emotions, and perceived efficacy in that influence.
Methods: A cross-sectional online survey was conducted in 34 provinces in China during the first wave of the COVID-19 pandemic. A moderated mediation analysis was conducted to examine whether risk perception and negative emotions mediated and perceived efficacy moderated the relationship between infection cues and preventive behaviors.
Results: A total of 26511 participants responded to the survey and 20205 valid responses (76.2%) were obtained for further analysis. The moderated mediation results show that infection cues positively predicted preventive behaviors in a manner mediated by risk perception ($B_{indirect}$=0.135, 95% CI 0.118 to 0.153) and negative emotions ($B_{indirect}$=0.140, 95% CI 0.122 to 0.159). Moreover, perceived efficacy moderated the influence of infection cues not only on preventive behaviors (B=0.013, P=.01) but also on risk perception (B=0.130, P<.001) and negative emotions (B=0.232, P<.001). The higher the perceived efficacy, the stronger these influences were.
Conclusions: These findings validated our IPEAM, which elucidates the mechanisms underlying the promoting effect of infection cues on preventive behaviors during the initial stage of the COVID-19 pandemic. This study suggests that governments should establish early warning and support systems based on the dynamic surveillance of infection cues.

Keywords: COVID-19; infection cues; preventive behaviors; risk perception; negative emotions; perceived efficacy; China

Introduction

The coronavirus disease 2019 (COVID-19) pandemic has disrupted the lives of everyone worldwide [1, 2]. This public health emergency of international concern has resulted in illness and death in millions of people, and the numbers of cases and deaths are still rapidly increasing [3]. Local health authorities usually issue warning messages about cases of infection, and such warning messages are regarded as one of the most used approaches to promoting the adoption of preventive behaviors during a pandemic [4–6]. Therefore, it is necessary to investigate whether and how infection cues promote the adoption of preventive behaviors during the COVID-19 pandemic.

To illustrate the mechanism by which warning messages influence behavioral reactions, the protective action decision model (PADM) was proposed to explain people's actions in response to natural hazards and disasters [5]. The PADM suggests that warning messages can elicit perceptual and emotional responses to threats, resulting in behavioral responses, and these processes depend on receiver characteristics, such as their beliefs. The PADM has been applied to various environmental hazards, including floods [7], hurricanes [8], and wildfires [9]. However, warning messages during

pandemics have received much less attention. Unlike natural disasters, pandemics involve contagious diseases and can usually be persistent, in which infection cues would play an important but obscure role. Therefore, a specialized model for infection cues under the context of the COVID-19 pandemic is still needed.

Based on this model, we herein propose the information-perception/emotion-action model (IPEAM) to enhance the practical application of these theories in the specific context of the COVID-19 pandemic. This model elucidates the mechanism by which infection cues influence preventive behaviors. In this model, infection cues (I) were regarded as a kind of warning message that can directly make people aware of the infections of their relatives and friends. An individual's risk perception of infection and negative emotions (P/E) is defined by their core cognitive and emotional reactions to the COVID-19 pandemic. Preventive behaviors related to the COVID-19 pandemic are considered behavioral reactions (A). Moreover, in this model, perceived efficacy, which is an important personal characteristic, plays a significant moderating role in the relationship between warning messages and an individual's psychological reactions, such as alertness to infection cues and motivation to adopt protective behaviors.

COVID-19 Infection Cues and Preventive Behaviors

Infection cues (I) are the confirmed cases of COVID-19 among family members, friends, or acquaintances. Given that most disease transmission occurs among family members, friends, colleagues, and neighbors, which has been observed for various pandemics [10–13], the presence of infection cues indicates an increased likelihood of infection [14]. Preventive behaviors involve actions to avoid infection during an influenza pandemic, such as hygiene behaviors, mask wearing, and uptake of vaccinations [15]. Empirical research has suggested that infection cues promote the adoption of preventive behaviors. Rudisill [16] found that during the H1N1 epidemic in Great Britain, people who had friends who contracted H1N1 influenza engaged in more avoidance behaviors. Similarly, having family members or friends diagnosed with Ebola was also positively associated with the adoption of preventive behaviors, such as practicing frequent hand washing and avoiding mass gatherings [17]. Recently, people whose immediate family members, close friends, or relatives tested positive for COVID-19 were found to more frequently wear a facemask in public and clean the surfaces they touched [18]. Based on this evidence, we hypothesized that COVID-19-related infection cues serve as the core warning messages in the IPEAM and are positively associated with the adoption of preventive behaviors.

Risk Perception as a Mediator

Risk perception involves how people subjectively assess the probability of a specific accident and how much they are concerned about the corresponding consequence [19]. As the IPEAM suggests, the risk perception due to the presence of warning messages can encourage individuals to adopt preventive behaviors. First, people who receive infection cues are likely to perceive themselves as being at greater risk because they share both environmental and social surroundings with infected family members or acquaintances [12, 17]. Second, people with higher levels of risk perception are more likely to comply with specific public health recommendations [20]. Previous studies have found a close relationship between risk perception and the adoption of preventive behaviors in various health-related contexts [21–23]. Previous studies on pandemics have shown that the perception of greater risk leads to the adoption of more preventive behaviors [24, 25]. A recent study demonstrated that risk perception during the COVID-19 pandemic, which involves both susceptibility and severity, could predict the adoption of preventive behaviors [26]. Furthermore, a survey study conducted in ten countries found that risk perception is significantly correlated with not only discussions about the disease held with family members and friends but also the preventive

actions taken by those family members and friends [27]. Therefore, we hypothesized that risk perception could mediate the relationship between COVID-19-related infection cues and the adoption of preventive behaviors.

Negative Emotions as a Mediator

Similarly, COVID-19-related infection cues may also promote the adoption of preventive behaviors by increasing the strength of emotional reactions, particularly those involving negative emotions. Converging evidence has shown that people who receive infection cues experience more negative emotions, such as anxiety, depression, and fear. During the COVID-19 pandemic, people with infected family members have been found to have higher levels of anxiety [28]. Another study also showed that people whose friends or relatives were diagnosed with COVID-19 had higher depression and anxiety scores [29]. In addition, negative emotions have been shown to contribute to health-related behavioral changes during pandemics [30]. Previous study has found that people with a moderate level of anxiety were most likely to adopt more precautionary measures [24]. Recently, increased anxiety and depression symptoms have also been found to cooccur with various behavioral changes, such as decreased physical activity [31]. In addition to anxiety and depression, fear induced by the pandemic can also motivate individuals to adopt protective measures, including social distancing and frequent hand washing [32]. Furthermore, people who were worried about their family members reported more frequent hand washing and more frequent disinfection of their living quarters [33], which together suggested a potential mediating role of negative emotions. Hence, we hypothesized that negative emotions could also mediate the relationship between COVID-19-related infection cues and the adoption of preventive behaviors.

Perceived Efficacy as a Moderator

In the IPEAM, perceived efficacy may play a moderating role in the relationship between infection cues and the adoption of preventive behaviors. Perceived efficacy is an individual's belief in their ability to cope with specific risks [34, 35] and consists of self-efficacy and response efficacy [36]. First, perceived efficacy could influence how people process the warning messages they receive, which may trigger the perception that they are at greater risk. A previous study found that the effect of increased social media exposure on risk perception was pronounced among individuals with a higher level of self-efficacy [37]. People with low self-efficacy tend to adopt negative emotion-focused coping strategies to reduce their negative emotions rather than to actively take actions to solve problems [38]. In contrast, people with high levels of perceived efficacy are more likely to believe that they should take actions themselves to alleviate risk. A meta-analysis also confirmed that perceived efficacy could enhance the positive impact of risk appraisal on the adoption of preventive behaviors [39]. Therefore, while confronting infection cues, people who have higher levels of perceived efficacy may be more likely to engage in preventive behaviors.

Current Study

Building upon previous theories and findings, this study is among the first to investigate the mechanism underlying the association between infection cues and the adoption of preventive behaviors and the important roles of risk perception, negative emotions, and perceived efficacy in that relationship at the peak of the COVID-19 pandemic in China. The following major research hypotheses were addressed (Figure 1): (H1) infection cues, such as having family members, friends, and acquaintances contract COVID-19, can promote stricter adherence to preventive behaviors; (H2) infection cues can increase people's perceived level of risk and negative emotions and thereby increase their tendency to adopt preventive behaviors; and (H3) perceived efficacy can moderate the direct relationship between infection cues and the adoption of preventive behaviors and the moderating effects of risk perception and negative emotions. Specifically, the direct and moderated

relationships between infection cues and the adoption of preventive behaviors is stronger among individuals with high levels of perceived efficacy than among those with low levels of perceived efficacy.

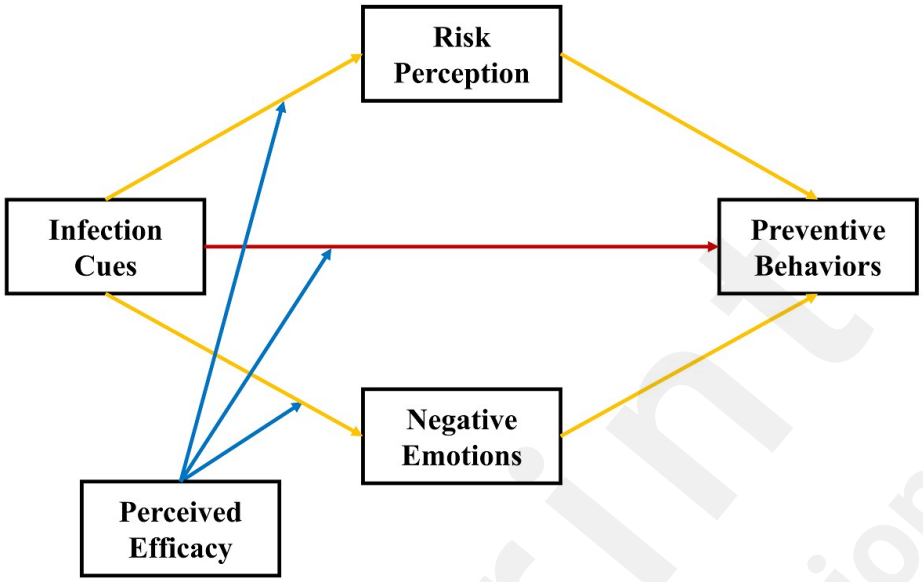

Figure 1. The hypothesized model.
Note: H1 is in red, H2 is in yellow, and H3 is in blue.

Methods

Participants and Procedures

The present study was approved by the Ethics Committee of the Institute of Psychology of the Chinese Academy of Sciences. Data collection was conducted from February 4 to 6, 2020. During this period, the total number of confirmed cases of COVID-19 exceeded 20,000 in China. A national cross-sectional web-based survey was conducted involving a nonprobability (convenience) sample of the Chinese population with the Tencent online platform [40]. We provided a quick response code that participants could use to access the electronic version of the survey, which they could then complete, submit, and share [41, 42]. Therefore, the data were collected by snowball sampling through repeated one-to-many sharing on social media. After the participants read and signed the informed consent form, we asked them to respond to 11 items regarding infection cues, risk perception, negative emotions, perceived efficacy, and preventive behaviors. In the present study, these items were chosen to reflect these variables in the context of the COVID-19 pandemic, and most of them had good or acceptable reliability. To ensure the quality of the data from the respondents, we excluded 6306 of the 26511 surveys based on two criteria. First, 4765 surveys from individuals who completed the full survey in less than 1 minute were excluded because answering too quickly may be the result of failing to read the questions carefully [43]. Second, questions for which the participants were required to choose a certain option were also included. In total, 1,541 surveys were excluded due to incorrect answers to these questions, which indicated that those respondents did not read the questionnaire items carefully. After these exclusions, 20205 (76.21%) surveys remained for inclusion in the present analyses. Table 1 summarizes the sample.

Table 1. Demographic characteristics of the sample (N=20205), n (%).

Characteristic	With infection cues (n=5527)	Without infection cues (n=14678)	Total (N=20205)
Age (years)			

12–17	1593 (28.8)	2161 (14.7)	3754 (18.6)
18–25	1868 (33.8)	5283 (36.0)	7151 (35.4)
26–35	1483 (26.8)	4545 (30.9)	6028 (29.8)
36–45	415 (7.5)	1967 (13.4)	2382 (11.8)
46–61	168 (3.0)	722 (4.9)	890 (4.4)
Gender			
Female	1722 (31.2)	6198 (42.2)	7920 (39.2)
Male	3805 (68.8)	8480 (57.8)	12285 (60.8)
Education			
High school or lower	2114 (38.2)	6247 (42.6)	8361 (41.4)
College/technical school	1414 (25.6)	3246 (22.1)	4660 (23.1)
University undergraduate degree	1732 (31.3)	4643 (31.6)	6375 (31.6)
Master’s degree or higher	267 (4.8)	542 (3.7)	809 (4.0)
Occupation			
Student	1524 (27.6)	4994 (34.0)	6518 (32.3)
Enterprise employee	1802 (32.6)	4331 (29.5)	6133 (30.4)
Self-employed	530 (9.6)	1735 (11.8)	2265 (11.2)
Factory/agricultural worker	484 (8.8)	1625 (11.1)	2109 (10.4)
Civil servant	620 (11.2)	688 (4.7)	1308 (6.5)
Professional	341 (6.2)	676 (4.6)	1017 (5.0)
Others	226 (4.1)	629 (4.3)	855 (4.2)
Region of China			
East China (e.g., Shandong)	1176 (21.3)	4113 (28.0)	5285 (26.2)
North China (e.g., Beijing)	1750 (31.7)	3963 (27.0)	5713 (28.3)
Central China (e.g., Hubei)	529 (9.6)	1608 (11.0)	2137 (10.6)
South China (e.g., Guangdong)	305 (5.5)	1907 (13.0)	2212 (10.9)
Northeast China (e.g., Liaoning)	1574 (28.5)	2070 (14.1)	3644 (18.0)
Northwest China (e.g., Xinjiang)	80 (1.4)	402 (2.7)	482 (2.4)
Southwest China (e.g., Chongqing)	113 (2.0)	615 (4.2)	728 (3.6)

Measures

COVID-19 Infection Cues

COVID-19 infection cues were assessed with the following question, to which the respondents were asked to provide a yes or no answer: “Has someone among your family members, friends, and acquaintances been diagnosed with COVID-19 by a local hospital or the health department?”

Risk Perception

Risk perception was measured with two questions: “In your opinion, how contagious is COVID-19?” and “In your opinion, how likely are you to contract COVID-19?” For these two items, the respondents were asked to evaluate the degree of risk they perceived to be associated with COVID-19, ranging from 1=very low to 7=very high. The overall risk perception score was determined by summing the scores for these two questions, with higher scores indicating greater risk perception. The Cronbach α was .59 in the present study.

Negative Emotions

Negative emotions were assessed with three questions: “In the last 10 days, what intensity of anxiety have you experienced?”; “In the last 10 days, what intensity of depression have you experienced?”;

and “In the last 10 days, what intensity of fear have you experienced?” For these three items, the respondents were asked to rate the intensity of their negative emotions from 1=very low to 7=very high. The total score for negative emotions was the sum of the scores for the three questions. Higher scores indicated a higher level of negative emotions. The Cronbach α was .89 in the present study.

Perceived Efficacy

Perceived efficacy was assessed with four items taken from a well-established perceived efficacy scale [44]: “I believe the pandemic will be fully controlled in the foreseeable future”; “I am confident that the pandemic will be overcome”; “To cope with the pandemic, I can discriminate between true information and rumors about COVID-19”; and “To combat the pandemic, I do not post or forward any messages about COVID-19 that have not been officially confirmed.” For these four items, the respondents were asked to rate their perceived efficacy from 1=strongly disagree to 7=strongly agree. The total score was equal to the sum of the scores for these four items, and higher scores indicated a higher level of perceived efficacy. The Cronbach α was .79 in the present study.

Preventive Behaviors

Preventive behaviors were assessed with one item: “I have adopted or will adopt COVID-19 preventive measures (e.g., wearing masks, washing hands, keeping social distancing, taking vaccinations, and so on) as soon as they are available.” The respondents were asked to evaluate the extent to which they would adopt these preventive behaviors from 1=strongly disagree to 7=strongly agree.

Statistical Analyses

Statistical analyses were conducted using SPSS, version 26.0 (IBM Corp). Descriptive analyses were carried out using the mean (SD) for quantitative variables and frequency (%) for qualitative variables. In this study, we first conducted bivariate correlation analyses of these variables to examine the general relationships among infection cues, risk perception, negative emotions, perceived efficacy, and preventive behaviors. Then, we used the PROCESS macro (Model 8) to test our moderated mediation model, as suggested by Hayes [45]. The PROCESS macro for SPSS is an observed variable ordinary least squares and logistic regression path analysis modeling tool that can provide estimates of model coefficients and assessments of the direct and/or indirect effects of variables in the model. In addition, the PROCESS models also use a bootstrapping procedure (a total of 5000 resamples in the present study) to generate a robust standard error for the parameter estimation and the bias-corrected 95% CIs associated with the significance of indirect effects, regardless of the normality of the sample distribution. Specifically, PROCESS Model 8 included three models [46], in which risk perception, negative emotions, and preventive behaviors were the dependent variables. This model addressed the effect of the interaction between infection cues and perceived efficacy on risk perception (the first aspect of mediation), the effect of the interaction between infection cues and perceived efficacy on negative emotions (the second aspect of mediation), and the effect of the interaction between infection cues and perceived efficacy on the adoption of preventive behaviors (the residual direct relationship). Interaction effects and conditional indirect and direct effects can be identified when the confidence intervals do not contain zero. In these analyses, we controlled for relevant sociodemographic covariates (i.e., gender, age, and education) by entering them as predictor variables into regression equations. Thus, these covariates were not underlying factors explaining the direct and indirect associations of infection cues with the adoption of preventive behaviors.

Results

Preliminary Analyses

The descriptive statistics and correlation matrices are presented in Table 2. Infection cues, preventive behaviors, risk perception, and negative emotions were positively correlated with each other. Perceived efficacy was positively correlated with preventive behaviors and risk perception and negatively correlated with infection cues and negative emotions.

Table 1. Descriptive statistics and correlations among variables (N=20205).

Variables	Mean (SD)	1	2	3	4	5	6	7	8
1 Gender[a]	N/A[d]								
r		1							
P value		N/A							
2 Age	26.09 (9.67)								
r		-.231	1						
P value		<.001	N/A						
3 Education[b]	N/A								
r		-.047	.159	1					
P value		<.001	<.001	N/A					
4 Infection cues[c]	N/A								
r		.101	-.151	.030	1				
P value		<.001	<.001	<.001	N/A				
5 Preventive behaviors	5.08 (1.73)								
r		-.017	.060	.049	.047	1			
P value		.02	<.001	<.001	<.001	N/A			
6 Risk perception	7.67 (3.23)								
r		-.012	-.023	.046	.269	.205	1		
P value		.10	.001	<.001	<.001	<.001	N/A		
7 Negative emotions	11.48 (5.32)								
r		-.026	.016	.053	.264	.186	.459	1	
P value		<.001	.02	<.001	<.001	<.001	<.001	N/A	
8 Perceived efficacy	22.88 (4.57)								
r		-.073	.162	.047	-.136	.396	.042	-.015	
P value		<.001	<.001	<.001	<.001	<.001	<.001	.04	N/A

[a]Gender:0=female, 1=male.
[b]Education: 1=High school or lower, 2=College/technical school, 3=University undergraduate degree, 4=Master's degree or higher.
[c]Infection cues: 0=no, 1=yes.
[d]N/A: not applicable.

Moderated Mediation

The main results generated by the SPSS PROCESS macro are presented in Table 3; the results consisted of five parts: Model 1, Model 2, Model 3, the conditional direct effect analysis, and the conditional indirect effect analysis. Model 1 tested the effects of infection cues and perceived efficacy on risk perception. Model 2 examined the effects of infection cues and perceived efficacy on negative emotions. Model 3 investigated the effects of infection cues, risk perception, negative

emotions, and perceived efficacy on preventive behaviors. Model 1 ($F_{6,20198}$=325.277, R^2=0.088, *P*<.001), Model 2 ($F_{6,20198}$=906.005, R^2=0.239, *P*<.001), and Model 3 ($F_{8,20196}$=662.574, R^2=0.208, *P*<.001) showed that infection cues positively predicted the adoption of preventive behaviors (B=0.141, β=.036, *P*<.001) after controlling for gender, age, and education, which supported H1 (Figure 2). In addition, infection cues positively predicted risk perception (B=2.116, β=.292, *P*<.001), and risk perception positively predicted the adoption of preventive behaviors (B=0.064, β=.119, *P*<.001). Infection cues positively predicted negative emotions (B=3.430, β=.287, *P*<.001), and negative emotions positively predicted the adoption of preventive behaviors (B=0.041, β=.126, *P*<.001), supporting H2.

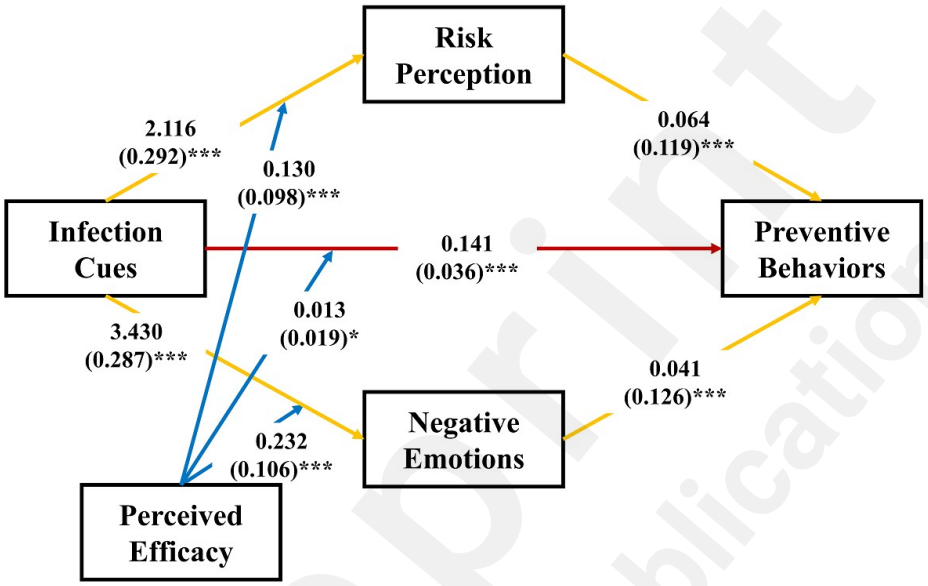

Figure 2. The moderated mediation model.

Note: The values shown are the unstandardized (standardized) coefficients. *P<.05. **P<.01. ***P<.001.

The interaction between infection cues and perceived efficacy had a significant effect on the adoption of preventive behaviors (B=0.013, β=.019, *P*=.01). Meanwhile, the interaction between infection cues and perceived efficacy had significant effects on risk perception (B=0.130, β=.098, *P*<.001) and negative emotions (B=0.232, β=.036, *P*<.001), supporting H3. Furthermore, as shown by the results regarding the conditional direct effect (Table 4), all three of the conditional direct effects (based on the moderator values at the mean plus and minus one standard deviation) were positive and significantly different from zero, indicating that infection cues had a stronger direct predictive role in individuals with high levels of perceived efficacy than in individuals with low levels of perceived efficacy. As shown in the result for conditional indirect effect 1, all three of the conditional indirect effects were positive and significantly different from zero. This finding suggested that the indirect effect of infection cues on preventive behaviors through risk perception was higher among the individuals with a high level of perceived efficacy than among individuals with a low level of perceived efficacy due to the interaction of infection cues and perceived efficacy. Meanwhile, as shown by the result for conditional indirect effect 2, these three conditional indirect effects were positive and significantly different from zero, which indicated that the indirect influence of infection cues on preventive behavior through negative emotions was stronger in the individuals with high levels of perceived efficacy than in those with low levels of perceived efficacy.

Table 3. Conditional process analysis. [a]

	β[b]	B[c] (SE)	*t*	*P* value	95% CI
Model 1					

Outcome: Risk perception					
Gender	-.035	-0.233 (0.046)	-5.099	<.001[c]	-0.323 to -0.144
Age	-.007	-0.002 (0.002)	-0.983	.33	-0.007 to 0.002
Education	.036	0.108 (0.020)	5.332	<.001	0.068 to 0.147
Infection cues	.292	2.116 (0.050)	42.167	<.001	2.018 to 2.214
Perceived efficacy	.026	0.054 (0.005)	11.133	<.001	0.044 to 0.063
Infection cues × Perceived efficacy	.098	0.130 (0.011)	12.155	<.001	0.109 to 0.151
Model 2					
Outcome: Negative emotions					
Gender	-.043	-0.472 (0.076)	-6.238	<.001	-0.520 to -0.324
Age	.040	0.022 (0.004)	5.572	<.001	0.014 to 0.030
Education	.036	0.176 (0.033)	5.289	<.001	0.111 to 0.242
Infection cues	.287	3.430 (0.083)	41.340	<.001	3.267 to 3.593
Perceived efficacy	-.044	0.012 (0.008)	1.490	.14	-0.004 to 0.028
Infection cues × Perceived efficacy	.106	0.232 (0.018)	13.100	<.001	0.197 to 0.266
Model 3					
Outcome: Preventive behaviors					
Gender	.014	0.051 (0.023)	2.217	.03	0.006 to 0.096
Age	.002	0.000 (0.001)	0.365	.72	-0.002 to 0.003
Education	.018	0.029 (0.010)	2.900	.004	0.010 to 0.049
Infection cues	.036	0.141 (0.027)	5.317	<.001	0.089 to 0.193
Risk perception	.119	0.064 (0.004)	16.585	<.001	0.056 to 0.072
Negative emotions	.126	0.041 (0.002)	17.514	<.001	0.036 to 0.045
Perceived efficacy	.387	0.150 (0.002)	61.801	<.001	0.145 to 0.155
Infection cues × Perceived efficacy	.019	0.013 (0.005)	2.464	.01	0.003 to 0.024

[a]Results obtained with bootstrapping (n=5000).
[b]Standardized coefficients are reported.
[c]Unstandardized coefficients are reported.

Table 4. Conditional indirect and direct effect analyses.[a]

	β	B (SE)	95% CI
Conditional indirect effect 1[b]			
M – 1 SD	.023	0.097 (0.007)	0.084 to 0.112
M	.035	0.135 (0.009)	0.118 to 0.153
M + 1 SD	.046	0.173 (0.012)	0.150 to 0.197
Conditional indirect effect 2[c]			
M – 1 SD	.023	0.097 (0.007)	0.083 to 0.111
M	.036	0.140 (0.009)	0.122 to 0.159
M + 1 SD	.050	0.183 (0.013)	0.160 to 0.209
Conditional direct effect			
M – 1 SD	.017	0.081 (0.033)	0.016 to 0.146
M	.036	0.141 (0.027)	0.089 to 0.193
M + 1 SD	.055	0.202 (0.039)	0.125 to 0.278

[a]Results obtained with bootstrapping (n=5000).
[b]Conditional indirect effect 1 was infection cues → risk perception → preventive behaviors.
[c]Conditional indirect effect 2 was infection cues → negative emotions → preventive behaviors.

Discussion

Principal Results

In this study, we found that individuals who received COVID-19-related infection cues, that is, those whose family members or friends contracted COVID-19, exhibited more preventive behaviors. Such cues could also increase both their risk perception and negative emotions, indirectly enhancing their adoption of preventive behaviors. Furthermore, perceived efficacy generally strengthened the effects of other factors, including infection cues, risk perception, and negative emotions, thereby promoting the adoption of preventive behaviors. These findings validate the IPEAM we proposed, in which the psychological mechanism involves the promotion of preventive behaviors by infection cues in the context of the COVID-19 pandemic. The government should take infection cues into account, guide people in assessing threats scientifically and improve people's confidence in the feasibility of overcoming the pandemic, which will contribute to achieving control over the COVID-19 pandemic and effectively address this public health crisis.

Impact of Infection Cues on the Adoption of Preventive Behaviors

Our results indicate that people who receive infection cues are more inclined to engage in preventive behaviors. This finding is in line with several previous studies [18, 47]. As the IPEAM suggested, once a family member, friend, or acquaintance tests positive for COVID-19, people perceive that they are already in danger and that the personal threat of the COVID-19 pandemic is imminent. Given that the virus is transmitted through person-to-person contact [16], as soon as people are aware of infection cues, they engage in more preventive behaviors. In contrast, people who have not received infection cues have vague perceptions and ambiguous attitudes regarding the COVID-19 pandemic because of the limited warning messages primarily based on hearsay. In summary, infection cues are an important starting point from which people recognize, reappraise, and react to a pandemic.

Mediating Effects of Risk Perception and Negative Emotions

As hypothesized, we found that infection cues promoted the adoption of preventive behaviors via increased levels of both risk perception and negative emotions. Part of this finding is in line with that of a previous study that suggested that another type of warning message obtained through social media can increase the adoption of preventive behaviors via increased risk perception and increased negative emotions [48]. Both psychological and behavioral reactions could be regarded as adaptive responses to confronting the overwhelming situation caused by a pandemic [49]. On the one hand, infection cues prompt people to increase their risk perception of the environments that they have been sharing with infected people. Driven by the desire for self-protection, people with higher levels of risk perception are more likely to take comprehensive precautionary measures against infection [24]. In addition, a study conducted during the H5N1 influenza epidemic found that people adopted preventive behaviors not only as a means of self-protection but also to protect others [47]. When people perceive the threat posed by the pandemic, they comply with recommendations to adopt preventive behaviors out of a sense of social responsibility to prevent the further spread of COVID-19. On the other hand, infection cues result in a higher level of negative emotions because people worry about the health and safety of their family members, friends, and acquaintances [50]. In addition, people with higher levels of negative emotions are more concerned about the specific threat and take more effective actions to prevent the occurrence of negative consequences. Therefore, a stable moderate level of negative emotions during the pandemic is beneficial because it reminds individuals to pay more attention to the pandemic, seek effective preparatory measures, and engage in preventive behaviors.

Perceived Efficacy Moderating the Effect of Infection Cues on Preventive Behaviors

Another important finding in the current study pertains to the moderators. Perceived efficacy not only directly moderated the effect of infection cues on the adoption of preventive behaviors but also indirectly moderated this effect via both risk perception and negative emotions. First, for individuals with high levels of perceived efficacy, infection cues better promote the adoption of preventive behaviors. When people have high levels of perceived efficacy, they are more likely to believe that preventive measures are effective and reliable [51]. Therefore, individuals with higher levels of perceived efficacy favorably estimate the effectiveness of the measures they can take and hence actively engage in more preventive behaviors as soon as they become aware of infection cues. Second, the positive effect of infection cues on risk perception is significantly enhanced in individuals with high levels of perceived efficacy. Given that individuals' beliefs can modulate the impact of warning messages on risk perception [37], people with high levels of perceived efficacy give more attention to the fact that infections have occurred in their social surroundings and more carefully reassess the level of risk associated with the COVID-19 pandemic. Third, the effect of infection cues on negative emotions was enhanced in individuals with high levels of perceived efficacy. It has been suggested that people with high levels of perceived efficacy are motivated to control their risk by considering strategies to avert the threat. People with low levels of perceived efficacy believe that they are unable to change the level of threat and thus cope with their negative emotions through maladaptive responses, such as denial [38]. In a sense, during a pandemic, it is adaptive and beneficial for people to have a moderate level of negative emotions and remain alarmed as it prompts them to prepare themselves to cope with the situation adequately while it lasts.

Information-Perception/Emotion-Action Model

The current study aimed to demonstrate how infection cues promote preventive behaviors in the context of the COVID-19 pandemic; that information can be used to improve communication about public health and risks to help contain the outbreak of COVID-19. The resulting moderated mediation model presented here facilitates a better understanding of the relationship between infection cues and the adoption of preventive behaviors. According to the IPEAM, infection cues are an important part of the social and environmental context and thereby provoke psychological and behavioral reactions. When people are confronted with urgent warnings, they estimate their perceived risk and take stock of their negative emotions regarding the threat, which will lead to their adoption of adaptive behaviors [5]. Specifically, infection cues, which are available through various channels, provide individuals with detailed, specific, timely pandemic-related information. Instead of abstract and uncertain information, infection cues provide a clear indication that a particular person in an individual's surroundings contracted COVID-19. The subsequent vivid description of the details of the clinical symptoms and medical treatments can elicit a more firmly rooted belief in the existence of this pandemic. Given that concrete warning messages could produce situational risk assessments [52], individuals who receive infection cues are more vigilant and perceive themselves to be at greater risk. Infection cues also provoke more concern about personal consequences, including casualties, property damage, interruptions of essential services (e.g., water and power), and disruptions to daily activities in their families and communities [53]. In such a context of uncertainty, individuals feel more negative emotions and take the necessary actions to protect both themselves and their families. According to construal level theory [54], individuals who receive concrete messages retain more information than those who receive abstract messages, and their stronger perceptions and emotional reactions lead to more changes in their behavior. In addition, people have varying beliefs about their preventive behaviors. If individuals believe that they can avoid infection and ultimately defeat the pandemic, they will exhibit stronger psychological and behavioral reactions to infection cues.

Implications

In the context of a novel pandemic, effective communication of warning messages can help people adopt preventive behaviors. However, such communication remains challenging for governments and health authorities. The findings of the current study have several clinical and public health implications. First, infection cues draw attention to the need to implement preventive measures, making them an effective and convenient strategy for the local management of the COVID-19 pandemic, especially given the multiwave nature of pandemics. Obtaining information on infection cues is relatively easy, which means that infection cues could be used as an effective indicator in efforts to predict and track the implementation of preventive behaviors. Additionally, some personal information and their trajectory and location can influence individuals to give attention to local pandemic-related information and engage in appropriate preventive behaviors. Therefore, the government should release infection-related information promptly. To date, some countries have prioritized the medical needs of people with infection cues [55–57]. Second, a reasonable level of risk perception and a moderate level of negative emotions about COVID-19 are beneficial for both governments and individuals until full control over the pandemic has been achieved. People's excessive optimism and consequent underestimation of the level of risk may lead to a failure to control the pandemic. Unlike natural disasters such as earthquakes and hurricanes, pandemics are persistent and involve a contagious disease. Appropriate levels of risk perception and negative emotions are conducive to controlling the COVID-19 pandemic. However, the government should strengthen communication efforts so that people have a more accurate understanding of the risks and their resulting negative emotions and can translate that understanding into effective preventive actions. Third, governments and health authorities should provide positive guidance to enhance individuals' confidence and their sense that it is their social responsibility to work together to overcome the long-term adverse effects on mental health in the context of COVID-19 and return to normal life as soon as possible. Individuals tend to panic and lose their sense of control, which can prevent them from engaging in effective preventive behaviors, leading to stigmatization and aggression associated with the disease. In conclusion, policies should be made to help individuals who receive infection cues channel their cognitive and emotional awareness of risk into the implementation of effective preventive measures.

Limitations

Several limitations of the present study must be noted. First, this cross-sectional study did not investigate dynamic changes in or potential interactions among the studied variables during the COVID-19 pandemic. Future studies with longitudinal or experimental designs are needed to continuously track the dynamic changes in people's risk perception, negative emotions, and preventive behaviors in various infection cue contexts. Second, this study focused only on the presence or absence of infection cues; however, neither the number of infection cues nor the degree of intimacy between individuals and their infection cues was considered. These factors related to infection cues should be investigated in further research. Third, although the reliability and validity of this project were acceptable, the number of questions in the online survey used in this study was relatively limited. Large-scale offline investigations are difficult to carry out during pandemics, and researchers need to balance the brevity of online surveys with their reliability and validity. Therefore, the identification of simple and effective online questionnaires that could be used to address societal emergencies is an urgent problem that needs to be solved in the future.

Conclusions

This study collected large-scale data during the COVID-19 pandemic in China and determined the mechanism by which infection cues promote the adoption of preventive behaviors. Our findings demonstrate that individuals who receive infection cues engage in more preventive behaviors due to

their increased risk perception and negative emotions and that high levels of perceived efficacy further enhance these effects. This study identified the mechanism by which infection cues contributed to the adoption of preventive behaviors during the COVID-19 pandemic and suggests that governments should establish early warning and support systems based on the dynamic surveillance of infection cues.

Acknowledgments

This work was supported by the National Natural Science Foundation of China under grant numbers 31571161, 31200782, and 31640039; the CAS Key Laboratory of Behavioral Science, Institute of Psychology, under grant number Y5CX052003; and the Humanities and Social Science Research of the Ministry of Education of China under grant number 18YJC190002. The funding sources had no involvement in any part of the manuscript.

Conflicts of Interest

None declared.

Abbreviations

IPEAM: Information-Perception/Emotion-Action Model
PADM: Protective Action Decision Model

References

1. Shanafelt T, Ripp J, Trockel M. Understanding and Addressing Sources of Anxiety Among Health Care Professionals During the COVID-19 Pandemic. JAMA. 2020 Apr 7. doi:10.1001/jama.2020.5893. PMID:32259193.
2. Rothe C, Schunk M, Sothmann P, Bretzel G, Froeschl G, Wallrauch C, et al. Transmission of 2019-nCoV Infection from an Asymptomatic Contact in Germany. N Engl J Med. 2020 Mar 5;382(10):970-1. doi:10.1056/NEJMc2001468. PMID:32003551.
3. World Health Organization. COVID-19 Weekly Epidemiological Update. 2021. https://www.who.int/docs/default-source/coronaviruse/situation-reports/20210427_weekly_epi_update_37.pdf [accessed May 2, 2021]
4. Tang CS, Wong CY. Psychosocial factors influencing the practice of preventive behaviors against the severe acute respiratory syndrome among older Chinese in Hong Kong. J Aging Health. 2005 Aug;17(4):490-506. doi:10.1177/0898264305277966. PMID:16020576.
5. Lindell MK. Communicating imminent risk. In: Rodriguez H, Trainor J, Donner W, editors. Handbook of disaster research. 2nd edition. New York: Springer; 2018. p. 449-77. doi:10.1007/978-3-319-63254-4 ISBN: 9783319632537
6. Carey JM, Chi V, Flynn DJ, Nyhan B, Zeitzoff T. The effects of corrective information about disease epidemics and outbreaks: Evidence from Zika and yellow fever in Brazil. Sci Adv. 2020 Jan;6(5):eaaw7449. doi:10.1126/sciadv.aaw7449. PMID:32064329.
7. Lindell MK, Hwang SN. Households' perceived personal risk and responses in a multihazard environment. Risk Anal 2008 Apr;28(2):539-556. doi:10.1111/j.1539-6924.2008.01032.x. PMID:18419668.
8. Rickard LN, Yang ZJ, Schuldt JP, Eosco GM, Scherer CW, Daziano RA. Sizing Up a Superstorm: Exploring the Role of Recalled Experience and Attribution of Responsibility in Judgments of Future Hurricane Risk. Risk Anal 2017 Dec;37(12):2334-2349. doi:10.1111/risa.12779. PMID:28230272.
9. McCaffrey S, Wilson R, Konar A. Should I Stay or Should I Go Now? Or Should I Wait and

See? Influences on Wildfire Evacuation Decisions. Risk Anal 2018 Jul;38(7):1390-404. doi: 10.1111/risa.12944. PMID: 29168989.
10. Ma T, Heywood A, MacIntyre CR. Chinese travellers visiting friends and relatives - A review of infectious risks. Travel Med Infect Dis. 2015 Jul-Aug;13(4):285-94. doi:10.1016/j.tmaid.2015.05.004. PMID:26026478.
11. Uchida M, Tsukahara T, Kaneko M, Washizuka S, Kawa S. How the H1N1 influenza epidemic spread among university students in Japan: Experience from Shinshu University. AM J Infect Control. 2012 Apr;40(3):218-20. doi:10.1016/j.ajic.2011.03.012. PMID:21764179.
12. Ajelli M, Parlamento S, Bome D, Kebbi A, Atzori A, Frasson C, et al. The 2014 Ebola virus disease outbreak in Pujehun, Sierra Leone: epidemiology and impact of interventions. BMC Med 2015 Nov 26;13:281. doi:10.1186/s12916-015-0524-z. PMID:26607790.
13. Guo XD, Wang JD, Hu D, Wu LS, Gu L, Wang Y, et al. Survey of COVID-19 Disease Among Orthopaedic Surgeons in Wuhan, People's Republic of China. J Bone Joint Surg-Am Vol. 2020 May;102(10):847-54. doi:10.2106/jbjs.20.00417. PMID:32271208.
14. 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 Psychiat-Rev Can Psychiat. 2009 May;54(5):302-11. doi:10.1177/070674370905400504. PMID:19497162.
15. Bish A, Michie S. Demographic and attitudinal determinants of protective behaviours during a pandemic: a review. Br J Health Psychol 2010 Nov;15(4):797-824. doi: 10.1348/135910710X485826. PMID: 20109274.
16. Rudisill C. How do we handle new health risks? Risk perception, optimism, and behaviors regarding the H1N1 virus. J Risk Res 2013 Sep;16(8):959-80. doi:10.1080/13669877.2012.761271.
17. Betancourt TS, Brennan RT, Vinck P, VanderWeele TJ, Spencer-Walters D, Jeong J, et al. Associations between Mental Health and Ebola-Related Health Behaviors: A Regionally Representative Cross-sectional Survey in Post-conflict Sierra Leone. PLoS Med 2016 Aug;13(8):e1002073. doi:10.1371/journal.pmed.1002073. PMID:27505186.
18. Li SY, Feng B, Liao W, Pan WJ. Internet Use, Risk Awareness, and Demographic Characteristics Associated With Engagement in Preventive Behaviors and Testing: Cross-Sectional Survey on COVID-19 in the United States. J Med Internet Res. 2020 Jun 16;22(6):e19782. doi:10.2196/19782. PMID:32501801.
19. Li Q, Luo RL, Zhang XY, Meng GT, Dai BB, Liu X. Intolerance of COVID-19-Related Uncertainty and Negative Emotions among Chinese Adolescents: A Moderated Mediation Model of Risk Perception, Social Exclusion and Perceived Efficacy. Int J Environ Res Public Health 2021 Mar 11;18(6):2864. doi: 10.3390/ijerph18062864. PMID: 33799731.
20. Barr M, Raphael B, Taylor M, Stevens G, Jorm L, Giffin M, et al. Pandemic influenza in Australia: Using telephone surveys to measure perceptions of threat and willingness to comply. BMC Infect Dis 2008 Sep 15;8:117. doi:10.1186/1471-2334-8-117. PMID:18793441.
21. Klein WMP, Stefanek ME. Cancer risk elicitation and communication: Lessons from the psychology of risk perception. CA-Cancer J Clin 2007 May-Jun;57(3):147-67. doi:10.3322/canjclin.57.3.147. PMID:17507441.
22. Wackowski OA, Delnevo CD. Young Adults' Risk Perceptions of Various Tobacco Products Relative to Cigarettes: Results From the National Young Adult Health Survey. Health Educ Behav 2016 Jun;43(3):328-36. doi:10.1177/1090198115599988. PMID:26304709.

23. Schwarzer R, Lippke S, Luszczynska A. Mechanisms of Health Behavior Change in Persons With Chronic Illness or Disability: The Health Action Process Approach (HAPA). Rehabil Psychol 2011 Aug;56(3):161-70. doi:10.1037/a0024509. PMID:21767036.
24. Leung GM, Ho LM, Chan SK, Ho SY, Bacon-Shone J, Choy RY, et al. Longitudinal assessment of community psychobehavioral responses during and after the 2003 outbreak of severe acute respiratory syndrome in Hong Kong. Clin Infect Dis. 2005 Jun 15;40(12):1713-20. doi:10.1086/429923. PMID:15909256.
25. Leppin A, Aro AR. Risk Perceptions Related to SARS and Avian Influenza: Theoretical Foundations of Current Empirical Research. Int J Behav Med 2009 Mar;16(1):7-29. doi:10.1007/s12529-008-9002-8. PMID:19214752.
26. de Bruin WB, Bennett D. Relationships Between Initial COVID-19 Risk Perceptions and Protective Health Behaviors: A National Survey. Am J Prev Med 2020 Aug;59(2):157-67. doi:10.1016/j.amepre.2020.05.001. PMID:32576418.
27. 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 Aug 2;23(7-8):994-1006. doi:10.1080/13669877.2020.1758193.
28. Mazza C, Ricci E, Biondi S, Colasanti M, Ferracuti S, Napoli C, et al. A Nationwide Survey of Psychological Distress among Italian People during the COVID-19 Pandemic: Immediate Psychological Responses and Associated Factors. Int J Environ Res Public Health 2020 May 2;17(9):3165. doi:10.3390/ijerph17093165. PMID:32370116.
29. Ozdin S, Ozdin SB. Levels and predictors of anxiety, depression and health anxiety during COVID-19 pandemic in Turkish society: The importance of gender. Int J Soc Psychiatr 2020 Aug;66(5):504-11. doi:10.1177/0020764020927051. PMID:32380879.
30. Witte K, Allen M. A meta-analysis of fear appeals: implications for effective public health campaigns. Health Educ Behav. 2000 Oct;27(5):591-615. doi:10.1177/109019810002700506. PMID:11009129.
31. Huckins JF, daSilva AW, Wang W, Hedlund E, Rogers C, Nepal SK, et al. Mental Health and Behavior of College Students During the Early Phases of the COVID-19 Pandemic: Longitudinal Smartphone and Ecological Momentary Assessment Study. J Med Internet Res. 2020 Jun 17;22(6):e20185. doi:10.2196/20185. PMID:32519963.
32. Harper CA, Satchell LP, Fido D, Latzman RD. Functional Fear Predicts Public Health Compliance in the COVID-19 Pandemic. Int J Mental Health Addict 2020 Apr 27:1-14. doi:10.1007/s11469-020-00281-5. PMID:32346359.
33. Lau JTF, Yang X, Tsui H, Kim JH. Monitoring community responses to the SARS epidemic in Hong Kong: from day 10 to day 62. J Epidemiol Community Health 2003 Nov;57(11):864-70. doi:10.1136/jech.57.11.864. PMID:14600111.
34. Bandura A. Social cognitive theory: an agentic perspective. Annu Rev Psychol 2001;52:1-26. doi:10.1146/annurev.psych.52.1.1. PMID:11148297.
35. Strecher VJ, DeVellis BM, Becker MH, Rosenstock IM. The role of self-efficacy in achieving health behavior change. Health Educ Q 1986;13(1):73-92. doi:10.1177/109019818601300108. PMID:3957687.
36. Rippetoe PA, Rogers RW. Effects of components of protection-motivation theory on adaptive and maladaptive coping with a health threat. J Pers Soc Psychol. 1987 Mar;52(3):596-604. doi:10.1037/0022-3514.52.3.596. PMID:3572727.
37. Choi DH, Yoo W, Noh GY, Park K. The impact of social media on risk perceptions during the MERS outbreak in South Korea. Comput Hum Behav 2017 Jul;72:422-31. doi:10.1016/j.chb.2017.03.004. PMID:32288176.
38. Witte K. Putting the fear back into fear appeals: The extended parallel process model. Commun Monogr 1992 Dec;59(4):329-49. doi:10.1080/03637759209376276.

39. Sheeran P, Harris PR, Epton T. Does Heightening Risk Appraisals Change People's Intentions and Behavior? A Meta-Analysis of Experimental Studies. Psychol Bull 2014 Mar;140(2):511-43. doi:10.1037/a0033065. PMID:23731175.
40. Dadaczynski K, Okan O, Messer M, Leung AYM, Rosário R, Darlington E, et al. Digital Health Literacy and Web-Based Information-Seeking Behaviors of University Students in Germany During the COVID-19 Pandemic: Cross-sectional Survey Study. J Med Internet Res 2021;23(1):e24097. doi:10.2196/24097. PMID:33395396.
41. Yang X, Song B, Wu A, Mo PKH, Di J, Wang Q, et al. Social, Cognitive, and eHealth Mechanisms of COVID-19–Related Lockdown and Mandatory Quarantine That Potentially Affect the Mental Health of Pregnant Women in China: Cross-Sectional Survey Study. J Med Internet Res 2021;23(1):e24495. doi:10.2196/24495. PMID:33302251.
42. Mo PKH, Fong VWI, Song B, Di J, Wang Q, Wang L. Association of Perceived Threat, Negative Emotions, and Self-Efficacy With Mental Health and Personal Protective Behavior Among Chinese Pregnant Women During the COVID-19 Pandemic: Cross-sectional Survey Study. J Med Internet Res 2021;23(4):e24053. doi:10.2196/24053. PMID:33729983.
43. Han Y, Jiang B, Guo R. Factors Affecting Public Adoption of COVID-19 Prevention and Treatment Information During an Infodemic: Cross-sectional Survey Study. J Med Internet Res 2021;23(3):e23097. doi:10.2196/23097. PMID:33600348.
44. Dai BB, Fu D, Meng GT, Liu BS, Li Q, Liu X. The Effects of Governmental and Individual Predictors on COVID-19 Protective Behaviors in China: A Path Analysis Model. Public Adm Rev 2020 Sep;80(5):797-804. doi:10.1111/puar.13236. PMID:32836438.
45. Hayes AF. Introduction to mediation, moderation, and conditional process analysis: A regression-based approach. 2nd edition. New York: Guilford; 2017. ISBN: 9781462534654
46. Lau WKW, Leung MK, Wing YK, Lee TMC. Potential Mechanisms of Mindfulness in Improving Sleep and Distress. Mindfulness 2018;9(2):547-55. doi: 10.1007/s12671-017-0796-9. PMID: 29599851.
47. Lau JTF, Kim JH, Tsui HY, Griffiths S. Anticipated and current preventive behaviors in response to an anticipated human-to-human H5N1 epidemic in the Hong Kong Chinese general population. BMC Infect Dis 2007 Mar 15;7:18. doi:10.1186/1471-2334-7-18. PMID:17359545.
48. Oh SH, Lee SY, Han C. The Effects of Social Media Use on Preventive Behaviors during Infectious Disease Outbreaks: The Mediating Role of Self-relevant Emotions and Public Risk Perception. Health Commun. 2020 Feb 16:1-10. doi:10.1080/10410236.2020.1724639. PMID:32064932.
49. Maunder R, Hunter J, Vincent L, Bennett J, Peladeau N, Leszcz M, et al. The immediate psychological and occupational impact of the 2003 SARS outbreak in a teaching hospital. Can Med Assoc J 2003 May;168(10):1245-51. PMID:12743065.
50. Wang C, Pan R, Wan X, Tan Y, Xu L, Ho CS, et al. Immediate Psychological Responses and Associated Factors during the Initial Stage of the 2019 Coronavirus Disease (COVID-19) Epidemic among the General Population in China. Int J Environ Res Public Health 2020 Mar 6;17(5):1729. doi:10.3390/ijerph17051729. PMID:32155789.
51. de Zwart O, Veldhuijzen IK, Richardus JH, Brug J. Monitoring of risk perceptions and correlates of precautionary behaviour related to human avian influenza during 2006 - 2007 in the Netherlands: results of seven consecutive surveys. BMC Infect Dis. 2010 May 12;10:114. doi:10.1186/1471-2334-10-114. PMID:20462419.
52. Huang S-K, Lindell MK, Prater CS, Wu H-C, Siebeneck LK. Household Evacuation Decision

Making in Response to Hurricane Ike. Nat Hazards Rev 2012;13(4):283-96. doi:doi:10.1061/(ASCE)NH.1527-6996.0000074.
53. Huang S-K, Lindell MK, Prater CS. Multistage Model of Hurricane Evacuation Decision: Empirical Study of Hurricanes Katrina and Rita. Nat Hazards Rev 2017;18(3):05016008. doi:doi:10.1061/(ASCE)NH.1527-6996.0000237.
54. Liberman N, Trope Y. The Psychology of Transcending the Here and Now. Science 2008 Nov 21;322(5905):1201-5. doi:10.1126/science.1161958. PMID:19023074.
55. Lewis D. Why many countries failed at COVID contact-tracing - but some got it right. Nature 2020 Dec;588(7838):384-7. doi:10.1038/d41586-020-03518-4. PMID:33318682.
56. Xing Y, Wong GWK, Ni W, Hu X, Xing Q. Rapid Response to an Outbreak in Qingdao, China. N Engl J Med 2020 Dec 3;383(23):e129. doi:10.1056/NEJMc2032361. PMID:33207089.
57. Pullano G, Di Domenico L, Sabbatini CE, Valdano E, Turbelin C, Debin M, et al. Underdetection of COVID-19 cases in France threatens epidemic control. Nature 2020 Feb;590(7844):134-9. doi:10.1038/s41586-020-03095-6. PMID:33348340.

Supplementary Files

Figures

The hypothesized model. Note: H1 is in red, H2 is in yellow, and H3 is in blue.