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Intolerance of uncertainty and COVID-19-related post-traumatic stress disorder symptoms in US and Korean college students: serial mediation by COVID-19 concerns and loneliness

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Abstract

Background This cross-national study aims to identify risk factors and mechanisms for developing COVID-19-related post-traumatic stress disorder (PTSD) symptoms in college students from the US and Korea. Given the prevalence of traumatic stress reactions during the pandemic, PTSD symptoms serve as an important indicator of psychological maladjustment. College students, identified as a vulnerable population, are the focus of this research. To address the lack of cross-national studies on PTSD symptoms and related psychological factors, we recruited participants from the US and Korea—two countries with distinct cultural orientations (e.g., individualism vs. collectivism) and pandemic contexts. This sampling approach allowed us to test whether the same psychological pathways would be observed across culturally different contexts. Specifically, the study examines intolerance of uncertainty as a risk factor and investigates the mediating effects of COVID-19 concerns and loneliness on the relationship between intolerance of uncertainty and COVID-19-related PTSD symptoms.

Methods The study included 448 college students from the US and 674 college students from Korea, aged 18 to 29, who completed an online survey measuring intolerance of uncertainty, COVID-19 concerns, loneliness, and COVID-19-related PTSD symptoms. Data were collected from September 2020 to May 2021 in the US and in August 2021 in Korea. Mediation analyses were used to assess the indirect effects of intolerance of uncertainty on COVID-19-related PTSD symptoms through COVID-19 concerns and loneliness. We assessed the significance of indirect effects using bootstrap analyses with 5,000 resamples and 95% confidence intervals. Furthermore, we compared the differences in indirect effects between US and Korean students in each mediation model using a likelihood ratio test.

Results Preliminary analyses showed that US college students reported significantly higher levels of PTSD symptoms, loneliness, whereas Korean students reported greater COVID-19 concerns. Simple mediation analyses showed that

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COVID-19 concerns and loneliness were significant mediators in the relationship between intolerance of uncertainty and COVID-19-related PTSD symptoms in both samples. Additionally, COVID-19 concerns and loneliness had significant serial mediating effects on the relationship between intolerance of uncertainty and COVID-19-related PTSD symptoms in both samples. Lastly, the indirect effect of intolerance of uncertainty on COVID-19-related PTSD symptoms mediated by COVID-19 concerns was significantly higher among college students in the US.

Conclusions This study provides comprehensive insights into the mechanisms underlying COVID-19-related PTSD symptoms in college students from the US and Korea, emphasizing the roles of intolerance of uncertainty, COVID-19 concerns, and loneliness, which have implications for designing effective interventions and support strategies during the pandemic.

Keywords COVID-19, Intolerance of uncertainty, COVID-19 concerns, Loneliness, PTSD symptoms, College students

Introduction

The COVID-19 pandemic and associated health measures have brought about unprecedented changes to the lives of people worldwide, with a significant impact on mental health. Accordingly, the relationship between the COVID-19 pandemic and mental health has been extensively studied, with many studies focusing on post-traumatic stress disorder (PTSD) symptoms resulting from the pandemic. The COVID-19 pandemic was considered a traumatic event as a global and national threat [1–4], and studies reported that traumatic stress reactions were prevalent during the pandemic. Xiong et al. [5] confirmed a high level of PTSD among the general population in eight countries during the pandemic. A study of adults in Ireland, in which the prevalence of depression, anxiety, and PTSD were investigated before and after the pandemic, revealed that only the prevalence of PTSD showed a significant increase [6]. Yuan et al. [7] conducted a meta-analysis of 88 studies and found that PTSD was a prevalent issue among individuals who had experienced outbreaks of infectious diseases. A meta-analysis of 38 articles focusing exclusively on college students revealed that the prevalence of PTSD during COVID-19 was relatively high [8]. As such, COVID-19-related PTSD symptoms could be meaningful as major indicators for identifying the levels of maladjustment and distress caused by the pandemic.

In studies on PTSD symptoms caused by the pandemic, young adults and student status have been mentioned as risk factors [5, 6, 9]. College students have particularly been identified as members of a vulnerable population in many studies [4, 10]. For instance, in a study of nearly 2,500 US college students, approximately 45% reported high levels of symptoms associated with negative mental health outcomes, 17.4% of students reported increased anxiety, and 14.6% of students reported increased stress [11]. The college years represent a transition period between adolescence and adulthood, and because of the nature of this developmental stage, college students face various psychological crises during this period [12, 13]. Having to face stressful situations related to the COVID-19 pandemic during such a period could cause college students to experience even greater psychological distress compared with other age groups. Therefore, the risk factors and mechanisms of PTSD symptoms should be elucidated to prevent and reduce PTSD symptoms among college students during the pandemic.

This study focused on intolerance of uncertainty (IU) as a risk factor for PTSD symptoms. Inozu et al. [3] reported that IU can be asserted as a potential risk factor for psychological symptoms that have emerged during the COVID-19 pandemic, based on repeated evidence from previous studies. The COVID-19 pandemic is a traumatic event that has brought about great uncertainty; thus, IU would inevitably be considered a critical factor for explaining various psychological symptoms [14]. Understanding the pathways by which IU leads to specific mental disorders or psychological symptoms, such as PTSD, can be aided by the integrative model of uncertainty tolerance proposed by Hillen et al. [15]. According to this model, the perception of uncertainty triggers cognitive, emotional, and behavioral responses, which ultimately lead to the emergence of specific psychological symptoms. For example, when a person perceives great uncertainty about a situation, they perceive it as a threat (cognitive), feel worried and fearful (emotional), and avoid it (behavioral), and this chain of reactions is associated with the emergence of various mental disorders [3, 15]. As such, IU has been recognized as a specific target factor for treatment [16], and it has been reported that understanding how IU negatively affects emotional factors (e.g., constant worry) is important for significant symptom reduction [17]. In the present study, we aimed to examine the role of COVID-19 concerns and loneliness as emotional factors contributing to the development and maintenance of symptoms in the relationship between IU and PTSD symptoms. In the following sections, we first review recent empirical evidence linking IU to PTSD symptoms, and then provide the theoretical and empirical rationale for including COVID-19 concerns and loneliness as mediating emotional mechanisms in this relationship.

Intolerance of uncertainty (IU) and PTSD symptoms

IU is defined as a cognitive bias that affects how a person perceives, interprets, and responds to uncertain situations on cognitive, emotional, and behavioral levels [18]. Individuals who have a high level of such bias are easily agitated from not being able to tolerate uncertainty, which inevitably makes them vulnerable to anxiety and worry. Accordingly, IU has been investigated in relation to a variety of anxiety-related conditions [19], and findings on its relationship with PTSD symptoms have been introduced recently. Fetzner et al. [20] found IU to be significantly related to PTSD symptoms of avoidance, numbing, and arousal. Banducci et al. [21] showed that elevated IU is significantly associated with increased PTSD symptoms. A study on clinical samples of trauma-exposed individuals also found that IU is a significant predictor of PTSD symptoms even after controlling for anxiety sensitivity and negative affect [19]. Based on these previous findings and the aforementioned integrative model of uncertainty tolerance [15], the present study aimed to identify the specific path through which IU leads to PTSD symptoms.

COVID-19 concerns and loneliness as mediators

The present study posits COVID-19 concerns and loneliness as emotional mechanisms that mediate the relationship between IU and PTSD symptoms, drawing on a range of theoretical frameworks and empirical findings that underscore their psychological and behavioral relevance during the COVID-19 pandemic.

In this study, we define COVID-19 concerns as encompassing both fear of infection and worry about threats posed by the pandemic, including perceived danger and potential contamination. This conceptualization aligns with prior work suggesting that individuals' emotional responses to uncertainty during a pandemic involve both fear and worry about health-related risks [22]. According to Hillen's model, worry and fear are core emotional reactions triggered by perceived uncertainty. Individuals with high IU are prone to interpret ambiguous situations as threatening, which leads to heightened and sustained levels of fear and worry [18, 19, 23]. Consistent with this theoretical framework, empirical studies have shown that IU is positively associated with elevated levels of COVID-19-related fear or worry [24, 25]. Beyond being a consequence of IU, COVID-19 concerns may also serve as an emotional mechanism that exacerbates PTSD symptoms. Drawing from Ehlers & Clark's [26] cognitive model of PTSD, chronic worry may reinforce maladaptive cognitive patterns such as intrusive rumination, which are strongly associated with elevated PTSD symptoms in trauma-exposed individuals. Furthermore, the pandemic-related fear has been associated with increased physiological stress responses, contributing to the maintenance and intensification of trauma-related symptoms [27]. Empirical studies have also shown that higher levels of COVID-19 concerns are associated with greater PTSD symptom severity [28]. During the COVID-19 pandemic, research further demonstrated that fear or worry related to the virus mediates the relationship between IU and various mental health outcomes, including depression, mental well-being, and emotional eating [29–31]. These findings suggest that COVID-19 concerns not only reflects a consequence of IU but also functions as a reinforcing emotional mechanism that heightens susceptibility to PTSD.

Loneliness, another mediator in our study, is a distressing psychological experience that occurs when an individual feels their social connectedness is insufficient [32]. Loneliness is one of the emotional difficulties caused by the COVID-19 pandemic that most people experienced before social distancing rules were relaxed. The loneliness reported by many people during the pandemic is related to the uncertainty of the pandemic. According to Hillen et al.'s [15] model, IU promotes avoidance behavior from threatening situations; therefore, it is possible that individuals with high IU during COVID-19 experienced elevated loneliness due to social isolation, which involved minimizing social contact to reduce the threat of infection. This was supported by studies investigating the relationship between IU and loneliness during the pandemic. In a study involving older adults, Parlapani et al. [33] found that IU exacerbated feelings of loneliness. Similarly, Smith et al. [34] discovered that the impact of social isolation on distress became more pronounced with higher levels of IU. A study on workers in higher educational institutions in Pakistan during the pandemic found that loneliness mediates the relationship between IU and mental well-being [35]. Loneliness is also considered a potential risk factor that contributes to the development and maintenance of PTSD symptoms during the pandemic. In particular, the social ecology of PTSD proposed by Charuvastra and Cloitre [36] underscores the centrality of social connectedness in modulating emotional responses to trauma and shaping vulnerability to PTSD. Empirical findings support this theoretical link. For instance, a lack of perceived connectedness—or loneliness—has been shown to exacerbate PTSD symptoms [37, 38]. Studies conducted during the pandemic have found that loneliness is significantly associated with greater severity of PTSD symptoms [39]. These findings suggest that loneliness, as a consequence of IU, may contribute to both the onset and persistence of trauma-related symptoms during the COVID-19 pandemic.

Building on the mediating roles of COVID-19 concerns and loneliness, the present study further examines the possibility that these two constructs function sequentially within a broader explanatory pathway from IU to

PTSD symptoms. Individuals who experience greater fear of infection or worry about pandemic-related threats may engage in more avoidant behaviors—such as limiting social interaction or avoiding public spaces—which, in turn, contributes to reduced social connectedness and greater feelings of loneliness. This behavioral tendency is consistent with Protection Motivation Theory [40], which posits that individuals who perceive a health threat as highly severe and feel personally vulnerable are more likely to adopt avoidance-oriented coping behaviors. In the context of the COVID-19 pandemic, such avoidance—driven by COVID-19 concerns—may result in decreased social engagement and increased loneliness. Empirical findings support this hypothesis. For instance, in a study on U.S. adults, COVID-19-related worries predicted traumatic stress, mediated by social isolation [41]. A large cross-national study of approximately 3,500 individuals from four countries (the U.S., U.K., Norway, and Australia) conducted nine months after the initial outbreak found that concerns about the future were significantly associated with emotional loneliness and that pandemic-related worry influenced perceived loneliness [42]. Kayis et al. [43] similarly reported that fear of COVID-19 predicted poorer mental well-being, with loneliness operating as a mediating factor. These findings collectively support the notion that COVID-19 concern is not only a consequence of IU but also a behavioral catalyst that leads to reduced social interaction and increased loneliness. Within this framework, COVID-19 concern may serve as an initial emotional response that activates self-protective withdrawal behaviors, while loneliness represents a secondary emotional outcome rooted in disrupted social bonds. Thus, we propose that COVID-19 concern and loneliness function as sequential mediators in the relationship between IU and COVID-19-related PTSD symptoms. Testing this sequential mediation model offers insight into the cascading emotional and interpersonal mechanisms through which IU may translate into PTSD symptoms in the context of a global health crisis.

Meanwhile, this study set sex, age, and exposure to traumatic events before the COVID-19 pandemic as controlled variables. Research has identified that these variables influence fear or concern, loneliness, and PTSD symptoms. Specifically, women show higher levels of concern [44, 45], a greater sense of loneliness [46, 47], and greater vulnerability to PTSD symptoms [19, 45] than men. In studies targeting young adults in their twenties, age has shown significant positive correlations with anxiety, loneliness, and PTSD symptoms [48–50]. People with pre-existing trauma tend to show higher levels of fear or concern and loneliness, and greater vulnerability to PTSD symptoms than their counterparts [41].

The present study is significant for its identification of the underlying mechanisms that contribute to COVID-19-related PTSD in college students, providing theoretical and therapeutic implications. Although the confusion and uncertainty of the early stages of the pandemic have been greatly reduced in the post-COVID-19 era, the findings of this study will serve as important foundational data for planning PTSD prevention and intervention strategies regarding college students in disaster situations similar to COVID-19.

Comparison of college students in the US and South Korea

The present study compared the relationship between IU and COVID-19-related PTSD symptoms among college students in the United States (US) and South Korea, which are culturally distinct populations, at different points in the pandemic (e.g., extent of disease spread, vaccination rates, and control policies).

In general, the US has an individualistic culture, while South Korea has a collectivistic culture [51]. These cultural characteristics have been identified as contributing to differences in the levels of worry, anxiety, and loneliness experienced during the pandemic and influencing responses to mitigation policies. Research has shown that collectivist societies have lower levels of loneliness and higher levels of worry and anxiety about COVID-19 infection than individualistic societies [52–55]. Regarding prevention policies, measures such as social distancing and mandatory masks have been implemented slowly in individualistic societies because they emphasize individual freedom and autonomy [56]. Therefore, the present study compared college students in the US, an individualistic country, and in South Korea, a collectivistic country, to examine how these cultural differences affect the levels of IU, COVID-19 concerns, loneliness, and PTSD symptoms and the relationships between the variables.

The effects of the COVID-19 pandemic on the mental health of college students may vary depending on COVID-19 prevalence, vaccination rate, and government infection prevention and control measures. In our study, data were collected from US students (September 2020 to May 2021) and Korean students (August 2021) at different points during the pandemic. In the US, data were collected at the peak of the outbreak when the number of confirmed COVID-19 cases was increasing sharply and the vaccination rate was also increasing to the point of 50% of the population being vaccinated. Meanwhile, in South Korea, the number of confirmed cases had plateaued, and the vaccination rate reached approximately 30%, with higher rates among the older population (http://ourworldindata.org). Moreover, the US and Korea had differences concerning infection prevention and control guidelines issued by the government. The

US government implemented mitigation policies that focused on reducing the number of critical patients, such as establishing temporary hospitals and increasing the number of available hospital beds [57, 58]. Meanwhile, the Korean government focused on preventing the spread of infection by implementing extensive COVID-19 testing, contact tracing, early isolation of close contacts, and mandatory mask-wearing [57, 59]. Considering these epidemiological differences between the US and Korea, this study hypothesized that PTSD symptoms would be more prevalent among US college students than their Korean counterparts. This hypothesis was grounded in the assumption that individuals exposed to more severe pandemic-related conditions—such as higher infection and fatality rates—would experience greater psychological distress.

The present study aimed to compare cross-national differences in the relationship between IU and COVID-19-related PTSD symptoms by examining a sample of college students from two countries that experienced different environments and infection prevention as well as control measures during the COVID-19 pandemic. A comparative analysis of US and South Korean college students will provide insights into the way cultural characteristics influence how individuals respond to pandemic situations. This will provide empirical data to confirm that cultural characteristics should be carefully considered to reduce the incidence of PTSD and manage mental health more effectively during infectious disease disasters such as COVID-19.

The present study

This study aimed to identify the mediation effects of COVID-19 concerns and loneliness in the relationship between IU and COVID-19-related PTSD symptoms in US and Korean college students. We also aimed to test the serial mediation effects of COVID-19 concerns and loneliness to specify the psychological mechanism that can explain the path by which IU affects COVID-19-related PTSD symptoms. For such objectives, the following hypotheses were established:

• **hypothesis 1** • IU is positively related to COVID-19-related PTSD symptoms.

• **hypothesis 2** • COVID-19 concerns mediate the relationship between IU and COVID-19-related PTSD symptoms.

• **hypothesis 3** • Loneliness mediates the relationship between IU and COVID-19-related PTSD symptoms.

• **hypothesis 4** • COVID-19 concerns and loneliness sequentially mediate the relationship between IU and COVID-19-related PTSD symptoms.

The study also planned for a more detailed examination of the differences between the two countries by performing an additional analysis on the comparison of the indirect effects between US and Korean students for each mediation model while testing the aforementioned hypotheses.

Methods

Participants and procedure

The cross-sectional online survey was conducted from September 2020 to May 2021 in the US and in August 2021 in South Korea. The inclusion criteria for participants were as follows: (1) students enrolled in colleges/universities during the COVID-19 pandemic, and (2) those who voluntarily agreed to participate in the study. The participants were recruited through REDCap, an online survey platform in the US, and EMBRAIN, an online survey company in Korea. Ethical approval for the study was obtained from the Institutional Review Board of Columbia University in the US (Protocol Number: 7994) and Yonsei University in Korea (Approval Number: 7001988-202106-HR-1244-02). All participants were informed of their right to discontinue the survey at any time without prejudice and were guaranteed anonymity and confidentiality. Written informed consent was obtained from all participants.

To align with our focus on young adulthood, only data from individuals between the ages of 18 and 29 who were enrolled as undergraduate students in 4-year universities were considered. In the US, a total of 448 participants were included in the analysis. The US sample comprised 359 females (80.1%) and 89 males (19.9%), with a mean age of 21.04 years (SD = 2.23). Regarding participants' racial/ethnic backgrounds, 55.1% were white, 19.2% were Hispanic, 11.6% were Asian, 2.9% were African American, and 11.2% were classified as other/mixed/unknown. In terms of year in school, 32.4% were freshmen, 21.8% were sophomores, 27.0% were juniors, and 17.6% were seniors. In Korea, a total of 674 participants were included in the analysis. The Korean sample comprised 476 females (70.6%) and 198 males (29.4%), with a mean age of 22.26 years (SD = 2.13). All participants shared the same ethnic background. In terms of the participants' year in school, 12.2% were freshmen, 24.0% were sophomores, 26.4% were juniors, and 37.3% were seniors.

Measures

Intolerance of uncertainty

We measured IU using the short version of the Intolerance of Uncertainty Scale (12 items) developed by Carleton et al. [60] This scale comprises items designed to

measure prospective and inhibitory anxiety in uncertain situations, including items such as "Unforeseen events upset me greatly" and "Uncertainty keeps me from living a full life." Each item was rated on a five-point Likert scale (1 = *Not at all characteristic of me* to 5 = *Entirely characteristic of me*). The reliability (Cronbach's α) of the scale was 0.91 in Carleton et al.'s study [35] and 0.88 in the US and 0.90 in Korea in our study.

COVID-19 concerns

We measured COVID-19 concerns using the COVID-19 Stress Scales developed by Taylor et al. [22] It comprises 36 items in five domains (COVID-19 danger and contamination fears; COVID-19 fears about economic consequences; COVID-19 xenophobia; COVID-19 compulsive checking and reassurance seeking; and COVID-19 traumatic stress symptoms). We used six items related to COVID-19 danger and contamination fears, such as "I am worried about catching the virus" and "I am worried that our healthcare system won't be able to protect my loved ones." Each item was rated on a five-point Likert scale (1 = *Not at all* to 5 = *Extremely*). The reliability (Cronbach's α) of the scale was 0.94 to 0.95 in Taylor et al.'s study [50], and 0.92 in both the US and Korea samples in our study.

Loneliness

We measured loneliness in the past two weeks using the five-item version of the revised UCLA Loneliness Scale. Example items are "I felt alone and apart from others" and "I felt lonely." Each item was rated on a five-point Likert scale (1 = *Never* to 5 = *Always*). The reliability (Cronbach's α) of the scale was 0.94 in the US and 0.96 in Korean samples in our study, respectively.

COVID-19-related PTSD symptoms

We measured COVID-19-related PTSD symptoms using the Primary Care PTSD Screen for DSM-5 (PC-PTSD-5) developed by Prins et al. [61] PC-PTSD-5 is a dichotomous scale (*No* = 0, *Yes* = 1) comprising five items used to screen for possible PTSD in primary care settings. Each participant can have a total score ranging between 0 and 5 points, and the optimally sensitive cutoff score is 3 points [61, 62]. The respondents were instructed to answer each question as they recalled the traumatic event they had experienced. In this study, the event was limited to the COVID-19 pandemic; we measured COVID-19-related PTSD symptoms in the past month. The items included "Had nightmares about COVID-19 or thought about COVID-19 when you did not want to" and "Been constantly on guard, watchful, or easily startled." With a cutoff of 3 points, the prevalence of COVID-19-related PTSD symptoms in the US and Korean samples was 37.95% and 16.46%, respectively. In previous studies, PC-PTSD-5 demonstrated good diagnostic accuracy and clinical utility in primary care settings [61], as well as good test-retest reliability (r = .89), concurrent validity (r = .81), and internal consistency (Cronbach's α = 0.87) [62]. In this study, Cronbach's α was 0.69 in the US and 0.68 in Korean samples, respectively.

Control variables

We used sex (*male* = 0, *female* = 1), age, and pre-existing traumatic events before the COVID-19 pandemic (*No* = 0, *Yes* = 1) as control variables. For pre-existing traumatic events, the participants were presented with eight categories (natural disaster, terrorist or mass shooting event, transportation accident, exposure to toxic substance, physical assault, assault with a weapon, sexual assault, and combat or exposure to a warzone) and specific events under each category (for terrorist or mass shooting events, examples included 9/11, Oklahoma City bombing, Pulse nightclub shooting, and Parkland High School shooting). The participants were asked whether they had experienced the event themselves, witnessed the event happening to someone else, or became aware of an event that happened to a close family member or friend. Since the category of terrorist or mass shooting events included events that occurred in the US as examples, the version of the scale used in South Korea excluded this category and used only seven categories.

Data analyses

Data analyses were performed using IBM SPSS Statistics for Windows 25.0 and Mplus 7.0. First, the percentage of missing data varied widely, from approximately 1% (loneliness) to 10% (PTSD symptoms) in the US and from approximately 1% (loneliness) to 8% (PTSD symptoms) in the Korean samples. Accordingly, we used the multiple imputation technique to handle missing data. Second, descriptive statistics and correlation analyses were performed on the major variables used in the study, and the differences in the variables between the US and Korean college students were tested using chi-squared and independent t-test analyses. Third, the mediation models were examined through a series of path analyses, using the maximum likelihood (ML) estimator. Simple mediation analyses were conducted to examine the indirect effect of IU on PTSD symptoms through COVID-19 concerns (IU → COVID-19 concerns → PTSD symptoms) and through loneliness (IU → loneliness → PTSD symptoms). Next, a serial mediation analysis was performed to explore the mediating roles of COVID-19 concerns and loneliness in the relationship between IU and PTSD symptoms (IU → COVID-19 concerns → loneliness → PTSD symptoms). We determined the significance of all indirect effects by bootstrap analyses with 5,000 resamples and 95% confidence intervals (CI). If the

CI did not include a zero, then the indirect effect was assumed to be significant [63]. Lastly, a multi-group path analysis was used to evaluate differences in the indirect effects between US and Korean students in each mediation model. The likelihood ratio test, a method examining group differences in the indirect effects by chi-squared analysis results, was utilized [64]. To evaluate the goodness of fit of the models, we employed several fit indices, including the comparative fit index (CFI), standardized root mean square residual (SRMR), and root mean square error of approximation (RMSEA). The CFI greater than 0.90, and SRMR and RMSEA of 0.80 or lower were considered to indicate an acceptable model, as suggested by Browne and Cudeck [65] and Hu and Bentler [66]. Statistical significance was defined as a P-value < 0.05.

Prior to conducting analyses to test research hypotheses, we evaluated the construct validity of the measures. To achieve this, we established a four-factor measurement model consisting of IU, COVID-19 concerns, loneliness, and PTSD symptoms. The results showed that the four-factor model provided satisfactory fits in both samples (US: $\chi^2 = 985.940$, $df = 341$, CFI = 0.903, SRMR = 0.066, RMSEA = 0.065; Korea: $\chi^2 = 775.987$, $df = 341$, CFI = 0.923, SRMR = 0.054, RMSEA = 0.062).

Results

Preliminary analyses

Table 1 shows the descriptive statistics and correlation analysis results. The correlation analysis results showed positive correlations among IU, COVID-19 concerns, loneliness, and PTSD symptoms in both the US and Korean samples. Meanwhile, the control variable, sex, showed significantly positive correlations with only IU and PTSD symptoms in the US sample and only COVID-19 concerns, loneliness, and PTSD symptoms in the Korean sample. The other control variable, pre-existing traumatic events, showed significantly positive correlations with only loneliness and PTSD symptoms in the US sample and only IU, loneliness, and PTSD symptoms in the Korean sample. However, age did not show significant correlations with IU, COVID-19 concerns, loneliness, and PTSD symptoms in either the US or Korean samples. Therefore, only sex and pre-existing traumatic events were considered as controlled variables in hypothesis testing. In both the US and Korean samples, all variables had skewness less than 3.0 and kurtosis less than 8.0, indicating normal distribution [67]. Collinearity diagnostics results showed that the highest variance inflation factor value was 1.17 in the US sample and 1.20 in the Korean sample, which indicated that there was no problem with multicollinearity.

The chi-squared analysis results showed no significant difference in sex ratio between the US and Korean samples ($\chi^2(1) = 12.79$, $p < .001$). Independent t-test analyses results showed no significant difference in IU ($t(1120) = -0.09$, $p = .93$) but significant differences in pre-existing traumatic events ($t(1120) = 5.97$, $p < .001$), COVID-19 concerns ($t(1080) = -5.42$, $p < .001$), loneliness ($t(1078) = 9.72$, $p < .001$), and PTSD symptoms ($t(989) = 10.01$, $p < .001$) between the US and Korean participants. The US participants showed higher levels of pre-existing traumatic events (US: $M = 1.15$; Korea: $M = 0.73$), loneliness (US: $M = 14.86$; Korea: $M = 11.23$), and PTSD symptoms (US: $M = 2.07$; Korea: $M = 1.15$), whereas the Korean participants showed higher levels of COVID-19 concerns (US: $M = 15.52$; Korea: $M = 17.85$).

Simple mediation analyses

To test whether COVID-19 concerns and loneliness mediated the relationship between IU and COVID-19-related PTSD symptoms, we performed simple mediation analyses on the US and Korean samples (Fig. 1). Concerning the mediation effect of COVID-19 concerns, the models provided a perfect fit in both the US and Korean samples because they used all degrees of freedom to estimate the paths (i.e., $\chi^2 = 0$, $df = 0$, CFI = 1.00, SRMR = 0.00,

Table 1 Means, standard deviations, correlation coefficients of each study variable

Variable	1	2	3	4	5	6	7
1. Sex	-	−0.31**	-0.03	0.026	0.28**	0.17**	0.20**
2. age	−0.09	-	0.00	0.03	−0.05	−0.01	−0.07
3. Pre-existing Traumatic events	0.00	0.05	-	0.17**	0.05	0.19**	0.27**
4. Intolerance of Uncertainty	0.15**	0.01	0.05	-	0.22**	0.31**	0.28**
5. COVID-19 concerns	0.08	0.09	0.06	0.30**	-	0.26**	0.32**
6. Loneliness	0.06	−0.03.	0.22**	0.25**	0.22**	-	0.51**
7. PTSD symptoms	0.19**	0.01	0.23**	0.33**	0.38**	0.43**	-
M (US/Korean)	-	21.04 / 22.26	1.15 / 0.73	3.13 / 3.14	2.59 / 3.00	3.00 / 2.25	2.07 / 1.15
SD (US/Korea)	-	2.23 / 2.13	1.03 / 1.26	0.77 / 0.72	1.16 / 1.14	1.22 / 1.17	1.57 / 1.35
Skewness (US / Korea)	-	1.36 / 0.65	1.16 / 1.93	0.13 / 0.01	0.44 / −0.24	−0.18 / 0.52	0.31 / 1.15
Kurtosis (US / Korea)	-	2.08 / 0.11	1.27 / 5.46	−0.42 / −0.28	−0.75 / −0.97	-1.02 / −0.84	−0.96 / 0.54

M, mean; *SD*, standard deviation; Correlation coefficients of US participants are below the diagonal, Correlation coefficients of Korean participants are above the diagonal. **$p < .01$

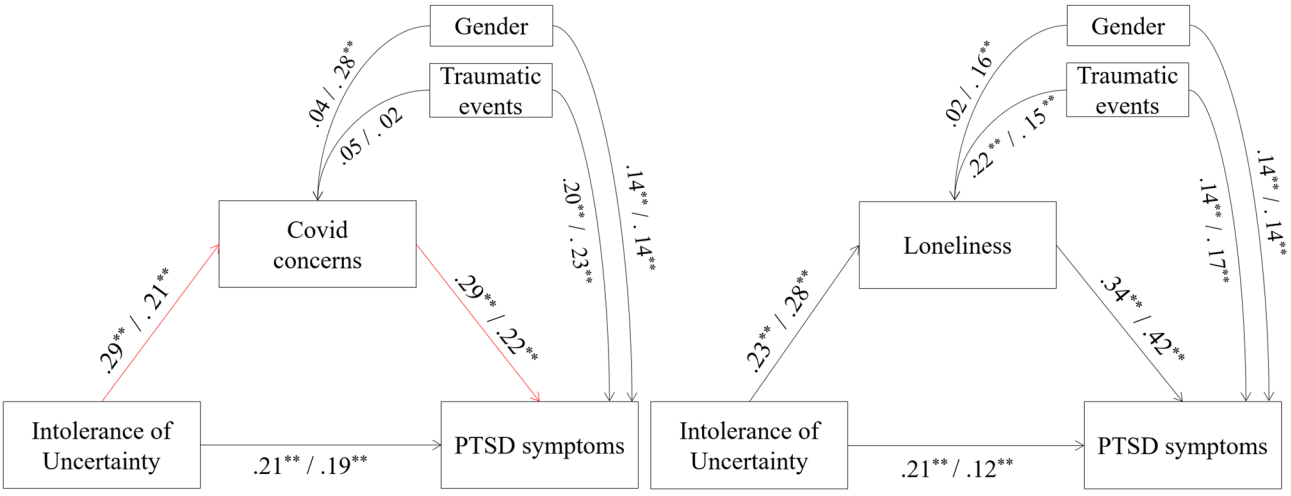

Fig. 1 Simple mediation analyses of COVID-19 concerns and loneliness in the relation between intolerance of uncertainty and COVID-19-related PTSD symptoms. Two standardized coefficients on the path are US / Korea. Red arrows indicate significant differences in the indirect effect between the US and Korean samples. $^{**}p<.01$

RMSEA = 0.00). IU was significantly and positively related to PTSD symptoms (US: $\beta = 0.21$, $p<.001$; Korea: $\beta = 0.19$, $p<.001$) and COVID-19 concerns (US: $\beta = 0.29$, $p<.001$; Korea: $\beta = 0.21$, $p<.001$) in both countries. We also found COVID-19 concerns to be significantly and positively related to PTSD symptoms (US: $\beta = 0.29$, $p<.001$; Korea: $\beta = 0.22$, $p<.001$). Bootstrapping analyses results on the significance of the indirect effect of IU on PTSD symptoms through COVID-19 showed that 95% upper- and lower-level CIs did not include 0 in both countries, confirming that the indirect effect was significant (US: 95% CI: [0.009, 0.021]; Korea: 95% CI: [0.004, 0.011]).

Concerning the mediation effect of loneliness, the models provided a perfect fit in both the US and Korean samples because they also used all degrees of freedom to estimate the paths (i.e., $\chi^2 = 0$, $df = 0$, CFI = 1.00, SRMR = 0.00, RMSEA = 0.00). IU was significantly and positively related to PTSD symptoms (US: $\beta = 0.21$, $p<.001$; Korea: $\beta = 0.12$, $p<.001$) and loneliness (US: $\beta = 0.23$, $p<.001$; Korea: $\beta = 0.28$, $p<.001$) in both countries. Loneliness was significantly and positively related to PTSD symptoms (US: $\beta = 0.34$, $p<.001$; Korea: $\beta = 0.42$, $p<.001$). Bootstrapping analyses results on the significance of the indirect effect of IU on PTSD symptoms through loneliness showed that 95% upper- and lower-level CIs did not include 0 in both countries, confirming that the indirect effect was significant (US: 95% CI: [0.008, 0.020]; Korea: 95% CI: [0.013, 0.025]).

Serial mediation analyses

We tested the serial mediation of COVID-19 concerns and loneliness in the relationship between IU and PTSD symptoms in the US and Korean data (Table 2; Fig. 2). The models provided a perfect fit in both the US and Korean samples because they used all degrees of freedom to estimate the paths (i.e., $\chi^2 = 0$, $df = 0$, CFI = 1.00, SRMR = 0.00, RMSEA = 0.00). IU had a significant and positive effect on COVID-19 concerns (US: $\beta = 0.29$, $p<.001$; Korea: $\beta = 0.21$, $p<.001$) and loneliness (US: $\beta = 0.19$, $p<.001$; Korea: $\beta = 0.24$, $p<.001$) in both countries. COVID-19 concerns had a positive effect on loneliness (US: $\beta = 0.15$, $p<.001$; Korea: $\beta = 0.17$, $p<.001$) and PTSD symptoms (US: $\beta = 0.42$, $p<.001$; Korea: $\beta = 0.16$, $p<.001$) when the effect of IU was controlled. Loneliness had a positive effect on PTSD symptoms (US: $\beta = 0.31$, $p<.001$; Korea: $\beta = 0.39$, $p<.001$) when the effects of IU and COVID-19 concerns were controlled.

Bootstrapping analyses results on the significance of the indirect effects showed that the indirect effects through the paths of IU → COVID-19 concerns → PTSD symptoms (US: 95% CI: [0.007, 0.018]; Korea: 95% CI: [0.003, 0.008]) and IU → Loneliness → PTSD symptoms (US: 95% CI: [0.005, 0.016]; Korea: 95% CI: [0.010, 0.021]) were significant in both samples. Moreover, the indirect effect of the serial mediation model (IU → COVID-19 concerns → Loneliness → PTSD symptoms) was significant in both countries (US: 95% CI: [0.001, 0.005]; Korea: 95% CI: [0.001, 0.004]).

Comparing indirect effects between the US and Korea

Comparison of the US and Korean samples in the simple mediation models showed a significant difference in the indirect effect of the IU → COVID-19 concerns → PTSD symptoms path ($\chi^2(1) = 3.999$, $p = .045$, CFI = 0.99, SRMR = 0.02, RMSEA = 0.07). However, the difference in the indirect effect of the IU → Loneliness → PTSD symptoms path was not significant ($\chi^2(1) = 1.078$, $p = .299$, CFI = 1.00, SRMR = 0.01, RMSEA = 0.01). The difference in the indirect effects between the US and Korean samples in the serial mediation model (IU → COVID-19

Table 2 Results of serial mediation model test (US / Korea)

	B	SE	*p*	95% CI Lower level	95% CI Upper level
PTSD symptoms on:					
IU	0.03 / 0.02	0.01 / 0.01	0.00 / 0.00	0.01 / 0.00	0.04 / 0.03
COVID-19 concerns	0.06 / 0.03	0.01 / 0.01	0.00 / 0.00	0.04 / 0.02	0.07 / 0.04
Loneliness	0.08 / 0.09	0.01 / 0.01	0.00 / 0.00	0.06 / 0.07	0.10 / 0.11
Sex	0.52 / 0.28	0.14 / 0.09	0.00 / 0.00	0.02 / 0.11	0.79 / 0.45
Pre-existing traumatic events	0.17 / 0.23	0.05 / 0.05	0.00 / 0.00	0.07 / 0.14	0.26 / 0.33
COVID-19 concerns on:					
IU	0.22 / 0.17	0.04 / 0.03	0.00 / 0.00	0.15 / 0.11	0.29 / 0.22
Sex	0.68 / 4.17	0.82 / 0.58	0.41 / 0.00	-0.02 / 3.03	2.31 / 5.31
Pre-existing traumatic events	0.25 / 0.13	0.25 / 0.27	0.33 / 0.62	-0.24 / -0.41	0.74 / 0.64
Loneliness on:					
IU	0.13 / 0.16	0.03 / 0.03	0.00 / 0.00	0.06 / 0.12	0.18 / 0.22
COVID-19 concerns	0.13 / 0.14	0.05 / 0.04	0.00 / 0.00	0.04 / 0.08	0.22 / 0.22
Sex	0.14 / 1.48	0.75 / 0.48	0.85 / 0.00	-1.35 / 0.50	1.59 / 2.40
Pre-existing traumatic events	1.02 / 0.04	0.24 / 0.23	0.00 / 0.00	0.56 / 0.38	1.50 / 1.26
Results of bootstrapping analyses					
		Effect	**Boot*SE***	**95% CI Lower level**	**95% CI Upper level**
Total effect		0.050 / 0.037	0.008 / 0.006	0.035 / 0.026	0.065 / 0.049
IU → COVID-19 concerns → PTSD symptoms		0.012 / 0.005	0.003 / 0.001	0.007 / 0.003	0.018 / 0.008
IU → Loneliness → PTSD symptoms		0.010 / 0.015	0.003 / 0.003	0.005 / 0.010	0.016 / 0.021
IU → COVID-19 concerns → Loneliness → PTSD symptoms		0.002 / 0.002	0.001 / 0.001	0.001 / 0.001	0.005 / 0.004

B, unstandardized coefficients; *SE*, standard error; Bootstrap sample size = 5000; CI, confidence interval

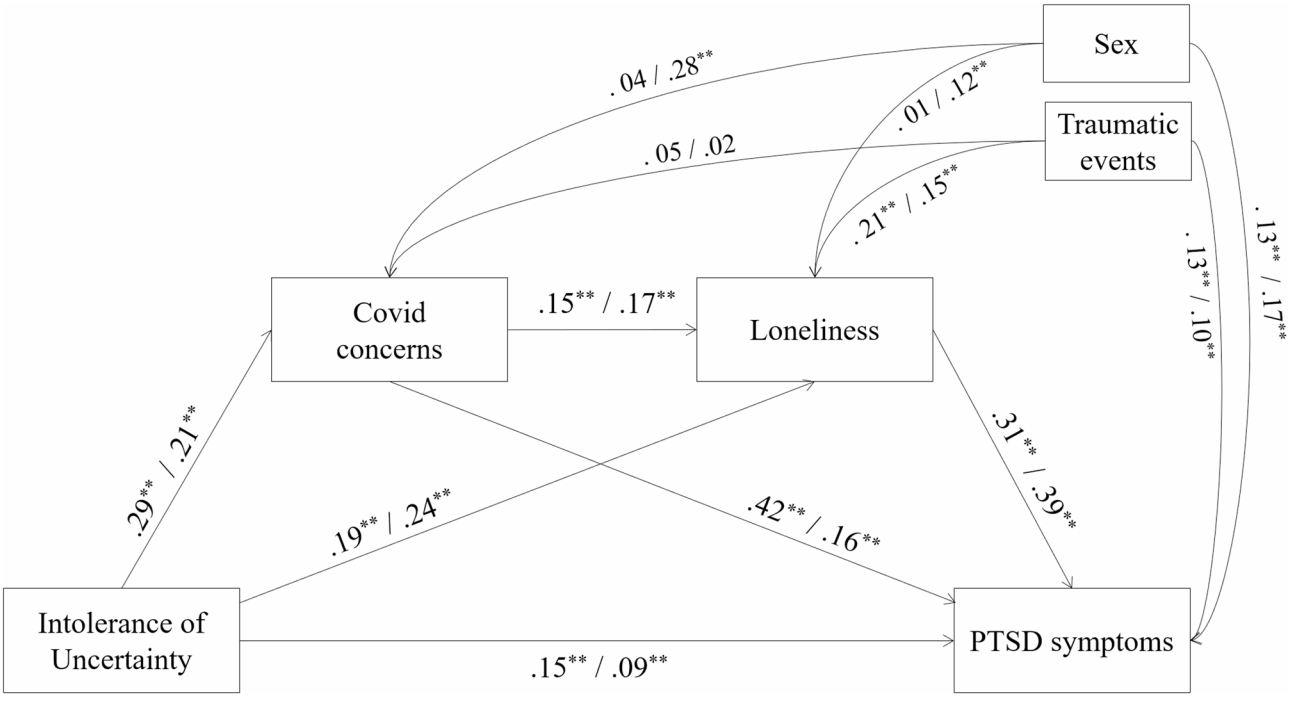

Fig. 2 Serial mediation analyses of COVID-19 concerns and loneliness in the relation between intolerance of uncertainty and COVID-19-related PTSD symptoms. Two standardized coefficients on the path are US / Korea. $^{**}p < .01$

concerns → Loneliness → PTSD symptoms) was not significant ($\chi^2(1) = 0.014$, $p = .906$, CFI = 1.00, SRMR = 0.00, RMSEA = 0.00).

Discussion

This study aimed to promote an understanding of the mechanisms that develop PTSD symptoms through a comprehensive examination of the roles of COVID-19 concerns and loneliness in the effect of IU on COVID-19-related PTSD symptoms in US and Korean college students. The major findings based on the research hypotheses were as follows.

First, IU can significantly and positively predict COVID-19-related PTSD symptoms, supporting Hypothesis 1. Such findings were consistent with previous studies reporting that individuals with high IU may become easily agitated amid uncertain situations and overestimate the threats, which can increase the likelihood of PTSD symptoms [19–21, 23]. Given the high infectivity of COVID-19 that threatens human health and lives, the COVID-19 pandemic could be considered a traumatic event [1, 2, 4]. Throughout the data collection phase for this study, the cumulative count of confirmed COVID-19 cases and associated fatalities exhibited marked elevation in the US compared to Korea. Correspondingly, the prevalence of PTSD symptoms within our study sample was higher in the US. Nevertheless, consistent results were found in data from both the US and Korean samples—the effects of IU on PTSD symptoms could not be differentiated between the two countries. These findings demonstrate that IU is a significant variable in explaining PTSD symptoms, even across diverse pandemic circumstances.

Second, COVID-19 concerns showed a significant mediation effect on the relationship between IU and COVID-19-related PTSD symptoms in both the US and Korean samples, supporting Hypothesis 2. The finding showed that in a pandemic situation, individuals with high IU would perceive a greater risk of COVID-19 infection, increasing fear and anxiety about infection, and these pathological and excessive concerns would then lead to PTSD symptoms. Studies have already identified IU as a major factor for predicting worry or anxiety [18, 19] and that high levels of anxiety can result in serious stress reactions to trauma [68]. Our findings could be viewed in the same context as the results reported in previous studies, while also being consistent with the latest research results reporting identification of the mediating effects of fear of COVID-19 infection on the association between IU and mental health issues [29–31].

Third, loneliness showed a significant mediation effect on the relationship between IU and COVID-19-related PTSD symptoms in both the US and Korean samples, supporting Hypothesis 3. Among college students in both countries, those with higher IU had higher levels of perceived loneliness, and such elevated loneliness was likely to increase the manifestation of PTSD symptoms. Individuals with high IU tend to display concurrent cognitive, emotional, and behavioral responses, with their behavioral reactions often oriented toward avoiding uncertain situations [15]. In the context of COVID-19, individuals with high IU have been observed to engage in behaviors such as distancing themselves from social gatherings to minimize exposure to uncertain situations and potential infection [69]. Consequently, the avoidance response observed in individuals with high IU may contribute to heightened feelings of loneliness stemming from social isolation. Previous research has demonstrated a significant association between this loneliness and the development of PTSD symptoms [70]. Given the overall lack of research examining the relationship between IU, loneliness, and PTSD symptoms, our results are meaningful as data that empirically validate the relationship between these factors. Based on these findings, loneliness works as a bridge between IU and PTSD symptoms.

Fourth, we found significant serial mediation effects of COVID-19 concerns and loneliness in the relationship between IU and COVID-19-related PTSD symptoms in both the US and Korean samples, supporting Hypothesis 4. Despite the absence of direct evidence from previous studies on the relationship between IU, COVID-19 concerns, loneliness, and COVID-19-related PTSD symptoms, some studies have identified the role of concerns in promoting loneliness [41–43, 47]. Our findings were consistent with previously reported results, showing that individuals with high IU tend to have higher levels of COVID-19 concerns, suggesting the possibility of the path by which it can lead to loneliness, which can facilitate the manifestation of COVID-19-related PTSD symptoms. Given that individuals with high IU become easily agitated in uncertain situations and worry excessively, they may overestimate the dangers of COVID-19 and have a greater fear of infection. Therefore, such individuals are likely to minimize their social relationships to reduce the risk of infection, which could lead to loneliness that consequently makes them more vulnerable to PTSD.

Lastly, our cross-national study on US and Korean college students also attempted to explore differences between the two countries. The analyses results showed significant differences between the US and Korean samples concerning the level of COVID-19 concerns, loneliness, and PTSD symptoms. The PTSD symptoms were greater in the US compared to Korea. In the context of COVID-19, the substantial increase in confirmed cases and experiences of losing someone to the virus were considered pivotal factors contributing to PTSD symptoms [4, 8]. During the data collection phase for the US sample, the cumulative COVID-19-related fatalities in the US

ranged from 189,515 to 591,460. Simultaneously, during the data collection for the Korean sample, the cumulative number of deaths in Korea ranged from 2,099 to 2,292. These distinct phases in the evolution and impact of COVID-19 seemingly accounted for differences in PTSD scores between the two countries. For COVID-19 concerns and loneliness, Korea demonstrated a higher level of COVID-19 concerns but a lower level of loneliness compared to the US. Previous research has indicated that collectivist societies have higher levels of worry and anxiety about COVID-19 infection and lower levels of loneliness than individualistic societies [53, 55]. These studies explain that in collectivist cultures, where there is a greater sense of interconnectedness, close relationships can lead to greater fear and worry of being infected from family, friends, and coworkers, as well as a fear of infecting others. Research has also shown that social connectedness in collectivistic cultures has a protective effect toward loneliness [52, 54]. According to Hofstede's classification [51], the US is considered an individualistic country, whereas Korea is classified as a collectivist country. The findings of our study align with and contribute to existing research on cultural disparities in the context of the COVID-19 pandemic, providing additional support to the notion that cultural characteristics influence individuals' responses to the pandemic.

The comparison of indirect effects between the US and Korea showed a statistically significant difference between the two countries concerning the indirect effect of IU on COVID-19-related PTSD symptoms through COVID-19 concerns, with a larger indirect effect found in US college students. This difference could be related to the individualistic cultural characteristics of the US and its relatively high prevalence of PTSD. First, with respect to cultural characteristics, the data collection period in the US coincided with the peak outbreak of the pandemic, but epidemic prevention measures were loosely implemented. Individualistic societies, emphasizing individual freedom, autonomy, and independence, such as the US, were slower to adopt measures like lockdowns, social distancing, and face mask mandates [56]. Citizens often resisted these epidemic prevention measures, demanding that the government respect their freedom, leading to higher numbers of confirmed COVID-19 cases and deaths [71, 72]. In this environment of less stringent social control to curb the virus's spread, individuals with high levels of IU may experience greater worry, consequently contributing to higher levels of PTSD. Hence, the mediating effect of COVID-19 concerns on the relationship between IU and PTSD symptoms may have appeared stronger in the US samples. These findings suggest that in individualistic societies with less strict epidemic prevention measures during COVID-19, the emotional and mental health of individuals with high IU may warrant increased attention. Second, in terms of prevalence, 37.95% of the US participants in this study reported experiencing PTSD-related symptoms, which is more than twice the prevalence rate of 16.46% reported in Korea. This means that the US samples can be considered a high-risk group for PTSD compared to the Korean samples. Previous studies have shown that physical and cognitive concerns are strongly associated with the development and maintenance of PTSD symptoms [73, 74]. Therefore, it is possible that the mediating effect of COVID-19 concerns as a risk factor was greater in the US sample, which experienced more PTSD symptoms than the Korean sample.

The simple and serial mediation effects assumed in this study showed partially different effect sizes, but the mediation effects in both countries were significant. The same paths were confirmed in both countries as well. This demonstrated that differences in levels of psychological factors or mental health aspects may appear depending on the pandemic situation or characteristics of each country, however, the relationship between variables associated with PTSD symptoms appeared similar in both countries. Our findings provide a basis for designing common intervention methods for college students who may be more vulnerable in disaster situations such as the COVID-19 pandemic. Traumatic events and disasters involve various uncertainties that tend to increase anxiety and worry [22], thus interventions need to target the reduction of uncertainty. Also, to prevent PTSD in college students with high IU, practitioners should identify students' levels of concerns and loneliness and provide interventions for them.

This study has theoretical implications in terms of identifying the underlying mechanism behind COVID-19-related PTSD symptoms and expanding our understanding of the development of PTSD symptoms. The COVID-19 pandemic may be experienced as a traumatic event for individuals, but not everyone develops PTSD symptoms. Accordingly, many studies have explored the risk factors that increase the likelihood of developing PTSD during COVID-19, with many reporting fixed factors such as sex, age, a prior PTSD diagnosis, and loss of friends or relatives [4, 76]. However, because these factors cannot be modified, it is important to identify factors that can be modified through interventions or treatments [19]. Therefore, this study is significant in that it identifies the impact of psychological factors on COVID-19-related PTSD symptoms that can be altered through interventions. Moreover, to our knowledge, no study has compared COVID-19-related PTSD symptoms and psychological factors in college students from different countries. This study compared the US and Korean college students on the psychological mechanisms that contribute to PTSD in the context of COVID-19. In doing so,

it offers insights into the influence of cultural characteristics on how individuals from these distinct backgrounds respond to the pandemic.

Moreover, our study has clinical implications in that it confirmed that interventions for preventing PTSD and relieving PTSD symptoms can be applied through various paths. Based on the variables examined in this study, we suggest the following interventions in a university context: First, providing accurate information is effective in relieving uncertainty [14]. During the pandemic, universities should provide appropriate and accurate information to students through various channels. Second, universities should support students to feel a sense of social connection during the pandemic. Recent studies have suggested that college belongingness is an important protective factor in alleviating college students' anxiety and loneliness during the pandemic, helping them to make psychological adjustments [75, 76]. Third, universities should identify groups that are vulnerable to mental burden, such as anxiety and excessive worry, and provide preventive and therapeutic interventions. Previous research has shown that being female and of diverse/open gender, being single, living alone, and being a first-year student were identified as risk factors associated with psychological distress during the pandemic [77]. It is therefore important to monitor the mental health of college students from these sociodemographic backgrounds and identify when help is needed. Lastly, our study confirmed that significant differences in the indirect effects between the US and Korea indicate that IU among American college students may have a stronger impact on COVID-19-related PTSD symptoms through COVID-19 concerns. This suggests that individuals with high IU may become more psychologically vulnerable in individualistic cultures, characterized by less stringent social control in response to high uncertainty pandemics, such as COVID-19. Given that IU is considered an important transdiagnostic variable in various psychopathologies [78, 79], universities need to assess students' IU to identify targets for preventive intervention during the pandemic. Furthermore, considering the theoretical and empirical support for cognitive behavioral treatments (CBT) as specific interventions for IU [80, 81], the development and implementation of CBT programs reflecting the pandemic context are recommended.

Limitations and future research

The limitations of this study and suggestions for future research are as follows: First, due to the utilization of a convenience sample, participants in this study may not fully represent the broader American and Korean college student populations. The sample composition could be skewed, with students more significantly affected by the pandemic potentially being more inclined to participate in the study. Consequently, the study population exhibited a notably higher percentage of females than males in both the US and Korean samples. A higher response rate from female students might be possibly linked to a prior study's findings indicating that female students are more susceptible to fearing COVID-19 infection [82]. In future studies, skewed sex distributions should be minimized to reduce any sex-based limitations in generalizing the findings. Moreover, future research could consider employing more rigorous sampling techniques and increasing the sample size to ensure a more representative and diverse participant pool. Second, our study was a cross-national study as data were collected from two countries: the US and Korea. For more in-depth cross-cultural comparisons, future studies should reconfirm and supplement the findings in this study in more countries. Such cross-cultural investigation could provide important data for elucidating the changes in the mental health of college students during the pandemic and establishing appropriate intervention methods for this population. Third, the scales we used adopted a self-reporting format, leading to the possibility of response biases. Participants might provide responses influenced by social desirability or the desire to conform to perceived societal norms. Additionally, participants may struggle to accurately remember and report past events or experiences. These could lead to an overestimation or underestimation of certain behaviors or experiences, ultimately affecting the accuracy of the collected data. Therefore, future studies should use measures to strengthen the objectiveness of the data measuring PTSD symptoms and psychological factors (e.g., clinician-rated or bioindicators). Recent studies have consistently reported associations between abnormalities in brain structure and function, such as in the hippocampus, amygdala, and prefrontal cortex, and biochemical abnormalities with the development of PTSD [83–85]. Therefore, to more fully understand the mechanisms underlying the development and maintenance of PTSD symptoms, it is necessary to collect and examine various physiological measures in addition to psychological and behavioral measures. Fourth, because of the cross-sectional study design, we were limited in identifying changes over time and confirming temporal relations between the variables. Therefore, future studies should use a longitudinal study design to examine linear changes over time or identify the directionality of influence between variables. Fifth, the COVID-19 context (e.g., pandemic waves, vaccination rates, and the strictness of government policies) varies widely across countries, and these differences may influence individuals' experiences. In this study, we interpreted the differences in our results between the two countries by considering their pandemic contexts and cultural characteristics. However, we were unable to pinpoint the specific causes

of these differences through empirical data analysis. Therefore, further research is needed to investigate the impact that diverse pandemic contexts across countries may have on individual psychological factors. Moreover, we set sex and pre-existing traumatic events as control variables based on previous study results. However, sex had no significant effect on COVID-19 concerns and loneliness in US college students, whereas pre-existing traumatic events had no significant effect on COVID-19 concerns in both Korean and US college students. Such findings may be attributed to the participant age group and scale used in this study being different from those in previous studies. Additionally, age did not show significant relationships with any variables. This may due to the mixed results observed in previous studies, where the relationships between age of young adults and COVID-19 concerns, loneliness, and PTSD symptoms showed both significant [48–50] and non-significant results [86, 87]. Future studies should include systematic reviews and meta-analyses that can provide a meaningful interpretation of the different results found in different studies. Lastly, the values of Cronbach's alpha for COVID-19-related PTSD symptoms were 0.69 in the US and 0.68 in Korean samples, respectively. To ensure the internal reliability of a scale, the suggested Cronbach's alpha is 0.7 or higher. However, because Cronbach's alpha is sensitive to the number of items, it is difficult to simply say that an internal reliability of less than 0.7 is inadequate [88]. While it is possible that the small number of items measuring PTSD symptoms resulted in a Cronbach's alpha lower than 0.7, another possibility is that the items differed in terms of difficulty level. Therefore, further research is needed to conduct item analyses of the COVID-19-related PTSD symptoms scale.

Conclusions

Our study showed that intolerance of uncertainty not only directly affects COVID-19-related PTSD symptoms among US and Korean college students but also indirectly through the serial mediating effects of COVID-19 concerns and loneliness. Our work provides an important practical reference for elucidating the risk factors and mechanisms of PTSD symptoms to prevent them in college students in COVID-19 pandemic situations.

Abbreviations

PTSD	Post-traumatic stress disorder
IU	Intolerance of uncertainty
CI	Confidence Intervals
ML	Maximum likelihood
CFI	Comparative fit index
SRMR	Standardized root mean square residual
RMSEA	Root mean square error of approximation

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Author contributions

J. G. K. and H. Y. contributed to the conceptualization, data analysis, and manuscript writing. D. S., G. L., L. S. M., L. V. A., and S. H. P. collected data. M. P. preprocessed the data. H. Y., S. H. P., J. H., Y-H. K., S. H., L. S. M., and L. V. A. funded the work. All authors edited the paper and approved the submitted version.

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Data availability

The datasets used during this study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study was reviewed and approved by the Institutional Review Board (IRB) of Yonsei University in Korea (Approval Number: 7001988-202106-HR-1244-02) and the IRB of Columbia University in the US (Protocol Number 7994). All the participants were informed of their right to discontinue the survey at any time without any prejudice, and guaranteed anonymity and confidentiality. All the participants gave their written informed consent. All methods were carried out in accordance with relevant guidelines and regulations.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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References

1. Buttanshaw LE, Purnell LR, El-Leithy SM, Pain AS. Understanding the experiences of people with posttraumatic stress disorder (PTSD) during the COVID-19 pandemic: A qualitative study. Psychol Trauma. 2022;14:1347–55. https://doi.org/10.1037/tra0001198.
2. Chamaa F, Bahmad HF, Darwish B, Kobeissi JM, Hoballah M, Nassif SB, et al. PTSD in the COVID-19 era. Curr Neuropharmacol. 2021;19:2164–79. https://doi.org/10.2174/1570159X19666210113152954.
3. Inozu M, Gök BG, Tuzun D, Haciomeroglu AB. Does cognitive flexibility change the nature of the relationship between intolerance of uncertainty and psychological symptoms during the COVID-19 outbreak in turkey?? Curr Psychol. 2023;42:17412–23. https://doi.org/10.1007/s12144-021-02450-8.
4. Ochnik D, Rogowska AM, Kuśnierz C, Jakubiak M, Wierzbik-Strońska M, Schütz A, et al. Exposure to COVID-19 during the first and the second wave of the pandemic and coronavirus-related PTSD risk among university students from six countries—a repeated cross-sectional study. J Clin Med. 2021;10:5564. https://doi.org/10.3390/jcm10235564.
5. Xiong J, Lipsitz O, Nasri F, Lui LMW, Gill H, Phan L, et al. Impact of COVID-19 pandemic on mental health in the general population: A systematic review. J Affect Disord. 2020;277:55–64. https://doi.org/10.1016/j.jad.2020.08.001.

6. Daly M, MacLachlan M, Maguire R, Power JM, Nolan A, Shevlin M, et al. Changes in PTSD, depression, and generalized anxiety before and during the COVID-19 pandemic in Ireland. J Affect Disord Rep. 2021;5:100184. https://doi.org/10.1016/j.jadr.2021.100184.
7. Yuan K, Gong Y-M, Liu L, Sun Y-K, Tian S-S, Wang Y-J, et al. Prevalence of post-traumatic stress disorder after infectious disease pandemics in the twenty-first century, including COVID-19: A meta-analysis and systematic review. Mol Psychiatry. 2021;26:4982–98. https://doi.org/10.1038/s41380-021-01036-x.
8. Hu B, Yang X, Tuo X. The prevalence of post-traumatic stress disorder in college students by continents and National income during the COVID-19 pandemic: A meta-analysis. Front Psychol. 2023;14:1129782. https://doi.org/10.3389/fpsyg.2023.1129782.
9. Bridgland VME, Moeck EK, Green DM, Swain TL, Nayda DM, Matson LA, et al. Why the COVID-19 pandemic is a traumatic stressor. PLoS ONE. 2021;16:e0240146. https://doi.org/10.1371/journal.pone.0240146.
10. Aristovnik A, Keržič D, Ravšelj D, Tomaževič N, Umek L. Impacts of the COVID-19 pandemic on life of higher education students: A global perspective. Sustainability. 2020;12:8438. https://doi.org/10.3390/su12208438.
11. Browning MH, Larson LR, Sharaievska I, Rigolon A, McAnirlin O, Mullenbach L et al. (2021). Psychological impacts from COVID-19 among university students: Risk factors across seven states in the United States. PloS One. 2021;16(1):e0245327. https://doi.org/10.1371/journal.pone.0273938
12. Huang J, Nigatu YT, Smail-Crevier R, Zhang X, Wang J. Interventions for common mental health problems among university and college students: A systematic review and meta-analysis of randomized controlled trials. J Psychiatr Res. 2018;107:1–10. https://doi.org/10.1016/j.jpsychires.2018.09.018.
13. Negi AS, Khanna A, Aggarwal R. Psychological health, stressors and coping mechanism of engineering students. Int J Adolesc Youth. 2019;24:511–20. https://doi.org/10.1080/02673843.2019.1570856.
14. Bavolar J, Kacmar P, Hricova M, Schrötter J, Kovacova-Holevova B, Köverova M, et al. Intolerance of uncertainty and reactions to the COVID-19 pandemic. J Gen Psychol. 2023;150:143–70. https://doi.org/10.1080/00221309.2021.1922346.
15. Hillen MA, Gutheil CM, Strout TD, Smets EM, Han PK. Tolerance of uncertainty: conceptual analysis, integrative model, and implications for healthcare. Soc Sci Med. 2017;180:62–75. https://doi.org/10.1016/j.socscimed.2017.03.024.
16. McEvoy PM, Mahoney AE. To be sure, to be sure: intolerance of uncertainty mediates symptoms of various anxiety disorders and depression. Behav Ther. 2012;43:533–45. https://doi.org/10.1016/j.beth.2011.02.007.
17. McEvoy PM, Erceg-Hurn DM. The search for universal transdiagnostic and trans-therapy change processes: evidence for intolerance of uncertainty. J Anxiety Disord. 2016;41:96–107. https://doi.org/10.1016/j.janxdis.2016.02.002.
18. Dugas MJ, Hedayati M, Karavidas A, Buhr K, Francis K, Phillips NA. Intolerance of uncertainty and information processing: evidence of biased recall and interpretations. Cognit Ther Res. 2005;29:57–70. https://doi.org/10.1007/s10608-005-1648-9.
19. Oglesby ME, Gibby BA, Mathes BM, Short NA, Schmidt NB. Intolerance of uncertainty and post-traumatic stress symptoms: an investigation within a treatment seeking trauma-exposed sample. Compr Psychiatry. 2017;72:34–40. https://doi.org/10.1016/j.comppsych.2016.08.011.
20. Fetzner MG, Horswill SC, Boelen PA, Carleton RN. Intolerance of uncertainty and PTSD symptoms: exploring the construct relationship in a community sample with a heterogeneous trauma history. Cognit Ther Res. 2013;37:725–34. https://doi.org/10.1007/s10608-013-9531-6.
21. Banducci AN, Bujarski SJ, Bonn-Miller MO, Patel A, Connolly KM. The impact of intolerance of emotional distress and uncertainty on veterans with co-occurring PTSD and substance use disorders. J Anxiety Disord. 2016;41:73–81. https://doi.org/10.1016/j.janxdis.2016.03.003.
22. Taylor S, Landry CA, Paluszek MM, Fergus TA, McKay D, Asmundson GJG. Development and initial validation of the COVID stress scales. J Anxiety Disord. 2020;72:102232. https://doi.org/10.1016/j.janxdis.2020.102232.
23. Badawi A, Steel Z, Harb M, Mahoney C, Berle D. Changes in intolerance of uncertainty over the course of treatment predict posttraumatic stress disorder symptoms in an inpatient sample. Clin Psychol Psychother. 2022;29:230–9. https://doi.org/10.1002/cpp.2625.
24. Voitsidis P, Nikopoulou VA, Holeva V, Parlapani E, Sereslis K, Tsipropoulou V, Diakogiannis I. The mediating role of fear of COVID-19 in the relationship between intolerance of uncertainty and depression. Psychol Psychother. 2021;94:884–93. https://doi.org/10.1111/papt.12315.
25. Satici B, Saricali M, Satici SA, Griffiths MD. Intolerance of uncertainty and mental wellbeing: serial mediation by rumination and fear of COVID-19. Int J Ment Health Addict. 2022;20:2731–42. https://doi.org/10.1007/s11469-020-00331-y.
26. Ehlers A, Clark DM. A cognitive model of posttraumatic stress disorder. Behav Res Ther. 2000;38:319–45. https://doi.org/10.1016/S0005-7967(99)00123-0.
27. Bridgland VME, Moeck EK, Green DM, Swain TL, Nayda DM, Matson LA, Hutchison NP, Takarangi MKT. Why the COVID-19 pandemic is a traumatic stressor. PLoS ONE. 2021;16:e0240146. https://doi.org/10.1371/journal.pone.0240146.
28. Makhashvili N, Javakhishvili JD, Sturua L, Pilauri K, Fuhr DC, Roberts B. The influence of concern about COVID-19 on mental health in the Republic of georgia: a cross-sectional study. Global Health. 2020;16:111. https://doi.org/10.1186/s12992-020-00641-9.
29. Deniz ME. Self-compassion, intolerance of uncertainty, fear of COVID-19, and well-being: A serial mediation investigation. Pers Individ Dif. 2021;177:110824. https://doi.org/10.1016/j.paid.2021.110824.
30. Pak H, Süsen Y, Denizci Nazlıgül MD, Griffiths M. The mediating effects of fear of COVID-19 and depression on the association between intolerance of uncertainty and emotional eating during the COVID-19 pandemic in Turkey. Int J Ment Health Addict. 2022;20:1882–96. https://doi.org/10.1007/s11469-021-00489-z.
31. Satici B, Saricali M, Satici SA, Griffiths MD. Intolerance of uncertainty and mental wellbeing: serial mediation by rumination and fear of COVID-19. Int J Ment Health Addict. 2022;20:2731–42. https://doi.org/10.1007/s11469-020-00305-0.
32. Peplau LA, Perlman D, Loneliness. A sourcebook of current theory, research, and therapy. NY: Wiley; 1982.
33. Parlapani E, Holeva V, Nikopoulou VA, Sereslis K, Athanasiadou M, Godosidis A, et al. Intolerance of uncertainty and loneliness in older adults during the COVID-19 pandemic. Front Psychiatry. 2020;11:842. https://doi.org/10.3389/fpsyt.2020.00842.
34. Smith BM, Twohy AJ, Smith GS. Psychological inflexibility and intolerance of uncertainty moderate the relationship between social isolation and mental health outcomes during COVID-19. J Contextual Behav Sci. 2020;18:162–74. https://doi.org/10.1016/j.jcbs.2020.09.005.
35. Rehman SU, Ullah R, Imran M, Iqbal K, Saleem Z, Khattak SR. Intolerance of uncertainty and mental well-being: importance role of loneliness and fear of COVID-19: evidence from higher educational institutions. Multicult Educ. 2021;7:147–54. https://doi.org/10.5281/zenodo.4750645.
36. Charuvastra A, Cloitre M. Social bonds and posttraumatic stress disorder. Annu Rev Psychol. 2008;59:301–28. https://doi.org/10.1146/annurev.psych.58.110405.085650.
37. Palmer BW, Hussain MA, Lohr JB. Loneliness in posttraumatic stress disorder: a neglected factor in accelerated aging? J Aging Longev. 2022;2:326–39. https://doi.org/10.3390/jal2040025.
38. Stickley A, Isaksson J, Koposov R, Schwab-Stone M, Sumiyoshi T, Ruchkin V. Loneliness and posttraumatic stress in US adolescents: a longitudinal study. J Affect Disord. 2024;361:113–19. https://doi.org/10.1016/j.jad.2024.06.015.
39. Liu CH, Zhang E, Wong GTF, Hyun S, Hahm HC. Factors associated with depression, anxiety, and PTSD symptomatology during the COVID-19 pandemic: clinical implications for U.S. Young adult mental health. Psychiatry Res. 2020;290:113172. https://doi.org/10.1016/j.psychres.2020.113172.
40. Rogers RW. A protection motivation theory of fear appeals and attitude change. J Psychol. 1975;91:93–114. https://doi.org/10.1080/00223980.1975.9915803.
41. Boyraz G, Legros DN, Tigershtrom A. COVID-19 and traumatic stress: the role of perceived vulnerability, COVID-19-related worries, and social isolation. J Anxiety Disord. 2020;76:102307. https://doi.org/10.1016/j.janxdis.2020.102307.
42. Bonsaksen T, Schoultz M, Thygesen H, Ruffolo M, Price D, Leung J, et al. Loneliness and its associated factors nine months after the COVID-19 outbreak: A cross-national study. Int J Environ Res Public Health. 2021;18:2841. https://doi.org/10.3390/ijerph18062841.
43. Kayis AR, Satici B, Deniz ME, Satici SA, Griffiths MD. Fear of COVID-19, loneliness, smartphone addiction, and mental wellbeing among the Turkish general population: A serial mediation model. Behav Inf Technol. 2022;41:2484–96. https://doi.org/10.1080/0144929X.2021.1933181.
44. Fedorenko EJ, Kibbey MM, Contrada RJ, Farris SG. Psychosocial predictors of virus and social distancing fears in undergraduate students living in a US COVID-19 hotspot. Cogn Behav Ther. 2021;50:217–33. https://doi.org/10.1080/16506073.2020.1866658.
45. Graffeo MT, Albano G, Salerno L, Di Blasi M, Lo Coco G. Intolerance of uncertainty and risk perception during the COVID-19 pandemic: the mediating

role of fear of COVID-19. Psych. 2022;4:269–76. https://doi.org/10.3390/psych4020023.
46. Bu F, Steptoe A, Fancourt D. Who is lonely in lockdown? Cross-cohort analyses of predictors of loneliness before and during the COVID-19 pandemic. Public Health. 2020;186:31–4. https://doi.org/10.1016/j.puhe.2020.06.036.
47. Lee CM, Cadigan JM, Rhew IC. Increases in loneliness among young adults during the COVID-19 pandemic and association with increases in mental health problems. J Adolesc Health. 2020;67:714–7. https://doi.org/10.1016/j.jadohealth.2020.08.009.
48. Chi X, Huang L, Hall DL, Li R, Liang K, Hossain M, et al. Posttraumatic stress symptoms among Chinese college students during the COVID-19 pandemic: A longitudinal study. Front Public Health. 2021;9:759379. https://doi.org/10.3389/fpubh.2021.759379.
49. Lee J, Solomon M, Stead T, Kwon B, Ganti L. Impact of COVID-19 on the mental health of US college students. BMC Psychol. 2021;9:95. https://doi.org/10.1186/s40359-021-00598-3.
50. Wathelet M, Fovet T, Jousset A, Duhem S, Habran E, Horn M, et al. Prevalence of and factors associated with post-traumatic stress disorder among French university students 1 month after the COVID-19 lockdown. Transl Psychiatry. 2021;11:327. https://doi.org/10.1038/s41398-021-01438-z.
51. Hofstede G. Culture's consequences: international differences in work-related values. CA: Sage; 1980.
52. Barreto M, Victor C, Hammond C, Eccles A, Richins MT, Qualter P. Loneliness around the world: age, gender, and cultural differences in loneliness. Pers Individ Differ. 2021;169:110066. https://doi.org/10.1016/j.paid.2020.110066.
53. Germani A, Buratta L, Delvecchio E, Mazzeschi C. Emerging adults and COVID-19: the role of individualism-collectivism on perceived risks and psychological maladjustment. Int J Environ Res Public Health. 2020;17:3497. https://doi.org/10.3390/ijerph17103497.
54. Heu LC, van Zomeren M, Hansen N. Lonely alone or lonely together? A cultural-psychological examination of individualism–collectivism and loneliness in five European countries. Per Soc Psychol Bull. 2019;45(5):780–93. https://doi.org/10.1177/0146167218796793.
55. Schermer JA, Branković M, Čekrlija Đ, MacDonald KB, Park J, Papazova E, et al. Loneliness and vertical and horizontal collectivism and individualism: A multinational study. Curr Res Behav Sci. 2023;4:100105. https://doi.org/10.1016/j.crbeha.2023.100105.
56. Chen Y, Biswas MI. Impact of National culture on the severity of the COVID-19 pandemic. Curr Psychol. 2023;42(18):15813–26. https://doi.org/10.1007/s12144-022-02906-5.
57. Chen H, Shi L, Zhang Y, Wang X, Jiao J, Yang M, et al. Response to the COVID-19 pandemic: comparison of strategies in six countries. Front Public Health. 2021;9:708496. https://doi.org/10.3389/fpubh.2021.708496.
58. Dave D, Friedson AI, Matsuzawa K, Sabia JJ. When do shelter-in-place orders fight COVID-19 best? Policy heterogeneity across States and adoption time. Econ Inq. 2021;59:29–52. https://doi.org/10.1111/ecin.12944.
59. Issac A, Stephen S, Jacob J, Vr V, Radhakrishnan RV, Krishnan N, et al. The pandemic league of COVID-19: Korea versus the united states, with lessons for the entire world. J Prev Med Public Health Dhandapani M 2020. 2020;53:228–32. https://doi.org/10.3961/jpmph.20.166.
60. Carleton RN, Norton MA, Asmundson GJ. Fearing the unknown: A short version of the intolerance of uncertainty scale. J Anxiety Disord. 2007;21:105–17. https://doi.org/10.1016/j.janxdis.2006.03.014.
61. Prins A, Bovin MJ, Smolenski DJ, Marx BP, Kimerling R, Jenkins-Guarnieri MA, et al. The primary care PTSD screen for DSM-5 (PC-PTSD-5): development and evaluation within a veteran primary care sample. J Gen Intern Med. 2016;31:1206–11. https://doi.org/10.1007/s11606-016-3703-5.
62. Jung YE, Kim D, Kim WH, Roh D, Chae JH, Park JE. A brief screening tool for PTSD: validation of the Korean version of the primary care PTSD screen for DSM-5 (K-PC-PTSD-5). J Korean Med Sci. 2018;33:e338. https://doi.org/10.3346/jkms.2018.33.e338.
63. MacKinnon DP, Lockwood CM, Williams J. Confidence limits for the indirect effect: distribution of the product and resampling methods. Multivar Behav Res. 2004;39:99. https://doi.org/10.1207/s15327906mbr3901_4.
64. Ryu E, Cheong J. Comparing indirect effects in different groups in single-group and multi-group structural equation models. Front Psychol. 2017;8:747. https://doi.org/10.3389/fpsyg.2017.00747.
65. Browne MW, Cudeck R. Alternative ways of assessing model fit. In: Bollen KALJS, editor. Testing structural equation models. Newbury Park, CA: Sage; 1993. pp. 136–62.
66. Hu LT, Bentler PM. Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. Struct Equ Model. 1999;6:1–55. https://doi.org/10.1080/10705519909540118.
67. Kline RB. Principles and practice of structural equation modeling. New York: Guilford; 2010.
68. Hardin SB, Weinrich S, Weinrich M, Garrison C, Addy C, Hardin TL. Effects of a long-term psychosocial nursing intervention on adolescents exposed to catastrophic stress. Issues Ment Health Nurs. 2002;23:537–51. https://doi.org/10.1080/01612840290052712.
69. Chung S, Lee T, Hong Y, Ahmed O, Silva WAD, Gouin JP. Viral anxiety mediates the influence of intolerance of uncertainty on adherence to physical distancing among healthcare workers in COVID-19 pandemic. Front Psychiatry. 2022;13:839656. https://doi.org/10.3389/fpsyt.2022.839656.
70. Fox R, McHugh Power JM, Coogan AN, Beekman ATF, van Tilburg TG, Hyland P. Posttraumatic stress disorder and loneliness are associated over time: a longitudinal study on PTSD symptoms and loneliness, among older adults. Psychiatry Res. 2021;299:113846. https://doi.org/10.1016/j.psychres.2021.113846.
71. Maaravi Y, Levy A, Gur T, Confino D, Segal S. The tragedy of the commons: How individualism and collectivism affected the spread of the COVID-19 pandemic. Front Public Health. 2021;9:37. doi10.3389/fpubh.2021.627559.
72. Rajkumar P. The relationship between measures of individualism and collectivism and the impact of COVID-19 across nations. Public Health Pract. 2021;2:100143. https://doi.org/10.1016/j.puhip.2021.100143.
73. Boffa JW, Schmidt NB. Reductions in anxiety sensitivity cognitive concerns prospectively mitigate trauma symptom development. Behav Res Ther. 2019;113:39–47. https://doi.org/10.1016/j.brat.2018.12.007.
74. Mitchell MA, Capron DW, Raines AM, Schmidt NB. Reduction of cognitive concerns of anxiety sensitivity is uniquely associated with reduction of PTSD and depressive symptoms: A comparison of civilians and veterans. J Psychiatr Res. 2014;48(1):25–31. https://doi.org/10.1016/j.jpsychires.2013.10.013.
75. Arslan G, Yıldırım M, Zangeneh M. Coronavirus anxiety and psychological adjustment in college students: exploring the role of college belongingness and social media addiction. Int J Ment Health Addict. 2022;20:1546–59. https://doi.org/10.1007/s11469-020-00460-4.
76. Arslan G. Loneliness, college belongingness, subjective vitality, and psychological adjustment during coronavirus pandemic: development of the college belongingness questionnaire. J Posit Sch Psychol. 2021;5:17–31. https://doi.org/10.47602/jpsp.v5i1.240.
77. Tsiouris A, Werner AM, Tibubos AN, Mülder LM, Reichel JL, Heller S, et al. Mental health state and its determinants in German university students across the COVID-19 pandemic: findings from three repeated cross-sectional surveys between 2019 and 2021. Front Public Health. 2023;11:1163541. https://doi.org/10.3389/fpubh.2023.1163541.
78. Carleton RN, Mulvogue MK, Thibodeau MA, McCabe RE, Antony MM, Asmundson GJ. Increasingly certain about uncertainty: intolerance of uncertainty across anxiety and depression. J Anxiety Disord. 2012;26:468–79. https://doi.org/10.1016/j.janxdis.2012.01.011.
79. Mahoney AE, McEvoy PM. A transdiagnostic examination of intolerance of uncertainty across anxiety and depressive disorders. Cogn Behav Ther. 2012;41:212–22. https://doi.org/10.1080/16506073.2011.622130.
80. Robichaud M, Dugas MJ. A cognitive-behavioral treatment targeting intolerance of uncertainty. In: Davey G, Wells A, editors. Worry and its psychological disorders: theory, assessment and treatment. Sussex, UK: Wiley; 2006. pp. 289–304.
81. Shapiro MO, Allan NP, Raines AM, Schmidt NB. A randomized control trial examining the initial efficacy of an intolerance of uncertainty focused psychoeducation intervention. J Psychopathol Behav Assess. 2022;45:379–90. https://doi.org/10.1007/s10862-022-10002-y.
82. Holm-Hadulla RM, Mayer CH, Wendler H, Kremer TL, Kotera Y, Herpertz SC. Fear, depression, and well-being during the COVID-19 pandemic in German and South African students: A cross-cultural comparison. Front Psychol. 2022;13:920125. https://doi.org/10.3389/fpsyg.2022.920125.
83. Karl A, Schaefer M, Malta LS, Dorfel D, Rohleder N, Werner A. A meta-analysis of structural brain abnormalities in PTSD. Neurosci Biobehav Rev. 2006;30:1004–31. https://doi.org/10.1016/j.neubiorev.2006.03.004.
84. Kunimatsu A, Yasaka K, Akai H, Kunimatsu N, Abe O. MRI findings in posttraumatic stress disorder. J Magn Reson Imaging. 2020;52(2):380–96. https://doi.org/10.1002/jmri.26929.
85. Harnett NG, Goodman AM, Knight DC. PTSD-related neuroimaging abnormalities in brain function, structure, and biochemistry. Exp Neurol. 2020;330:113331. https://doi.org/10.1016/j.expneurol.2020.113331.

86. Mayorga NA, Smit T, Garey L, Gold AK, Otto MW, Zvolensky MJ. Evaluating the interactive effect of COVID-19 worry and loneliness on mental health among young adults. Cogn Ther Res. 2022;46:11–9. https://doi.org/10.1007/s10608-021-10252-2.
87. Tang W, Hu T, Hu B, Jin C, Wang G, Xie C, et al. Prevalence and correlates of PTSD and depressive symptoms one month after the outbreak of the COVID-19 epidemic in a sample of home-quarantined Chinese university students. J Affect Disord. 2020;274:1–7. https://doi.org/10.1016/j.jad.2020.05.009.
88. Cortina JM. What is coefficient alpha? An examination of theory and applications. J Appl Psychol. 1993;78:98–104. https://doi.org/10.1037/0021-9010.78.1.98.

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