



Intolerance of uncertainty fuels preservice teachers' smartphone dependence through rumination and anxiety during the COVID-19 pandemic: A cross-sectional study

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ABSTRACT

Objectives: We aimed to explore the relationship among intolerance of uncertainty (IU), rumination, anxiety, and smartphone dependence (SPD) in preservice teachers during the COVID-19 pandemic.

Methods: Two cross-sectional studies were conducted with Chinese preservice teachers, using questionnaires on IU, rumination, anxiety, and SPD. Data were analyzed using AMOS 24.0 and SPSS 25.0, and the mediating mechanism was tested using the macro program Model 6. Study 1 recruited participants who were forcibly sequestered in a university due to an anti-epidemic policy during the COVID-19 crisis. Study 2 was surveyed online from different universities to replicate and enhance the reliability of Study 1 finding.

Results: Study 1 ($N = 553$, $M_{\text{age}} = 20.8 \pm 2.3$, 30.0% female) and Study 2 ($N = 1610$, $M_{\text{age}} = 21.1 \pm 2.1$, 51.4% female) both found that IU affected SPD through the independent mediators of rumination and anxiety, as well as the chain mediation of rumination \rightarrow anxiety. In Study 1, the indirect effect of IU on SPD was significant through rumination ($\beta = 0.16$, 95% CI [0.03, 0.06]), anxiety ($\beta = 0.11$, 95% CI [0.03, 0.06]), and the chain mediation ($\beta = 0.02$, 95% CI [0.01, 0.04]); in Study 2, the indirect effect of IU on SPD was significant through rumination ($\beta = 0.08$, 95% CI [0.05, 0.11]), anxiety ($\beta = 0.10$, 95% CI [0.08, 0.13]), and the chain mediation ($\beta = 0.02$, 95% CI [0.02, 0.03]).

Conclusion: Two cross-sectional studies found that preservice teachers' SPD is indirectly connected to IU, mediated by rumination and anxiety, and weakly mediated by the chain mediation of rumination and anxiety. Our findings may help educators understand the impact of anti-epidemic policies on preservice teachers and possible inclusive later interventions.

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1. Introduction

The COVID-19 epidemic is an unprecedented emergency affecting millions of people worldwide [1]. After the first confirmed case reported in Wuhan, China has been implementing restrictions on population movement and enforcing the strictest controls to prevent overwhelming its health system. Although required public health measures have been adopted, researchers surmised particularly mandatory social isolation might increase social isolation and loneliness [2,3], which in turn affects the possibility of mental illness [4], mental health outcomes [5], and lead to smartphone dependence (SPD) [6].

Smartphones are becoming a necessity for most students [7,8]. Educational inequality was already a persistent problem before the pandemic and remained pervasive worldwide, even in the most affluent countries [9]; the Chinese school system was also highly imbalanced [10]. Therefore, research on the psychological process of preservice teachers, especially in economically underdeveloped areas, is attracting attention [9,11]. SPD affects one's physical and mental health adversely, causing impaired social functions and decreasing levels of academic performance; it was caused by a variety of factors, especially when faced with the widespread anxiety and rumination triggered by the uncertain environment caused by the epidemic [5,8,12,13].

The Compensatory Internet Use Theory (CIUT) and Interaction of Person-Affect-Cognition-Execution (I-PACE) model provide powerful theoretical foundations for analyzing the impact of intolerance of uncertainty (IU) on SPD and whether the mediating effect of rumination or anxiety [14,15]. The CIUT suggests people engage in excessive technology overuse to alleviate negative emotions [15]. As a result, people may increase SPD to respond to distress and negative affect like social isolation imposed by the epidemic. It focuses on the excessive use of digital technology as a compensatory coping strategy and research on SPD has demonstrated that the CIUT could help explain SPD [16,17]. Additionally, IU is a critical component of psychopathology related to apprehension, state anxiety, and anxiety, which is defined as a tendency not to tolerate aversive responses triggered by a lack of perceived information on uncertainty situations, and is another relevant construct in this study [18]. IU is strongly associated with intolerant emotional distress and negative feelings [19,20], and CIUT conceptualizes SPD as an attempt to alleviate such negative emotions. Finally, the I-PACE model based on empirical findings suggests that the development of habitual behaviors is the outcome of interactions between susceptibility variables (e.g., social isolation), affective (e.g., anxiety), and cognitive responses to specific stimuli (e.g., rumination), and executive functions (e.g., decision-making or inhibitory control). In this process, the correlations among that help the development of habitual behaviors [14], and existing studies reported that the I-PACE model could explain SPD [21–23].

Therefore, the present study examined the mediating effect of rumination or anxiety and a chain of intermediaries consisting of rumination→ anxiety on the relationship between IU and SPD to help educators understand the impact of current anti-epidemic policies on preservice teachers. We proposed hypotheses presented below (our mediation model, see Fig. 1).

- H1. IU can predict SPD positively.
- H2. Rumination can mediate in predicting IU of SPD.
- H3. Anxiety can mediate in predicting IU of SPD.
- H4. IU can predict SPD via the chain mediating effects of rumination and anxiety.

2. Methods

2.1. Research design

We conducted two independent survey studies using convenience sampling to investigate whether SPD could be connected to IU and the potential intermediary role of rumination or anxiety. In both studies, we used the same scales and theoretical models, but with differences in the number of participants. The data from Study 1 were collected at a university; in Study 2, data were collected from different regions, and expanded the number of participants was to replicate and strengthen Study 1. This multi-sample design delivered credible and reproducible evidence that responded to the replication crisis in psychological science research [24–26]. According to Coutts and Hayes [27], when the number of participants were greater than 500, mediation models could be disregarded the probability of making one type of error and the reduction in statistical efficacy. In addition, we wanted to keep the sampling error within 3% and prioritize statistical power to confirm whether the results of Study 1 could be replicated, hence the sample size for Study 2 was rigorously calculated using the formula: $n = Z^2pq/d^2$. Here, n is the sample size. Considering the confidence interval at 95% ($Z = 1.96$),

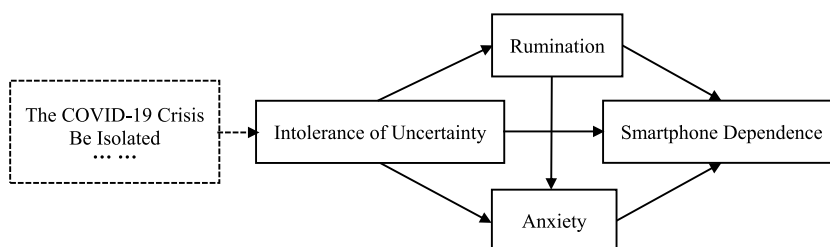


Fig. 1. Hypothesized model.

population proportion at 50% ($p = 0.5$), and margin of error at 3% ($d = 0.03$); the calculated sample size was 1067, which is the highest number in the sample size estimated based on the objectives of Study 2 [28,29]. All participants were recruited above 18 years old and informed in advance to participate voluntarily and could withdraw at any time. Finally, informed consent was obtained from all participants in Study 1 and Study 2 and the Ethics Committee of Ningxia University reviewed and approved research involving human participants in China (Project No. NXU-23-063).

2.2. Survey questionnaire

The same questionnaire was used in Study 1 and Study 2, i.e., it contained the following four scales and basic demographic information (see Appendix B for survey item details).

2.2.1. Intolerance of uncertainty Scale-12 (IUS-12)

The IUS-12 scale was developed by Carleton et al. [30], which was a simplified form of the 27-item IUS [31], adapted to the China context. It demonstrated good internal consistency and reliability [13]. It consisted of 12 items, and respondents rated the extent to which each item statement applied to them on a 5-point Likert-type scale (1 = not my characteristic at all to 5 = my characteristic at all). High scores indicate individuals were highly tolerant of uncertainty. The Cronbach's alphas were respectively 0.904 for Study 1 and 0.900 for Study 2.

2.2.2. Ruminative response Scale-10 (RRS-10)

The RRS-10 scale was designed to assess ruminative thoughts of negative self-focus stimulated by feelings of self-threat [32]. Items were set on a 4-point scale (1 = not at all, 4 = nearly always); scores were computed by summing all items, with higher scores indicating higher levels of ruminant. Furthermore, RRS translated into Chinese for research purposes was used, showing good validity and internal reliability [33]. The Cronbach's alphas were respectively 0.926 for Study 1 and 0.906 for Study 2.

2.2.3. Generalized anxiety disorder Scale-7 (GAD-7)

Anxiety was assessed via the GAD-7, using four options for seven items to describe during the past two weeks how often each symptom was experienced (0 = not at all, 1 = several days, 2 = over half the days, and 3 = nearly every day). High scores for each item indicated more severe symptoms [34], adapted to the Chinese context, and exhibited good consistency and reliability [35]. The Cronbach's alphas were respectively 0.941 for Study 1 and 0.936 for Study 2.

2.2.4. Mobile phone addiction index Scale-17 (MPAI-17)

The MPAI-17 scale was developed by Leung and Louis to identify symptoms of cell phone addiction and serve as a comprehensive assessment of cell phone addiction [36], extending the research of Bianchi and Phillips and meeting the assumptions of the Diagnostic and Statistical Manual of Mental Disorders for substance addiction symptoms [37]. Participants answered items on a 5-point rating

Table 1
Demographic characteristics in Study 1 and Study 2.

Demographic variables		n_1 (%)	n_2 (%)
Gender	Male	387 (70.0)	783 (48.6)
	Female	166 (30.0)	827 (51.4)
Birthplace	Urban	118 (21.3)	483 (30.0)
	Rural	435 (78.7)	1126 (69.9)
Grade	One	110 (19.9)	463 (28.8)
	Two	238 (43.0)	668 (41.5)
	Three	102 (18.4)	238 (14.8)
	Four	103 (18.6)	241 (15.0)
Subject Classification	Science and Engineering	167 (30.2)	726 (45.1)
	Humanities and Social Sciences	377 (68.2)	651 (40.4)
	Arts and Sports	9 (1.6)	233 (14.5)
Only child family		88 (15.9)	223 (13.9)
Romantic Relationship Length	None	308 (55.7)	908 (56.4)
	Less than one year	118 (21.3)	340 (21.1)
	1–2 years	61 (11.0)	196 (12.2)
	2–4 years	41 (7.4)	104 (6.5)
	More than four years	25 (4.5)	62 (3.9)
Father's Educational Background	High School and Below	497 (89.9)	1428 (88.7)
	College	31 (5.6)	92 (5.7)
	Bachelor	14 (2.5)	78 (4.8)
	Graduate and above	11 (2.0)	12 (0.7)
Mather's Educational Background	High School and Below	507 (91.7)	1476 (91.7)
	College	22 (4.0)	76 (4.7)
	Bachelor	14 (2.5)	47 (2.9)
	Graduate and above	10 (1.8)	11 (0.7)

Notes. $n_1 = 553$ for Study 1, $n_2 = 1610$ for Study 2; parentheses show the proportion of variables in the corresponding study.

scale (1 = not at all, 2 = rarely, 3 = occasionally, 4 = often, and 5 = always); a higher average score indicated more severe addiction, which has been widely used in the measurement of SPD [7,38]. The Cronbach alpha coefficients were 0.945 for Study 1 and 0.936 for Study 2, respectively.

2.2.5. Control variables

Several previous studies have highlighted associations between specific socio-demographic variables and SPD, such as denser use and addiction symptoms reported by women than by men [39]. To improve appropriateness and transparency in using control variables, our demographic questionnaire followed recommendations by Bernerth and Aguinis [40], including specific control variables (e.g., gender, grade, and birthplace) based on previous research.

2.3. Procedure

Study 1. We selected preservice teachers in northwest China who were forcibly sequestered in the university due to anti-epidemic policies, utilizing a paper questionnaire in the classroom to collect data in June 2022. To ensure objectivity, we contacted counsellors to distribute the paper questionnaire at class meetings. Participants completed and submitted separately. We distributed 600 questionnaires and returned 560, with a 93.3% response rate. After screening out invalid and incomplete responses, retained 553.

Study 2. The data was completed online from July to September through the Wenjuanxing website, an online survey platform in China. At each survey, participants were required to be preservice teachers and asked if there was a period when they were obliged not to leave their residence due to the anti-epidemic policies or other restrictive policies that unexpectedly disrupted their lives. If the answer was “no”, the participant’s data was removed, and they would not be invited to complete the following questionnaire. We distributed 2000 electronic questionnaires, receiving a response rate of 84.1% for 1682 returns. We retained 1610 responses after screening out incomplete and invalid ones.

2.4. Samples

Study 1. The participants were 553 preservice teachers (mean age: 20.8 ± 2.3 years) from a university in northwest China. They included 166 (30.0%) females and 387 (70.0%) males. Details are shown in Table 1.

Study 2. The participants were 1610 preservice teachers (mean age: 21.1 ± 2.1 years) from six universities in western China. They included 827 (51.4%) females and 783 (48.6%) males. See Table 1 for Details.

3. Results

3.1. Preliminary analyses

Initially, we performed preliminary data analysis and descriptive statistics for Study 1 and Study 2 (see Table 1). Then the Harman single factor was used to check common methodological biases and systematic measurement errors [41]. Exploratory factor analysis was conducted in SPSS 25.0, respectively, on all items in Study 1 and Study 2, including IUS-12, RRS-10, GAD-7, and MPAA-17. The results showed that seven factors had eigenvalues greater than 1 in both studies, and the first factor explained the variance is 13.9% in Study 1 and 14.0% in Study 2, both less than the critical criterion of 40%, respectively [11,42]. Although the potential for common method variance (CMV) does not eliminate, which suggests it might not confound the explanation of the results. Furthermore, confirmatory factor analysis (CFA) was performed in AMOS 24.0 for Study 1 and Study 2 to test our measurement model. The four-factor model in both Study 1 and Study 2 fitted the data well and was the best among other models (see Table 2), and all item loadings were significant for both studies (see Appendix A). The results indicate that our measurements in Study 1 and Study 2 were

Table 2
| Model comparison results.

Models	χ^2/df	Df	CFI	TLI	RMSEA	SRMR	$\Delta\chi^2$	Δdf
Study 1								
Four-factor Model	3.22	975	.881	.873	.063	.056		
Three-factor Model (a)	4.92	982	.788	.776	.084	.077	1694.167***	7
Three-factor Model (b)	5.84	980	.738	.724	.094	.091	2586.449***	5
One-factor Model	9.36	989	.544	.523	.123	.107	6117.127***	14
Study 2								
Four-factor Model	5.35	975	.907	.901	.052	.047		
Three-factor Model (a)	9.79	982	.810	.800	.074	.066	4392.713***	7
Three-factor Model (b)	11.21	980	.780	.768	.080	.081	5771.823***	5
One-factor Model	21.26	989	.559	.539	.112	.100	15805.267***	14

Notes. “+” indicates being combined into one factor.

Four-factor Model: IU, rumination, anxiety, SPD.

Three-factor Model (a): IU + rumination, anxiety, SPD.

Three-factor Model (b): IU, rumination + anxiety, SPD.

One-factor Model: IU + rumination + anxiety + SPD.

reliable.

3.2. Analytical strategy

In the data processing of the two studies, we used SPSS 25.0 for correlation analyses among the variables to test Hypotheses 1. Furthermore, to test the following hypotheses, we followed procedures suggested by Hayes et al. [43,44], which have been widely adopted [11,19]. Specifically, when conditions zero-order bivariate correlations were met, mediated moderation was established. The SPSS macro program Model 6 was to examine the multiple effects and acquire conditional indirect effect values simultaneously. The moderated mediation effect was assessed by the bootstrapping procedure that provided 95% confidence intervals [44,45].

3.3. Testing the hypotheses

IU, rumination, and anxiety were correlated with SPD significantly (see Table 3). However, rumination and anxiety also correlated significantly and positively. Additionally, rumination and anxiety positively correlated considerably with IU.

3.3.1. Testing the hypotheses for study 1

Table 4 presents the results of regression analysis with demographic variables as control variables, demonstrating that SPD is positively connected to IU ($\beta = 0.626, p < 0.001$), supporting H1. When considering the interaction of rumination and anxiety, IU was significantly associated with rumination ($\beta = 0.477, p < 0.001$) and anxiety ($\beta = 0.297, p < 0.01$), while rumination was significantly associated with anxiety ($\beta = 0.115, p < 0.01$) and SPD ($\beta = 0.242, p < 0.001$). Additionally, anxiety was associated with SPD ($\beta = 0.396, p < 0.001$). On the other hand, the direct effect of IU on SPD was significantly reduced ($\beta = 0.385, p < 0.001$). Therefore, rumination and anxiety significantly mediated the influence of IU on SPD, supporting H2-4. Moreover, a bootstrap estimation method (5000 samples) was used to test the total standardized indirect effects, which was 0.242 (see Table 5).

Specifically, the total mediating effect was generated by three pathways: IU→ ruminate→ SPD, and indirect effect 1 (0.115); IU→ anxiety→ SPD, and indirect effect 2 (0.107); and IU→ ruminate→ anxiety→ SPD, and indirect effect 3 (0.020). Table 5 showed that the bootstrap 95% confidence interval for indirect effects 1, 2, and 3 all did not contain zero and were significant, accounting for 18.42%, 17.05%, and 3.16% of the total effect, respectively. H2-4 were again tested. Comparison 1 showed that the 95% confidence interval for the difference between indirect effects 1 and 2 contained zero, indicating no significant difference between them. However, a significant difference was found in comparisons 2 and 3 (see Table 5), mainly because indirect effect 3 was dramatically smaller than the others. Furthermore, the rumination-independent mediating effect accounted for the highest proportion of the total effect (18.42%), similar to that of anxiety (17.05%), both of which were significantly higher than the chain-mediated effect (3.16%). The results suggested that IU is associated with SPD not only indirectly through independent mediating effects of rumination and anxiety but also weakly through the chain mediating effect of rumination and anxiety.

3.3.2. Testing the hypotheses for study 2

Table 6 presents the results of regression analysis with demographic variables as control variables, demonstrating that SPD is positively connected to IU ($\beta = 0.588, p < 0.001$), supporting H1. When considering the interaction of rumination and anxiety, IU was significantly associated with rumination ($\beta = 0.456, p < 0.001$) and anxiety ($\beta = 0.357, p < 0.001$), while rumination was significantly associated with anxiety ($\beta = 0.179, p < 0.001$) and SPD ($\beta = 0.172, p < 0.001$). Additionally, anxiety was associated with SPD ($\beta = 0.299, p < 0.001$). On the other hand, the direct effect of IU on SPD was significantly reduced ($\beta = 0.378, p < 0.001$). Therefore, rumination and anxiety significantly mediated the influence of IU on SPD, supporting H2-4. Moreover, a bootstrap estimation method (5000 samples) was used to test the total standardized indirect effects, which was 0.203 (see Table 5).

Specifically, the total mediating effect was generated by three pathways: IU→ ruminate→ SPD, and indirect effect 1 (0.076); IU→ anxiety→ SPD, and indirect effect 2 (0.104); and IU→ ruminate→ anxiety→ SPD, and indirect effect 3 (0.024). Table 7 showed that the 95% confidence interval for indirect effects 1, 2, and 3 all did not contain zero and were significant, accounting for 12.97%, 17.62%, and 4.03% of the total effect, respectively. H2-4 were again tested. Comparison 1 showed that the 95% confidence interval for the

Table 3
| Correlations among major study variables.

Variable	M	SD	1	2	3	4
Study 1						
1. IU	2.03	0.76	1			
2. Rumination	1.84	0.64	.571**	1		
3. Anxiety	1.31	0.55	.503**	.387**	1	
4. SPD	1.80	0.79	.607**	.510**	.508**	1
Study 2						
1. IU	2.17	0.77	1			
2. Rumination	2.07	0.68	.525**	1		
3. Anxiety	1.49	0.66	.523**	.414**	1	
4. SPD	2.01	0.79	.579**	.465**	.515**	1

Notes. M = Means, SD = Standard deviations; $n_1 = 553$ for Study 1, $n_2 = 1610$ for Study 2; ** $p < 0.01$.

Table 4
| Regression analysis of variables in Study 1.

Regression equation		Fitting index			Regression coefficient significance			
Result variable	Predictor variable	R	R ²	F	β	t	LLCI	ULCI
SPD		.628	.394	39.289***				
	IU				.626	17.806***	.557	.696
Rumination		.583	.339	30.998***				
	IU				.477	15.872***	.418	.536
Anxiety		.538	.289	22.048***				
	Rumination				.115	3.038**	.041	.190
	IU				.297	9.228***	.234	.360
SPD		.689	.475	44.414***				
	Anxiety				.396	6.781***	.255	.463
	Rumination				.242	5.116***	.149	.335
	IU				.385	8.998***	.301	.468

Notes. n₁ = 533; **p < 0.01, ***p < 0.001.

Table 5
| Mediation effect analysis.

	Indirect effect	Boot SE	Boot LLCI	Boot ULCI	The ratio of indirect to total effect
Total indirect effect	.242	.039	.168	.318	38.62%
Indirect effect 1	.115	.028	.062	.172	18.42%
Indirect effect 2	.107	.028	.055	.166	17.05%
Indirect effect 3	.020	.009	.004	.038	3.16%
Compare 1	.009	.044	-.078	.095	
Compare 2	.096	.028	.045	.153	
Compare 3	.087	.028	.038	.148	

Note. Boot SE = Standard error of indirect effects; indirect effect 1: IU → rumination → SPD; indirect effect 2: IU → anxiety → SPD; indirect effect 3: IU → rumination → anxiety → SPD.

Table 6
| Regression analysis of variables in Study 2.

Regression equation		Fitting index			Regression coefficient significance			
Result variable	Predictor variable	R	R ²	F	β	t	LLCI	ULCI
SPD		.659	.434	111.215***				
	IU				.588	28.289***	.547	.628
Rumination		.559	.312	80.619***				
	IU				.456	24.757***	.418	.494
Anxiety		.5583	.312	72.401***				
	Rumination				.179	7.293***	.125	.233
	IU				.357	16.796***	.305	.409
SPD		.659	.434	111.215***				
	Anxiety				.299	10.988***	.228	.366
	Rumination				.172	6.349***	.109	.233
	IU				.378	15.101***	.316	.441

Notes. n₂ = 1610; ***p < 0.001.

Table 7
| Mediation effect analysis.

	Indirect effect	Boot SE	Boot LLCI	Boot ULCI	The ratio of indirect to total effect
Total indirect effect	.203	.020	.165	.243	34.62%
Indirect effect 1	.076	.015	.048	.106	12.97%
Indirect effect 2	.104	.014	.078	.131	17.62%
Indirect effect 3	.024	.005	.015	.034	4.03%
Compare 1	-.027	.021	-.069	.015	
Compare 2	.053	.016	.023	.084	
Compare 3	.080	.013	.056	.107	

Note. Boot SE = Standard error of indirect effects; indirect effect 1: IU → rumination → SPD; indirect effect 2: IU → anxiety → SPD; indirect effect 3: IU → rumination → anxiety → SPD.

difference between indirect effects 1 and 2 contained zero, indicating no significant difference between them. However, a significant difference was found in comparisons 2 and 3 (see Table 7), mainly because indirect effect 3 was dramatically smaller than the others. Furthermore, the anxiety-independent mediating effect accounted for the highest proportion of the total effect (17.62%), similar to that of rumination (12.97%), both of which were significantly higher than the chain-mediated effect (4.03%). The results suggested that IU is associated with SPD not only indirectly through independent mediating effects of rumination and anxiety but also weakly through the chain mediating effect of rumination and anxiety.

4. Discussion

We investigated the potential consequences of COVID-19 on Chinese preservice teachers by using two independent studies. In both studies, due to using the same scales, and theoretical models, but with differences in the number of participants, we validated the covariance structure of Study 1 and Study 2 in SmartPLS 3.0 with a consistent multigroup analysis, i.e., all path coefficients were compared for the variability of the results [46]. No significant differences were found between the two studies for all path coefficients (see Appendix A), which indicated the reliability of the final research findings. Finally, we found that levels of SPD were elevated by IU (e.g., enforced isolation due to anti-epidemic policy requirements) in preservice teachers. Meanwhile, rumination and anxiety would be involved in interpreting this relationship.

The theoretical contributions of our studies are as follows. First, we found that IU serves as a significant association variable of SPD for preservice teachers in China, consistent with previous studies examining other groups [13,47], which means that IU is a significant available factor to account for Chinese preservice teachers' SPD. The global SPD rate was 28.3%, with a remarkably higher prevalence among young college students compared to other adults, and 41.93% among Asian medical students [8,48]. Therefore, exploring the influence of IU on SPD might have significant implications for mitigating or intervening in SPD among this particular group of preservice teachers. This finding also supports previous empirical findings and our first hypothesis, which follows the CIUT. Previous studies showed higher SPD was associated with lower IU, greater rumination, and higher anxiety [17,35,49]. More importantly, we used more participants in total ($N = 2143$) than in an earlier study ($N = 271$) to test the impact of IU on SPD ($r = 0.242$, $p < 0.001$) in the US [50].

Second, it would be meaningful to explore the internal process of how IU could affect SPD to attain preventive control outcomes. We found that rumination is a mediator of the IU to impact SPD, implicating that IU may promote SPD by augmenting rumination as a cognitive process [51,52], and available experimental evidence suggested that rumination affected SPD in college students, and the strength of the association varied from 0.26 to 0.44 [35,49]. Simultaneously, the findings also showed that anxiety is a mediating variable that verifies IU may explain SPD by affecting anxiety. IU was thought to be a significant component underlying anxiety disorders [53], previous studies have mostly studied the relationship between them, suggesting that higher IU was positively associated with anxiety, i.e., higher IU might suffer from higher anxiety [47,54,55]. However, anxiety emphasizes more on a sense of uncontrollability and its consequences [56]. In line with the I-PACE model, from our study, susceptibility variables triggered under the COVID-19 pandemic, when troubled by uncertainty, could be mitigated by the development of habitual behaviors of SPD, specifically through cognitive ruminant and negative emotional anxiety responses to specific stimuli, with a greater tendency to reduce their inhibitory control and engage in short-term behaviors (e.g., smartphone use), which might be acquired as a maladaptive coping strategy upon being distressed by uncertainty [13].

In addition, the chain mediation from rumination to anxiety is observed, and we also found that the three pathways were similar in both studies, and IU \rightarrow rumination \rightarrow anxiety \rightarrow SPD had the lowest indirect effect accounting for less than 5% of the total effect, which was statistically significant, but probably not as substantial in practice [57]. Yet it might be a possible novel finding that would require consideration in further studies whether individuals could influence anxiety and further reduce SPD through rumination. Although the present study found independent mediating effects and a mediating chain effect of rumination and anxiety, the psychological processes are relatively complex, and other factors might merit further exploration.

Finally, strict adherence to anti-epidemic policy is critical to controlling infection and cutting off transmission routes, and the protection of vulnerable populations must be upheld [1]. Nevertheless, it cannot be denied that the resultant uncertainty is widespread worldwide, which requires us to proactively focus on special groups over a long time [47,55]. Preservice teachers are students at present, they would be teachers and affect the development of the nation later, and focusing on them has special significance [11]. Therefore, according to our study, there are practical implications as follows. First, transparent and timely disclosure of information to the public is critical. Individuals who are IU might engage in the necessary psychological self-adjustment and reduce uncertainty [58], and individual counseling services and timely mental health interventions might be beneficial. In the future, fear of the unknown and IU should be explored as explicit rather than implicit components of school psychoeducation, as well as explicit goals of exposure and cognitive restructuring [59]. Second, Confucianism is the prevailing philosophy that shapes teaching and learning in China, whose principles stress fairness and quality in education and recommend one should "reflect on their faults many times a day" [60]. Reflection may be triggered by adverse effects or lead to adverse effects in the short term and may eventually be adaptive in reducing negative affect [35,61]. However, it may also exacerbate anxiety and SPD. Hence, thinking less might be a workable strategy for individuals with higher IU. And at last, SPD could become problematic if used to escape real-life problems [7,17,28]. The present study's findings from a specific group of preservice teachers, a representative sample of university students, actually open new avenues for prevention and regulatory policies under the current anti-epidemic policies. Notably, a more systematic promotion of problem-solving-based coping strategies in schools could help to reduce anxiety and stress and thus eventually impact and reduce SPD in students [5,7,28].

5. Strengths, limitations, and future research

This research used two independent surveys with a large total sample size ($N = 2163$) to investigate a unique cohort of Chinese preservice teachers. Moreover, Study 2 replicated the results of Study 1 based on an enlarged number of participants to obtain more reliable and reproducible findings. However, because of the methodological limitations within the cross-sectional questionnaire, on the one side, potential concerns about common methodological bias (e.g., social acceptance effects) might arise from using self-reported data in Study 1 and Study 2 [42]. But such bias is less concerned when exploring interaction or moderating effects [62]. Nevertheless, the later studies could still collect data from multiple sources. On the other side, although we intentionally increased the number of participants in the measurement process and validated the theoretical model at different time points in various regions and with other data collection methods, the causal relationship needs to be further studied by experimental design to obtain more accurate causal inferences, especially the mechanisms of mediating variables.

6. Conclusion

This study explored the relationship between IU and SPD, along with the possible intermediary variables between them in Chinese preservice teachers. We performed two studies and found that preservice teachers' SPD is indirectly connected to IU through the independent mediator of rumination and anxiety, and also weakly through the chain mediation of rumination and anxiety. Our findings enrich the IU and SPD theory literature by broadening the analysis of the consequences, as well as testing the buffering role of rumination and anxiety. We hope that our research will inspire more studies to expand the literature on IU and SPD, let more people pay attention to preservice teachers, and help educators understand the impact of current anti-epidemic policies on Chinese preservice teachers.

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Data availability statement

The raw data would be made available without any reservation. Requests to access that should be directed to YSH, yongshh@126.com.

Author contribution statement

Sensen Zhang: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper. </p>

Shaohong Yong: Conceived and designed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper. </p>

Yulun Tang; He Feng; Luan Chen; Yanli Deng; Jiatai Chen: Performed the experiments; Analyzed and interpreted the data. </p>

Linlin Zhang: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper. </p>

Declaration of competing interest

The authors declare no competing interests.

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