ORIGINAL ARTICLE

PsyCh Journal

The association between intolerance of uncertainty and Internet addiction during the second wave of the coronavirus disease 2019 pandemic: A multiple mediation model considering depression and risk perception

Ronglei Luo[1] | Qi Li[2] | Guangteng Meng[3,4] | Ya Zheng[5] | Kesong Hu[6] | Xiaoya Zhang[3,4] | Bibing Dai[1] (ID) | Xun Liu[3,4] (ID)

[1]Department of Psychiatry and Psychology, School of Basic Medical Sciences, Tianjin Medical University, Tianjin, China

[2]Beijing Key Laboratory of Learning and Cognition, School of Psychology, Capital Normal University, Beijing, China

[3]CAS Key Laboratory of Behavioral Science, Institute of Psychology, Beijing, China

[4]Department of Psychology, University of Chinese Academy of Sciences, Beijing, China

[5]Department of Psychology, Dalian Medical University, Dalian, China

[6]Department of Psychology, Lake Superior State University, Sault St. Marie, Michigan, USA

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

Abstract

Repeated outbreaks of coronavirus disease 2019 (COVID-19) have forced people to shift most of their work and life activities from offline to online, leading to a growing problem of Internet dependence and even Internet addiction. However, the mechanism of the association between COVID-19-related intolerance of uncertainty (COVID-19 IU) and Internet addiction during the second wave of COVID-19 is still unclear. The current study explored the association between COVID-19 IU and Internet addiction as mediated by depression and risk perception based on the Uncertainty-Depression-Perception-Addiction model (UDPA). A total of 1,137 adult participants were recruited, and COVID-19 IU, depression, risk perception, Internet addiction, and demographic variables were analyzed. The results showed that COVID-19 IU was significantly and positively associated with Internet addiction and that this relationship was mediated in parallel by depression and risk perception. Our findings further extend the Interaction of Person-Affect-Cognition-Execution (I-PACE) model from the perspective of applicability in the unique context of COVID-19. Furthermore, the study suggests that individuals could decrease their dependence on the Internet to prevent Internet addiction during the second wave of the pandemic through effective interventions that include lowering COVID-19 IU, improving emotion regulation, and developing reasonable perceptions of risk.

KEYWORDS
depression, Internet addiction, intolerance of uncertainty, risk perception, the second wave of coronavirus disease 2019

INTRODUCTION

The worldwide coronavirus disease 2019 (COVID-19) pandemic has severely disrupted people's lives (Giuntella et al., 2021). Numerous countries have implemented population-wide restrictions, including lockdowns and physical distancing mandates (Daly et al., 2021). During the period of isolation, surfing the Internet became a mainstream lifestyle activity, resulting in increasing seriousness of the phenomenon of Internet addiction (Li et al., 2021b). A survey found that over 60% of people showed some degree of Internet addiction during the COVID-19 outbreak (Priego-Parra et al., 2020). Internet addiction is defined as an inability to control online participation. According to Davis's cognitive-behavioral model, Internet addiction has been conceptualized as abnormal behaviors that result from vulnerability, such as diathesis, and life events, such as stress, in a diathesis-stress framework (Davis, 2001). The epidemic of COVID-19, as a chronic and highly contagious disease with repeated outbreaks, has been a serious source of stress for people around the world. Similar to the first wave of COVID-19, the second wave has had a great impact on the health and lives of people in many countries and regions (Coccia, 2021), but it also has unique characteristics. For example, many people are frustrated and depressed by months of lockdown, canceled activities, stress, and economic challenges

Ronglei Luo and Qi Li contributed equally to this work.

(Hafeez et al., 2021). The evolving second wave of COVID-19 brought many new uncertainties, such as coping with the emergence of new variants (Hafeez et al., 2021). Uncertainty, psychological distress, and depression have accumulated as multiple waves of the pandemic continue, which could lead people to spend more time online. Hence, there is an urgent need to identify the mechanism of the impact of uncertainty on Internet addiction in the specific context of repeated COVID-19 outbreaks.

In recent years, the Interaction of Person-Affect-Cognition-Execution (I-PACE) model has been widely used to explain the development and maintenance of Internet addiction (Brand et al., 2019; Brand et al., 2016). According to this model, Internet addiction behaviors occur in interactions between variables related to an individual's predisposition and his or her perception of specific situations. The predisposing variables represent an individual's core characteristics. A series of emotional and cognitive responses induced by these predisposing characteristics or external Internet-related stimuli may influence behaviors related to excessive Internet use. Based on this model, the current study proposes the Uncertainty-Depression-Perception-Addiction (UDPA) mediation model to elucidate the mechanism of impacts on Internet addiction disorder during the COVID-19 pandemic. In this model, COVID-19-related intolerance of uncertainty (COVID-19 IU) is defined as the disposition of being incapable of tolerating aversive responses triggered by the perceived absence of COVID-19-related information (Dai et al., 2020; Li et al., 2021a), which is a core characteristic of people faced with uncertainty caused by the pandemic. This perception of uncertainty is followed by emotional and cognitive responses (Hillen et al., 2017). Emotional responses include a wide variety of emotional states. Among these, depression has been regarded as a prominent emotion during the long, recurrent outbreak stage of COVID-19 (Fukase et al., 2021). Cognitive responses include various types of appraisal; one of the most immediate responses is risk appraisal, which is likely to increase as the outbreak continues (Ibuka et al., 2010). Additionally, preoccupation with the Internet, unsuccessful attempts to control Internet participation, and the use of the Internet to escape or relieve a negative mood are considered specific Internet addiction behaviors. Therefore, it is necessary to explore how COVID-19 IU is associated with Internet addiction behavior via depression and risk perception during the long stage of recurrent outbreaks of COVID-19.

Given that quarantine is recommended during COVID-19, individuals with personal traits such as intolerance of uncertainty (IU) are likely to spend more time on the Internet than other individuals. People with the trait of IU often have cognitive biases (e.g., negative beliefs, attention biases for threatening information; Sexton & Dugas, 2009) that are risk factors for many problematic behaviors (Frangos et al., 2010; Hamonniere & Varescon, 2018). Indeed, IU has been found to be related to several problematic behaviors, including drinking to control or avoid negative emotions (Kraemer et al., 2015) and eating disorders (Brown et al., 2017). Recent evidence has tentatively revealed a positive correlation between IU and excessive Internet and smartphone use (Fergus, 2013; Rozgonjuk et al., 2019). However, few studies have examined this correlation in the second wave of COVID-19. Because of the chronicity of this pandemic, people must endure long durations of uncertainty related to COVID-19. Such an environment is highly likely to strengthen and habitualize individual behaviors such as chatting online, seeking information, and passing time via the Internet; inevitably, people may spend more of their time online than offline. Thus:

Hypothesis 1 (H1): COVID-19 IU is positively associated with Internet addiction.

Intolerance of uncertainty is an important transdiagnostic variable within various emotional disorders. Studies have shown that IU is significantly and positively associated with anxiety and depression (Carleton et al., 2012; Ladouceur et al., 2000a). Coping with emotions during the pandemic is a dynamic process for people. Symptoms of anxiety peaked in the early stages of this high-risk infectious disease outbreak and subsequently decreased as time passed (Bendau et al., 2021). However, repeated outbreaks and the emergence of new variants plunged people into a feeling of being out of control; in this situation, depression may become more prominent, especially for people who are more susceptible to struggling with uncertainty. Duan et al. (2020) found that compared to the first wave, depression significantly increased in the second wave of the COVID-19 pandemic. This finding suggests that depression might be an important emotional variable in the second wave of COVID-19 considering that people with high IU who must deal with the pandemic for a long period of time may feel more helpless and out of control than other people. IU was found to predict depression symptoms concurrently and over 6 weeks (Miranda et al., 2008), and a decrease in IU was related to reduced levels of depressive symptoms post-treatment (Boswell et al., 2013). Compensatory Internet use theory proposes that individuals tend to use technology excessively to alleviate depression (Kardefelt-Winther, 2014). Psychiatric disorders contribute to or exacerbate the symptoms or course of addiction, and among clinical symptoms, depression is most closely related to Internet addiction (Ha et al., 2007; Ko et al., 2012). In a previous study of high school students, depression predicted the initiation and persistence of Internet addiction (Chang et al., 2014). As a dysfunctional way to cope with negative emotional experiences, Internet addiction may be associated with depression (Jeong et al., 2020). Furthermore, prolonged isolation and repeated COVID-19 outbreaks may continuously reinforce this mediation process. Based on these previous findings, we propose:

Hypothesis 2 (H2): Depression mediates the relationship between COVID-19 IU and Internet addiction (Figure 1).

During the pandemic, perceiving and appraising risks associated with COVID-19 are among the most important cognitive processes that are engaged when people are confronted with high levels of uncertainty. Risk perception refers to people's subjective assessment of the general fatality rates and their own specific likelihood of being infected with the virus or dying from the disease (Leppin & Aro, 2009). Individuals with high COVID-19 IU may perceive a greater risk of this infectious disease. On the one hand, the literature has shown that people with a high level of IU tend to perceive ambiguous cues as threats, evaluate
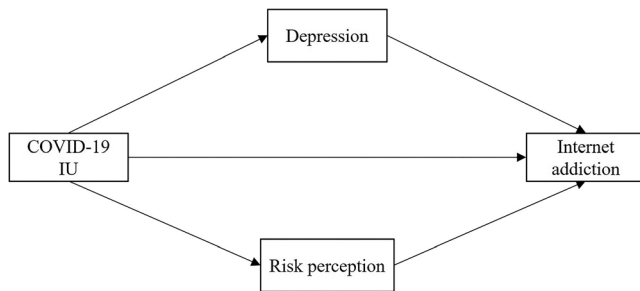
FIGURE 1 The hypothesized model. COVID-19 IU = coronavirus disease 2019-related intolerance of uncertainty

them more negatively, and overestimate the risks (Bredemeier & Berenbaum, 2008; Chen & Lovibond, 2016; Ladouceur et al., 2000a). Furthermore, when people cannot tolerate uncertainty, they have stronger motives to seek information (Rosen et al., 2007), which may in turn expose them to more threatening messages. On the other hand, as a kind of cognitive distortion, excessive risk perception may result in negative consequences, such as poorer decision-making (Ciccarelli et al., 2017), which may increase the risk of developing substance use disorder (Kirisci et al., 2004) and online game addiction (Li & Wang, 2013). In particular, when outbreaks occur repeatedly, people realize that they cannot control the spread of the epidemic in the short term, and the perceived risk increases over time (Ibuka et al., 2010). Such repeated threats and great uncertainty may reinforce the association between IU and Internet addiction. We therefore propose:

Hypothesis 3 (H3): Risk perception mediates the relationship between COVID-19 IU and Internet addiction.

METHOD

Participants

This cross-sectional study was approved by the Institutional Review Board of Tianjin Medical University (study number: 190002) and followed the principles of the Declaration of Helsinki. All participants gave written informed consent and they could withdraw from the study at any time without being penalized. A total of 1,137 eligible adults in Beijing completed our online survey, which was designed to obtain information including demographic variables and data on Internet addiction, COVID-19 IU, depression, and risk perception. The data were collected between 25 June 2020 and 29 June 2020, during the second wave of the COVID-19 outbreak in Beijing, China. Table 1 presents the sociodemographic characteristics of this study sample.

Measures

COVID-19-related intolerance of uncertainty

Four items to measure COVID-19 IU were adapted from the Intolerance of Uncertainty Scale (Buhr & Dugas, 2002) and

TABLE 1 Sociodemographic Characteristics of the Participants (n = 1,137)

	Frequency	Proportion (%)
Sex		
Female	486	42.74
Male	651	57.26
Age		
18–25 years	397	34.92
26–35 years	484	42.57
36–45 years	229	20.14
46–59 years	27	2.37
Marital status		
Married	640	56.29
Other	497	43.71
Education		
High school diploma or below	173	15.22
College degree	269	23.66
Bachelor's degree	552	48.55
Master's degree or above	143	12.58
Income		
None	106	9.32
Below 4000 yuan	183	16.09
4000–10,000 yuan	528	46.44
10,001–20,000 yuan	253	22.25
20,001 yuan and more	67	5.89

revised to fit the context of the pandemic: "The uncertainty of the pandemic has seriously impacted my studies, work and life," "The uncertainty of the pandemic ruins my plans," "The uncertainty of the pandemic makes me uneasy, anxious, or stressed," and "Confronted with the uncertainty of the pandemic, I cannot function very well in my studies, work and life." These items represent the ideas that uncertainty leads to the inability to act, uncertainty is stressful and upsetting, and unexpected events are negative and should be avoided. Responses were rated on a 7-point Likert scale (1 = *strongly disagree* to 7 = *strongly agree*), with total scores ranging from 4 to 28. Higher scores indicated a greater level of COVID-19 IU. In this study, Cronbach's α for COVID-19 IU was .904.

Depression

The two items used in this study to assess participants' depression levels were adapted from the Patient Health Questionnaire-2 (PHQ-2; Kroenke et al., 2003), which has been proven to be a valid and practical tool for assessing depression severity. This study used the two key symptoms indicating major depression on the PHQ-2: "little interest or pleasure in doing things" and "feeling down, depressed, or hopeless." In addition, common self-report scales ask

participants to report whether they have experienced depression in the past 7 days (e.g., the Self-Rating Depression Scale; Zung, 1965) or 14 days (e.g., Beck Depression Inventory-II; Beck et al., 1996); hence, we used the median, 10 days, as the period for measuring depression. To highlight depression caused by repeated COVID-19 outbreaks, we revised the two items as follows: "In the last 10 days, to what extent have you felt no interest or motivation to do anything since the pandemic has recurred in Beijing?" and "In the last 10 days, what level of intensity of depression or hopelessness have you experienced since the pandemic has recurred in Beijing?" Each item in this study used a 7-point Likert scale (1 = *very low* to 7 = *very high*). Scores for each item were summed to produce a scale of depression, with higher scores indicating higher levels of depression. Cronbach's α for depression was .845 in the present study.

Risk perception

Risk perception can be classified as either universal risk perception or personal risk perception depending on the object being assessed. These represent a general perception of fatality rates in the event of an outbreak and one's own perception of the probability of being infected with the virus (Leppin & Aro, 2009). Correspondingly, fatality and the probability of infection are two key components in the risk perception of infectious diseases. Two items were designed to measure participants' perceived level of risk posed by the recurrent pandemic: "In your opinion, what is the fatality rate of COVID-19 in this recurrent pandemic in Beijing?" and "In your opinion, how likely you are to get infected with COVID-19 in this recurrent pandemic in Beijing?" All items were rated on a 7-point Likert scale (1 = *very low* to 7 = *very high*). Scores for each item were summed to produce a scale of risk perception, with higher scores indicating perceptions of higher risk. Cronbach's α for risk perception in this study was .652.

Internet addiction

Four items were used to assess participants' levels of Internet addiction: "During the pandemic, I always wanted to use the Internet," "During the pandemic, I spent more time on the Internet than I intended," "During the pandemic, surfing the Internet severely impacted my studies, work, and

life," and "During the pandemic, surfing the Internet became a way for me to get rid of negative emotions." For this study, the items measuring Internet addiction were designed to meet the symptom criteria defined as Internet use disorder by the *DSM-5* (e.g., preoccupation with the Internet, unsuccessful attempts to control participation in the Internet, use of the Internet to escape or relieve a negative mood). All responses were rated on a 7-point Likert scale (1 = *strongly disagree* to 7 = *strongly agree*). The total scores ranged from 4 to 28, with higher scores indicating more severe Internet addiction. Cronbach's α for Internet addiction in this study was .866.

Analytic strategy

In this study, we conducted descriptive statistics and Pearson's correlation analysis with IBM SPSS Statistics for Windows, Version 22.0 (IBM Corp.). Then, we examined the multiple mediation model using the SPSS macro PROCESS (model 4) (http://www.afhyes.com) suggested by Hayes (2013) to test the multiple mediation model. Bootstrapping (5,000 bootstrap samples) with 95% confidence intervals (CI) was conducted to examine the significance of mediation effects. A 95% CI excluding zero indicated statistical significance.

RESULTS

Preliminary analyses

The correlations between the variables prior to testing the mediation model were calculated. As shown in Table 2, COVID-19 IU had significantly positive correlations with Internet addiction ($r = .60$, $p < .001$), depression ($r = .65$, $p < .001$), and risk perception ($r = .36$, $p < .001$). In addition, Internet addiction was positively associated with depression ($r = .44$, $p < .001$) and risk perception ($r = .29$, $p < .001$).

Testing the proposed model

The main results of our multiple mediation model are presented in Table 3 and Figure 2. When sex, age, marital status, education, and income were included in this study, Models A and B examined the effects of COVID-19 IU on depression

TABLE 2 Means, Standard Deviations, and Zero-Order Correlations Between the Variables

Variables	M	SD	1	2	3	4
1. COVID-19 IU	18.36	6.42	1			
2. Depression	7.48	3.42	.65***	1		
3. Risk perception	9.64	2.76	.36***	.32***	1	
4. Internet addiction	19.99	5.66	.60***	.44***	.29***	1

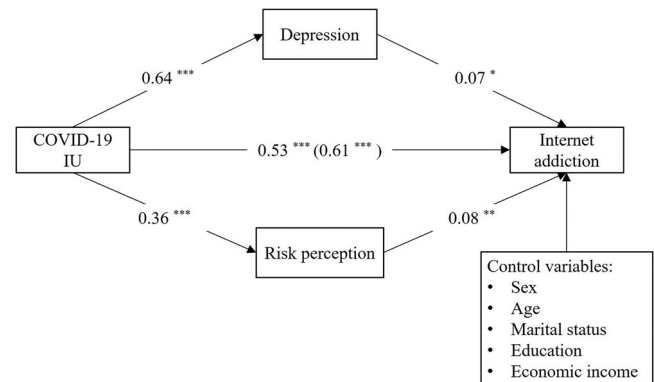*Note*. COVID-19 IU = coronavirus disease 2019-related intolerance of uncertainty. ***$p < .001$.

TABLE 3 The Results of Multiple Mediation Model Analyses

Model Model A	β	SE	t	p
Outcome variable: Depression				
Sex	.05	0.16	2.02	.04
Age	−.02	0.12	−0.80	.42
Marital status	−.04	0.20	−1.24	.22
Education	−.09	0.09	−3.62	<.001
Economic income	.05	0.09	1.83	.07
COVID-19 IU	.64	0.01	28.62	<.001
Model B				
Outcome variable: Risk perception				
Sex	.02	0.16	0.59	.55
Age	.03	0.12	0.90	.37
Marital status	−.01	0.20	−0.21	.83
Education	.03	0.09	0.88	.38
Economic income	.06	0.09	1.91	.06
COVID-19 IU	.36	0.01	12.92	<.001
Model C				
Outcome variable: Internet addiction				
Sex	−.002	0.27	−0.08	.94
Age	−.07	0.21	−2.46	.01
Marital status	.04	0.34	1.30	.20
Education	−.03	0.16	−1.12	.26
Economic income	−.05	0.15	−2.00	.05
COVID-19 IU	.53	0.03	16.9	<.001
Depression	.07	0.05	2.30	.02
Risk perception	.08	0.05	3.22	.001

Note: COVID-19 IU = coronavirus disease 2019-related intolerance of uncertainty.

FIGURE 2 Multiple mediation model. Path values are the standard regression coefficients. The total effect of COVID-19 IU on Internet addiction is shown in parentheses. COVID-19 IU = coronavirus disease 2019-related intolerance of uncertainty. *$p < .05$, **$p < .01$, ***$p < .001$

and risk perception, respectively. Model C was used to test the effects of COVID-19 IU, depression, and risk perception on Internet addiction.

Table 3 shows that COVID-19 IU was positively correlated with depression (β = .64, $p < .001$), which in turn was positively associated with Internet addiction (β = .07, $p = .02$). Therefore, depression played a partial mediating role in the link between COVID-19 IU and Internet addiction (indirect effect = 0.04, 95% CI = [0.001, 0.081]). Likewise, COVID-19 IU was positively associated with risk perception (β = .36, $p < .001$), and risk perception was positively correlated with Internet addiction (β = .08, $p = .001$), indicating that risk perception partially mediated the relationship between COVID-19 IU and Internet addiction (indirect effect = 0.026, 95% CI = [0.006, 0.047]). When the mediation variables were included in the model, COVID-19 IU was still related to Internet addiction (β = .53, $p < .001$), indicating a significant direct effect. In addition, age (β = −.07, $p = .01$) and income (β = −.05, $p = .05$) could significantly negatively predict Internet addiction, indicating that older age and higher income may be protective factors for Internet addiction.

DISCUSSION

The current study is the first to examine the potential mechanisms through which COVID-19 IU is associated with Internet addiction in the ongoing COVID-19 crisis with repeated outbreaks. The results showed that individuals with low levels of tolerance of uncertainty related to the pandemic had higher levels of Internet addiction than other individuals (H1). COVID-19 IU may be associated with Internet addiction by increasing depression (H2) and risk perception (H3). In addition, we found that people who were older and had higher income had lower levels of Internet addiction. The key contribution of this study is to advance our understanding of how COVID-19 IU is associated with Internet addiction based on the I-PACE model. The pathways of our mediation model provide timely suggestions for Internet addiction prevention and interventions to address the next waves of COVID-19.

Associations between COVID-19 IU and Internet addiction

As expected, we found that individuals with high COVID-19 IU had a higher level of Internet addiction. We speculate that people with IU traits tend to show worry (Dugas et al., 2004) and difficulty with self-control and regulation (Yang et al., 2021), which are risk factors for substance addiction and behavioral addiction (Ford & Blumenstein, 2012; Li et al., 2014; Marci et al., 2021). During the pandemic and its great uncertainty, individuals with these characteristics are particularly vulnerable to addictive behaviors, such as mobile phone addiction (Peng et al., 2022). Especially with multiple waves of outbreaks, individuals who are susceptible to uncertainty accumulate negative emotions (Dai et al., 2021; Li et al., 2021a) and are more likely to have behavioral problems such as Internet addiction. In addition, COVID-19 IU may increase the risk of Internet addiction by causing individuals to excessively seek information from the Internet and to use the Internet to escape from reality. According to the integrative

model of uncertainty tolerance, behavioral responses caused by the perception of uncertainty include excessive information seeking and decision avoidance (Hillen et al., 2017). On the one hand, people with high IU tend to frequently seek information online to increase their certainty, such as seeking medical information to reduce uncertainty associated with potential health problems (Starcevic et al., 2019). Especially during the second wave of the COVID-19 epidemic, the degree of uncertainty about the epidemic became more serious, which may have further promoted excessive information-seeking behavior among individuals with high IU. Due to measures such as lockdowns and reduced face-to-face contact, the Internet has become an important way for people to obtain relevant information. However, the Internet can also be used as a tool to escape uncertain reality (Whang et al., 2003), providing a virtual space for people to temporarily escape from real-world decision-making during repeated COVID-19 outbreaks. Therefore, high levels of COVID-19 IU might have increased the risk of Internet addiction during the second COVID-19 outbreak.

The mediating role of depression

Our results suggested that depression played a mediating role in the relationship between COVID-19 IU and Internet addiction. The results showed that COVID-19 IU was positively correlated with depression. IU is considered a shared element of emotional disorders (Boswell et al., 2013). We speculate that in the second wave of the COVID-19 epidemic, the recurrence of the epidemic was a stressful event for individuals who needed to deploy more resources to respond to the epidemic and who were prone to a sense of learned helplessness. In particular, individuals with high IU tend to have more negative thought patterns and believe that negative outcomes will occur in the future, ignoring the possibility of positive outcomes. This sense of hopelessness may increase the risk of depression (Miranda et al., 2008). In addition, depression may further exacerbate Internet addiction. According to compensatory Internet use theory, people excessively indulge in Internet use to escape life pressures and relieve negative emotions (Kardefelt-Winther, 2014). During the second wave of the COVID-19 epidemic, the online world seemed to be the main place for people to relieve depression due to the chronic lack of offline activities (Dong et al., 2020). In addition, depressed individuals are more likely to develop Internet addiction due to their low self-control ability (Özdemir et al., 2014). Therefore, during the second wave of the COVID-19 epidemic, individuals with high COVID-19 IU may have been more prone to depression. This processing of negative emotions may have increased their risk of developing Internet addiction.

The mediating role of risk perception

The current results suggest that risk perception plays a mediating role in the relationship between COVID-19 IU and Internet addiction. We found that IU was positively associated with risk perception, possibly because people with IU traits were more likely to overestimate risk (Bredemeier & Berenbaum, 2008; Chen & Lovibond, 2016; Ladouceur et al., 2000b). The repeated outbreaks of COVID-19 are constant reminders of the threat to human health and life, thereby heightening the assessment of risk. In addition, higher risk perceptions are associated with more Internet addiction behaviors. Repeated outbreaks of COVID-19 have increased perceived risk, and a sense of powerlessness may drive individuals to use the Internet to escape reality. This maladaptive coping style can contribute to Internet addiction over time (Brailovskaia & Margraf, 2021). Thus, during the second COVID-19 outbreak, individuals with high COVID-19 IU may have felt more threatened by the outbreak and developed Internet addiction in response to the threat.

Practical implications

In view of the high incidence of Internet addiction in the context of repeated COVID-19 outbreaks, based on the I-PACE model of Internet addiction (Brand et al., 2019; Brand et al., 2016), this study aimed to reveal the mechanism of the association between COVID-19 IU and Internet addiction during this particular period and to develop targeted Internet addiction prevention and treatment programs to address potential future waves of the pandemic. First, reducing COVID-19 IU may help decrease levels of Internet addiction. Since high COVID-19 IU is associated with a high risk of Internet addiction, a treatment called cognitive behavioral therapy – intolerance of uncertainty (CBT-IU), which specifically targets IU, has been developed to treat Internet addiction (Gillett et al., 2018; Ladouceur et al., 2000a). Second, Internet addiction may be prevented and alleviated by improving people's positive emotional states and lowering their risk perception. At the individual level, individuals should learn various stress-reduction techniques (e.g., meditation, autogenic training, and mindfulness practice) to maintain mental health (Király et al., 2020). At the community level, the government should monitor rumors that create panic in and limit excessive exposure to negative information to prevent excessive perceptions of risk, panic, and depression (Dai et al., 2021; Király et al., 2020). In addition, the government should strengthen the provision of physical and mental health assistance and promote telemedicine and eHealth platforms (Bokolo, 2021). Positive risk communication based on epidemic information should be conducted to promote reasonable perceptions among the public and to increase positive emotions (Dai et al., 2021; H. Li et al., 2020).

Limitations and prospects

The limitations of the current study should be considered. First, the cross-sectional design of this study limits any causal interpretations. Because we measured all variables at the same

point in time, we can only demonstrate correlations between variables in the proposed mediation model, not their causal associations. A longitudinal design and clinical trials should be used in the future to draw causal conclusions. It is necessary to emphasize that the current results are not conclusive, and caution in interpretation is required. Second, future research could further differentiate addiction subtypes. Internet addiction has different subtypes, such as Internet-gaming disorder, Internet-gambling disorder, Internet-communication disorder, Internet-pornography-use disorder, and Internet-shopping disorder (Brand et al., 2016). Different types of Internet addiction may have different psychological mechanisms (Montag et al., 2015). In our study, repeated COVID-19 outbreaks made more people surf the Internet at home. Therefore, we paid attention to the surge of general Internet addiction in the context of epidemic resurgence. In the future, the impact of epidemic resurgence on different types of Internet addiction and the underlying mechanism should be further explored. Finally, it is noteworthy that the reduction in the direct effect of COVID-19 IU on Internet addiction was limited after the inclusion of depression and risk perception in the model, namely, the indirect effect was small. This suggests that we should interpret the mediating role of depression and risk perception with caution. Due to the multiwave nature of the epidemic, more research is needed to further explore the potentially important roles of depression and risk perception in this process.

CONCLUSION

The current study constructed a UDPA model to provide a unique perspective for understanding the effects of individual differences in COVID-19 IU on Internet addiction during the second wave of COVID-19. These findings indicate a positive association between COVID-19 IU and Internet addiction and provide evidence that this association is mediated by depression and risk perception. Higher levels of COVID-19 IU are more strongly correlated with depression and risk perception, which in turn relate to a higher likelihood of Internet addiction. The current study provides a better understanding of the mechanisms linking COVID-19 IU and Internet addiction based on the I-PACE model and proposes practical suggestions for individuals and governments to cope with the issue of Internet addiction in the context of repeated COVID-19 outbreaks.

DISCLOSURE OF CONFLICT OF INTEREST
The authors declare no conflicts of interest.

ORCID
Bibing Dai https://orcid.org/0000-0003-2460-9155
Xun Liu https://orcid.org/0000-0003-1366-8926

REFERENCES

Beck, A. T., Steer, R. A., & Brown, G. K. (1996). *Manual for the Beck Depression Inventory–II*. San Antonio, TX: Psychological Corporation.

Bendau, A., Plag, J., Kunas, S., Wyka, S., Ströhle, A., & Petzold, M. B. (2021). Longitudinal changes in anxiety and psychological distress, and associated risk and protective factors during the first three months of the COVID-19 pandemic in Germany. *Brain and Behavior*, 11(2), e01964. https://doi.org/10.1002/brb3.1964

Bokolo, A. J. (2021). Application of telemedicine and eHealth technology for clinical services in response to COVID-19 pandemic. *Health and Technology*, 11(2), 359–366. https://doi.org/10.1007/s12553-020-00516-4

Boswell, J. F., Thompson-Hollands, J., Farchione, T. J., & Barlow, D. H. (2013). Intolerance of uncertainty: A common factor in the treatment of emotional disorders. *Journal of Clinical Psychology*, 69(6), 630–645. https://doi.org/10.1002/jclp.21965

Brailovskaia, J., & Margraf, J. (2021). The relationship between burden caused by coronavirus (Covid-19), addictive social media use, sense of control and anxiety. *Computers in Human Behavior*, 119, 106720. https://doi.org/10.1016/j.chb.2021.106720

Brand, M., Wegmann, E., Stark, R., Müller, A., Wölfling, K., Robbins, T. W., & Potenza, M. N. (2019). The interaction of person-affect-cognition-execution (I-PACE) model for addictive behaviors: Update, generalization to addictive behaviors beyond internet-use disorders, and specification of the process character of addictive behaviors. *Neuroscience and Biobehavioral Reviews*, 104, 1–10. https://doi.org/10.1016/j.neubiorev.2019.06.032

Brand, M., Young, K. S., Laier, C., Wölfling, K., & Potenza, M. N. (2016). Integrating psychological and neurobiological considerations regarding the development and maintenance of specific internet-use disorders: An interaction of person-affect-cognition-execution (I-PACE) model. *Neuroscience and Biobehavioral Reviews*, 71, 252–266. https://doi.org/10.1016/j.neubiorev.2016.08.033

Bredemeier, K., & Berenbaum, H. (2008). Intolerance of uncertainty and perceived threat. *Behaviour Research and Therapy*, 46(1), 28–38. https://doi.org/10.1016/j.brat.2007.09.006

Brown, M., Robinson, L., Campione, G. C., Wuensch, K., Hildebrandt, T., & Micali, N. (2017). Intolerance of uncertainty in eating disorders: A systematic review and meta-analysis. *European Eating Disorders Review*, 25(5), 329–343. https://doi.org/10.1002/erv.2523

Buhr, K., & Dugas, M. J. (2002). The intolerance of uncertainty scale: Psychometric properties of the English version. *Behaviour Research and Therapy*, 40(8), 931–945. https://doi.org/10.1016/S0005-7967(01)00092-4

Carleton, R. N., Mulvogue, M. K., Thibodeau, M. A., McCabe, R. E., Antony, M. M., & Asmundson, G. J. G. (2012). Increasingly certain about uncertainty: Intolerance of uncertainty across anxiety and depression. *Journal of Anxiety Disorders*, 26(3), 468–479. https://doi.org/10.1016/j.janxdis.2012.01.011

Chang, F.-C., Chiu, C.-H., Lee, C.-M., Chen, P.-H., & Miao, N.-F. (2014). Predictors of the initiation and persistence of internet addiction among adolescents in Taiwan. *Addictive Behaviors*, 39(10), 1434–1440. https://doi.org/10.1016/j.addbeh.2014.05.010

Chen, J. T.-H., & Lovibond, P. F. (2016). Intolerance of uncertainty is associated with increased threat appraisal and negative affect under ambiguity but not uncertainty. *Behavior Therapy*, 47(1), 42–53. https://doi.org/10.1016/j.beth.2015.09.004

Ciccarelli, M., Griffiths, M. D., Nigro, G., & Cosenza, M. (2017). Decision making, cognitive distortions and emotional distress: A comparison between pathological gamblers and healthy controls. *Journal of Behavior Therapy and Experimental Psychiatry*, 54, 204–210. https://doi.org/10.1016/j.jbtep.2016.08.012

Coccia, M. (2021). The impact of first and second wave of the COVID-19 pandemic in society: Comparative analysis to support control measures to cope with negative effects of future infectious diseases. *Environmental Research*, 197, 111099. https://doi.org/10.1016/j.envres.2021.111099

Dai, B., Fu, D., Meng, G., Liu, B., Li, Q., & Liu, X. (2020). The effects of governmental and individual predictors on COVID-19 protective behaviors in China: A path analysis model. *Public Administration Review*, 80(5), 797–804. https://doi.org/10.1111/puar.13236

Dai, W., Meng, G., Zheng, Y., Li, Q., Dai, B., & Liu, X. (2021). The impact of intolerance of uncertainty on negative emotions in COVID-19: Mediation by pandemic-focused time and moderation by perceived efficacy. *International Journal of Environmental Research and Public Health*, *18*(8), 4189. https://doi.org/10.3390/ijerph18084189

Daly, Z., Slemon, A., Richardson, C. G., Salway, T., McAuliffe, C., Gadermann, A. M., Thomson, K. C., Hiran, S., & Jenkins, E. K. (2021). Associations between periods of COVID-19 quarantine and mental health in Canada. *Psychiatry Research*, *295*, 113631. https://doi.org/10.1016/j.psychres.2020.113631

Davis, R. A. (2001). A cognitive-behavioral model of pathological internet use. *Computers in Human Behavior*, *17*(2), 187–195. https://doi.org/10.1016/S0747-5632(00)00041-8

Dong, H., Yang, F., Lu, X., & Hao, W. (2020). Internet addiction and related psychological factors among children and adolescents in China during the coronavirus disease 2019 (COVID-19) epidemic. *Frontiers in Psychiatry*, *11*, e751. https://doi.org/10.3389/fpsyt.2020.00751

Duan, H., Yan, L., Ding, X., Gan, Y., Kohn, N., & Wu, J. (2020). Impact of the COVID-19 pandemic on mental health in the general Chinese population: Changes, predictors and psychosocial correlates. *Psychiatry Research*, *293*, 113396. https://doi.org/10.1016/j.psychres.2020.113396

Dugas, M. J., Schwartz, A., & Francis, K. (2004). Brief report: Intolerance of uncertainty, worry, and depression. *Cognitive Therapy and Research*, *28*(6), 835–842. https://doi.org/10.1007/s10608-004-0669-0

Fergus, T. A. (2013). Cyberchondria and intolerance of uncertainty: Examining when individuals experience health anxiety in response to internet searches for medical information. *Cyberpsychology, Behavior and Social Networking*, *16*(10), 735–739. https://doi.org/10.1089/cyber.2012.0671

Ford, J. A., & Blumenstein, L. (2012). Self-control and substance use among college students. *Journal of Drug Issues*, *43*(1), 56–68. https://doi.org/10.1177/0022042612462216

Frangos, C. C., Frangos, C. C., & Sotiropoulos, I. (2010). Problematic internet use among Greek university students: An ordinal logistic regression with risk factors of negative psychological beliefs, pornographic sites, and online games. *Cyberpsychology, Behavior and Social Networking*, *14*(1–2), 51–58. https://doi.org/10.1089/cyber.2009.0306

Fukase, Y., Ichikura, K., Murase, H., & Tagaya, H. (2021). Depression, risk factors, and coping strategies in the context of social dislocations resulting from the second wave of COVID-19 in Japan. *BMC Psychiatry*, *21*(1), 33. https://doi.org/10.1186/s12888-021-03047-y

Gillett, C. B., Bilek, E. L., Hanna, G. L., & Fitzgerald, K. D. (2018). Intolerance of uncertainty in youth with obsessive-compulsive disorder and generalized anxiety disorder: A transdiagnostic construct with implications for phenomenology and treatment. *Clinical Psychology Review*, *60*, 100–108. https://doi.org/10.1016/j.cpr.2018.01.007

Giuntella, O., Hyde, K., Saccardo, S., & Sadoff, S. (2021). Lifestyle and mental health disruptions during COVID-19. *Proceedings of the National Academy of Sciences*, *118*(9), e2016632118. https://doi.org/10.1073/pnas.2016632118

Ha, J. H., Kim, S. Y., Bae, S. C., Bae, S., Kim, H., Sim, M., Lyoo, I. K., & Cho, S. C. (2007). Depression and internet addiction in adolescents. *Psychopathology*, *40*(6), 424–430. https://doi.org/10.1159/000107426

Hafeez, S., Din, M., Zia, F., Ali, M., & Shinwari, Z. K. (2021). Emerging concerns regarding COVID-19; second wave and new variant. *Journal of Medical Virology*, *93*(7), 4108–4110. https://doi.org/10.1002/jmv.26979

Hamonniere, T., & Varescon, I. (2018). Metacognitive beliefs in addictive behaviours: A systematic review. *Addictive Behaviors*, *85*, 51–63. https://doi.org/10.1016/j.addbeh.2018.05.018

Hayes, A. F. (2013). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach*. Guilford Press.

Hillen, M. A., Gutheil, C. M., Strout, T. D., Smets, E. M. A., & Han, P. K. J. (2017). Tolerance of uncertainty: Conceptual analysis, integrative model, and implications for healthcare. *Social Science & Medicine*, *180*, 62–75. https://doi.org/10.1016/j.socscimed.2017.03.024

Ibuka, Y., Chapman, G. B., Meyers, L. A., Li, M., & Galvani, A. P. (2010). The dynamics of risk perceptions and precautionary behavior in response to 2009 (H1N1) pandemic influenza. *BMC Infectious Diseases*, *10*(1), 296. https://doi.org/10.1186/1471-2334-10-296

Jeong, B., Lee, J. Y., Kim, B. M., Park, E., Kwon, J.-G., Kim, D.-J., Leee, Y., Cho, J.-S., & Lee, D. (2020). Associations of personality and clinical characteristics with excessive internet and smartphone use in adolescents: A structural equation modeling approach. *Addictive Behaviors*, *110*, 106485. https://doi.org/10.1016/j.addbeh.2020.106485

Kardefelt-Winther, D. (2014). A conceptual and methodological critique of internet addiction research: Towards a model of compensatory internet use. *Computers in Human Behavior*, *31*, 351–354. https://doi.org/10.1016/j.chb.2013.10.059

Király, O., Potenza, M. N., Stein, D. J., King, D. L., Hodgins, D. C., Saunders, J. B., Griffiths, M. D., Gjoneska, B., Billieux, J., Brand, M., Abbott, M. W., Chamberlain, S. R., Corazza, O., Burkauskas, J., Sales, C. M. D., Montag, C., Lochner, C., Grünblatt, E., Wegmann, E., … Demetrovics, Z. (2020). Preventing problematic internet use during the COVID-19 pandemic: Consensus guidance. *Comprehensive Psychiatry*, *100*, 152180. https://doi.org/10.1016/j.comppsych.2020.152180

Kirisci, L., Tarter, R. E., Vanyukov, M., Reynolds, M., & Habeych, M. (2004). Relation between cognitive distortions and neurobehavior disinhibition on the development of substance use during adolescence and substance use disorder by young adulthood: A prospective study. *Drug and Alcohol Dependence*, *76*(2), 125–133. https://doi.org/10.1016/j.drugalcdep.2004.04.015

Ko, C. H., Yen, J. Y., Yen, C. F., Chen, C. S., & Chen, C. C. (2012). The association between internet addiction and psychiatric disorder: A review of the literature. *European Psychiatry*, *27*(1), 1–8. https://doi.org/10.1016/j.eurpsy.2010.04.011

Kraemer, K. M., McLeish, A. C., & O'Bryan, E. M. (2015). The role of intolerance of uncertainty in terms of alcohol use motives among college students. *Addictive Behaviors*, *42*, 162–166. https://doi.org/10.1016/j.addbeh.2014.11.033

Kroenke, K., Spitzer, R. L., & Janet, B. W. W. (2003). The patient health Questionnaire-2: Validity of a two-item depression screener. *Medical Care*, *41*(11), 1284–1292. https://doi.org/10.1097/01.MLR.0000093487.78664.3C

Ladouceur, R., Dugas, M. J., Freeston, M. H., Léger, E., Gagnon, F., & Thibodeau, N. (2000b). Efficacy of a cognitive–behavioral treatment for generalized anxiety disorder: Evaluation in a controlled clinical trial. *Journal of Consulting and Clinical Psychology*, *68*(6), 957–964. https://doi.org/10.1037/0022-006X.68.6.957

Ladouceur, R., Gosselin, P., & Dugas, M. J. (2000a). Experimental manipulation of intolerance of uncertainty: A study of a theoretical model of worry. *Behaviour Research and Therapy*, *38*(9), 933–941. https://doi.org/10.1016/S0005-7967(99)00133-3

Whang, L. S.-M., Lee, S., & Chang, G. (2003). Internet over-Users' psychological profiles: A behavior sampling analysis on internet addiction. *Cyberpsychology & Behavior*, *6*(2), 143–150. https://doi.org/10.1089/109493103321640338

Leppin, A., & Aro, A. R. (2009). Risk perceptions related to SARS and avian influenza: Theoretical foundations of current empirical research. *International Journal of Behavioral Medicine*, *16*(1), 7–29. https://doi.org/10.1007/s12529-008-9002-8

Li, C., Dang, J., Zhang, X., Zhang, Q., & Guo, J. (2014). Internet addiction among Chinese adolescents: The effect of parental behavior and self-control. *Computers in Human Behavior*, *41*, 1–7. https://doi.org/10.1016/j.chb.2014.09.001

Li, H., Chen, X., & Huang, H. (2020). The novel coronavirus outbreak: What can be learned from China in public reporting? *Global Health Research and Policy*, *5*(1), 9. https://doi.org/10.1186/s41256-020-00140-9

Li, H.-H., & Wang, S. (2013). The role of cognitive distortion in online game addiction among Chinese adolescents. *Children and Youth Services Review*, *35*(9), 1468–1475. https://doi.org/10.1016/j.childyouth.2013.05.021

Li, Q., Luo, R., Zhang, X., Meng, G., Dai, B., & Liu, X. (2021a). Intolerance of COVID-19-related uncertainty and negative emotions among Chinese adolescents: A moderated mediation model of risk perception, social exclusion and perceived efficacy. *International Journal of Environmental Research and Public Health*, *18*(6), 2864. https://doi.org/10.3390/ijerph18062864

Li, Y., Sun, Y., Meng, S., Bao, Y., Cheng, J., Chang, X., Ran, M.-S., Sun, Y.-K., Kosten, T., Strang, J., Lu, L., & Shi, J. (2021b). Internet addiction increases in the general population during COVID-19: Evidence from China. *The American Journal on Addictions*, *30*(4), 389–397. https://doi.org/10.1111/ajad.13156

Marci, T., Marino, C., Sacchi, C., Lan, X., & Spada, M. M. (2021). Problematic internet use in early adolescence: The role of attachment and negative beliefs about worry. *Journal of Behavioral Addictions*, *10*(1), 194–200. https://doi.org/10.1556/2006.2021.00001

Miranda, R., Fontes, M., & Marroquín, B. (2008). Cognitive content-specificity in future expectancies: Role of hopelessness and intolerance of uncertainty in depression and GAD symptoms. *Behaviour Research and Therapy*, *46*(10), 1151–1159. https://doi.org/10.1016/j.brat.2008.05.009

Montag, C., Bey, K., Sha, P., Li, M., Chen, Y.-F., Liu, W.-Y., Zhu, Y.-K., Li, C.-B., Markett, S., Keiper, J., & Reuter, M. (2015). Is it meaningful to distinguish between generalized and specific internet addiction? Evidence from a cross-cultural study from Germany, Sweden, Taiwan and China. *Asia-Pacific Psychiatry*, *7*(1), 20–26. https://doi.org/10.1111/appy.12122

Özdemir, Y., Kuzucu, Y., & Ak, Ş. (2014). Depression, loneliness and internet addiction: How important is low self-control? *Computers in Human Behavior*, *34*, 284–290. https://doi.org/10.1016/j.chb.2014.02.009

Peng, Y., Zhou, H., Zhang, B., Mao, H., Hu, R., & Jiang, H. (2022). Perceived stress and mobile phone addiction among college students during the 2019 coronavirus disease: The mediating roles of rumination and the moderating role of self-control. *Personality and Individual Differences*, *185*, 111222. https://doi.org/10.1016/j.paid.2021.111222

Priego-Parra, B. A., Triana-Romero, A., Pinto-Gálvez, S. M., Ramos, C. D., Salas-Nolasco, O., Reyes, M. M., Ramos-de-la-Medina, A., & Remes-Troche, J. M. (2020). Anxiety, depression, attitudes, and internet addiction during the initial phase of the 2019 coronavirus disease (COVID-19) epidemic: A cross-sectional study in México. *medRxiv*, 2005. 2010.20095844. http://doi.org/10.1101/2020.05.10.20095844

Rosen, N. O., Knäuper, B., & Sammut, J. (2007). Do individual differences in intolerance of uncertainty affect health monitoring? *Psychology & Health*, *22*(4), 413–430. https://doi.org/10.1080/14768320600941038

Rozgonjuk, D., Elhai, J. D., Täht, K., Vassil, K., Levine, J. C., & Asmundson, G. J. G. (2019). Non-social smartphone use mediates the relationship between intolerance of uncertainty and problematic smartphone use: Evidence from a repeated-measures study. *Computers in Human Behavior*, *96*, 56–62. https://doi.org/10.1016/j.chb.2019.02.013

Sexton, K. A., & Dugas, M. J. (2009). Defining distinct negative beliefs about uncertainty: Validating the factor structure of the intolerance of uncertainty scale. *Psychological Assessment*, *21*(2), 176–186. https://doi.org/10.1037/a0015827

Starcevic, V., Baggio, S., Berle, D., Khazaal, Y., & Viswasam, K. (2019). Cyberchondria and its relationships with related constructs: A network analysis. *Psychiatric Quarterly*, *90*(3), 491–505. https://doi.org/10.1007/s11126-019-09640-5

Yang, Q., van den Bos, K., & Li, Y. (2021). Intolerance of uncertainty, future time perspective, and self-control. *Personality and Individual Differences*, *177*, 110810. https://doi.org/10.1016/j.paid.2021.110810

Zung, W. W. K. (1965). A self-rating depression scale. *Archives of General Psychiatry*, *12*(1), 63–70. https://doi.org/10.1001/archpsyc.1965.01720310065008