

# COVID-19 Uncertainty and Sleep: The Roles of Perceived Stress and Intolerance of Uncertainty during the Early Stage of the COVID-19 Outbreak

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## Research Article

**Keywords:** Uncertainty about COVID-19, Intolerance of Uncertainty, Perceived Stress, Poor Sleep

**Posted Date:** February 17th, 2021

**DOI:** <https://doi.org/10.21203/rs.3.rs-200280/v1>

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# Abstract

## Background.

The COVID-19 pandemic brings unprecedented uncertainty and stress. This study aimed to characterize sleep behaviors among Chinese residents during the early stage of the outbreak and to test the extent to which sleep quality was driven by COVID-19 uncertainty, intolerance of uncertainty, and perceived stress.

## Methods.

A cross-sectional correlational survey was conducted online. A total of 2,534 Chinese residents were recruited from February 7 to 14, 2020, the third week of lockdown. Self-report measures assessed uncertainty about COVID-19, intolerance of uncertainty, perceived stress, and sleep quality. Structural equation modeling was applied to test the relationships among uncertainty about COVID-19, intolerance of uncertainty, perceived stress, and sleep quality.

## Results.

Sleep disturbance was common, with approximately half of participants (47.1%) reporting going to bed after 12:00am, 23.0% taking 30 minutes or longer to fall asleep, and 30.3% sleeping a total of 7 hours or less. Higher uncertainty about COVID-19 was significantly positively correlated with higher intolerance of uncertainty ( $r = 0.506, p < 0.001$ ). Uncertainty about COVID-19 had a weak direct effect on poor sleep ( $\beta = 0.043, p < 0.05$ ); however, there was a robust indirect effect on poor sleep through intolerance of uncertainty ( $\beta = 0.506, p < 0.001$ ) and perceived stress ( $\beta = 0.479, p < 0.001$ ).

## Conclusions.

These findings suggest that intolerance of uncertainty and perceived stress are critical targets for reducing sleep disturbance during the COVID-19 pandemic. Given the sustained uncertainties and challenges managing COVID-19, it is likely that, if unmanaged, COVID-19 related uncertainty will persist and continue to impact sleep outcomes.

## Introduction

The World Health Organization's (WHO's) China Country Office was informed of cases of pneumonia of unknown cause detected in Wuhan City, Hubei Province, on December 31, 2019 [1]. On January 23, in response to the growing COVID-19 epidemic, the Chinese government locked down Wuhan City [2]. During the first 14 days of lockdown, confirmed cases in China increased dramatically from 571 on January 23 to 28,060 on February 6 [1]. Due to the enforcement of lockdown, most people were restricted to their homes. This confinement has resulted in a changed lifestyle, disrupted chronobiological rhythms, and

impacted on mental health [3, 4]. An online survey demonstrated that 30% of participants among Wuhan residents had a sleep disorder in the incipient pandemic [5]. Similarly, an Italian study reported 42.2% of the sample had sleep disturbances and, among them, 17.4% reported moderate/severe insomnia, where the first European country entered a nationwide lockdown [4]. Sleep is an integral part of proper human function [6]. Poorer sleep quality is associated with increased susceptibility to viral infections, lower cognitive functioning, poorer job performance, and worsened mental health [7]. Understanding the influencing mechanism of sleep during the COVID-19 pandemic may help the residents to maintain good sleep status and provide support for design and implementation of interventions for sleep health in pandemic condition.

When confronted with a such sudden and actual disaster, people realize uncertainty surround every aspect of life [8]. Uncertainty is one of the most major cognitive and psychological stressors [9]. Further, factors relating to stress are one of the most important concomitants of sleep complains in the general population [3, 10]. The concept of uncertainty in illness was defined as “the inability to determine the meaning of illness-related events” [11]. Applicable to COVID-19, uncertainty according to Mishel’s initial definition is a cognitive state that occurs when the decision maker is unable to assign definite values to objects and events and/or is unable to accurately predict outcomes because of a lack of sufficient cues [11]. Since this unexpected COVID-19 pandemic has swept across the world, limited knowledge of COVID-19 for diagnosis or treatment, unpredictability of the natural course of contagious illness, and gross disruption of societal functioning and people’s routines may all represent potential sources of uncertainty. Uncertainty has been identified as the greatest single psychological stressor for patients with a life-threatening illness [12].

Intolerance of uncertainty (IU) relates to the cognitive unacceptability of uncertainty and represents a dispositional characteristic from those people who are more likely to “find ambiguity stressful and upsetting, believe uncertainty is negative and should be avoided, and have difficulty functioning in uncertain situations” [13, 14]. Although uncertainty is pervasive and inherent in people’s daily life, individuals who have high degree of perceived uncertainty or who are high in IU experience might significantly impair their daily functioning [15, 16]. A substantial body of research suggests that individual difference in IU foster stress [15, 16]. Theoretical conceptualizations posit that those high in IU are likely to rely on maladaptive behaviors as a coping mechanism when faced with uncertain and potentially aversive situations [17].

A significant association between IU and sleep disturbances in young adults and more particularly Iranian adults was examined [18]. A large body of evidence on clinical research has demonstrated that generalized anxiety disorder (GAD) patients with greater IU suffer from sleep dysfunctions including longer sleep latency, decreased sleep duration, decreased total sleep efficiency, and increased waking periods during sleep time [19, 20]. Research by our group has also demonstrated strong associations between cancer-related uncertainty and insomnia severity among cancer survivors [21]. There is a plethora of studies on uncertainty for clinical patients with chronic diseases. However, research on uncertainty in a lethal and urgent infectious disease outbreak and its side effect is limited among non-

patients. The role of IU in sleep problems has not been studied extensively [14]. Unknown is how IU impacts the public in cognitively processing a COVID-19-related stressor, as well as how their sleeping behaviors are influenced by such serious outbreak-related events.

Based on the previous literature, IU appears to be an important element of cognitive vulnerability affecting sleep quality [20]. The current study seeks to explore the potential mechanism for influencing sleep quality under the early stage of COVID-19 outbreak, and to examine how IU and perceived stress impact the relations between uncertainty about COVID-19 and sleep in a sample of Chinese general residents. The following four hypotheses and research question were evaluated in this study. First, we expected a positive association between perceived uncertainty about COVID-19 and IU and, second, following prior studies, an association between IU and perceived stress [15, 22]. Third, in the line with previous research [23], we predicted a positive association between stress and poor sleep. Finally, we treat as exploratory the possibility that IU and stress would take mediating role between uncertainty about COVID-19 and poor sleep.

## Methods

### Study Design and Participants

This study utilized a cross-sectional correlational design. Our survey was developed on the Wenjuanxing Platform (<https://www.wjx.cn/app/survey.aspx>) and conducted online from February 7 to 14, 2020, the third week after the lockdown of Wuhan City. Twenty psychology students were trained as research assistants to recruit participants through WeChat and other websites using the snowball technique. Participants took approximately 15-minutes to complete the questionnaire. The study protocol was approved by the Ethics Committee of Shenzhen University, and written consent was obtained from all participants prior to administration of the questionnaire.

### Measures

The survey questionnaire covered five categories: (a) demographics, (b) sleep quality, (c) uncertainty about COVID-19, (d) intolerance of uncertainty, and (e) perceived stress.

### Dependent variables

#### Sleep Quality

Sleep quality was measured by the Pittsburgh Sleep Quality Index (PSQI) [24]. Subjective sleep quality, sleep bedtime, sleep latency, sleep duration, use of sleep medication, and daytime dysfunction were assessed. The six component scores were rated on a 0–3 scale, and then summed to yield a global sleep score which has a range of 0–18, with higher scores reflecting poorer sleep quality.

# Independent variables

## Demographic Characteristics

The following sociodemographic information was collected during the survey: date of birth, gender, place of residence, ethnicity, marital status, educational attainment, occupation and per capita annual family income.

## Uncertainty about COVID-19

The 10-item Uncertainty about COVID-19 Scale was developed with reference to the Mishel Uncertainty in Illness Scale [11]. We applied a 5-point Likert type scale ranging from strongly agree to strongly disagree in tapping public perception of uncertainty about the COVID-19 outbreak. Item scores were summated to obtain a total uncertainty score. The higher the score, the greater the perceived uncertainty about the disease. The Kaiser-Meyer-Olkin measure of sampling adequacy was 0.866, and Bartlett's test of sphericity was significant ( $P < 0.001$ ), suggesting the sample was factorable. The factor loading on each item exceeded 0.5. Finally, two distinct factors were extracted, and they accounted for 59% of the variance. The factor of "lack of information and clarity" was loaded on five items: "I have many unanswered questions about COVID-19," "I am unsure how to deal with a fever, cough or other symptoms," "The effectiveness of the treatments or medications COVID-19 patients are receiving is undetermined," "The transmission route of COVID-19 is unclear," "There are so many different opinions about the prognosis of COVID-19." The factor of "unpredictability" was loaded on another five items: "Because of the unpredictability of the COVID-19 outbreak, I cannot plan for the future," "Because of the COVID-19 outbreak, what I can do and cannot do is in flux," "I am unsure when the outbreak COVID-19 will end," "I am unsure when social normal order will return," "It is unclear what is going to happen to me." The Cronbach's alphas coefficient were 0.75 for lack of information and clarity, and 0.85 for unpredictably, respectively. The reliability coefficient for the Uncertainty about COVID-19 Scale was 0.85, suggesting good reliability.

## Intolerance of Uncertainty

Intolerance of Uncertainty was measured by the 12-item Intolerance of Uncertainty Scale (IUS-12) [25]. The IUS-12 consisted a stable two-factor structure, representing anxious and avoidance components of intolerance of uncertainty [25, 26]. Items are scored on a Likert scale ranging from 1 (not at all characteristic of me) to 5 (entirely characteristic of me), yielding possible total scores from 12 to 60. Higher the overall scores correspond to higher intolerant of uncertainty. The Cronbach's  $\alpha$  coefficient for Intolerance of Uncertainty Scale in this sample was 0.89.

## Perceived stress

Stress was measured by Perceived Stress Scale, Chinese version (CPSS) [27–29]. This scale comprised 14 items that assessed perception of stress during the month prior to survey. Items were rated on a 5-point Likert type scale, and ranged from 1 (never) to 5 (very often). Item scores were summed to yield a

total stress score. The higher the total score, the greater the perceived level of stress [27–29]. The internal reliability of the CPSS in this sample, measured by Cronbach's  $\alpha$ , was 0.77.

## Data analysis

All survey data were entered into a Microsoft Excel database, and then imported into SPSS (version 22.0) for statistical analysis. Descriptive statistics and univariate analysis on sleep status were conducted. Cronbach's alpha coefficient and exploratory factor analysis were used to examine the reliability and validity of the Uncertainty about COVID-19 Scale. Pearson correlational analysis was applied to explore the relationships among intolerance of uncertainty, uncertainty about COVID-19, perceived stress, and sleep status. Hypotheses were also tested by Structural Equation Modeling (SEM) with maximum likelihood estimation. Model fit was evaluated based on a Chi-square to degrees of freedom ratio ( $\chi^2/df$ ), adjusted goodness of fit index (AGFI), normed fit index (NFI), the Tucker-Lewis Index (TLI), the root mean square error of approximation (RMSEA), and the minimum value of F (FMIN).

## Results

The response rate could not be calculated because the study population was a convenience sample. A total of 2,534 participants were surveyed, of whom 2,215 (87.4%) completed valid questionnaires. Over two-thirds of the participants were female (67.2%) and urban residents (68.7%), 75.3% were single, and 50.2% were aged 20 to 24 years. The characteristics of the respondents are summarized in Table 1. The statistically significant differences in sociodemographic characteristics for poor sleep were for age, place of residence, ethnicity, and marital status.

Table 2 demonstrated the sleep status of participants during the early stage of COVID-19 outbreak. Among the total sample, 47.1% went to bed after 12:00 am, 23.0% took more than 30 minutes to fall asleep, and 30.3% of participants' sleep duration were less than 7 hours. The minority of participants (8.5%) used the sleeping medication and 20.9% rated their sleep quality bad or very bad. The half of participants experienced daytime dysfunction.

The descriptive statistics and bivariate correlations were displayed in Table 3. The mean of total score of sleep status was 4.82 (95% C.I. 4.71-4.94). Each item score for intolerance of uncertainty, uncertainty about COVID-19, and perceived stress were 3.03 (95% C.I. 3.00-3.06), 3.08 (95% C.I. 3.05-3.10), and 2.92 (95% C.I. 2.90-2.94), respectively. The correlation between intolerance of uncertainty and uncertainty about COVID-19 ( $r=0.506$ ,  $p<0.001$ ) and perceived stress and poor sleep ( $r=0.336$ ,  $p<0.001$ ) were positive. Meanwhile, intolerance of uncertainty ( $r=0.538$ ,  $p<0.001$ ) and uncertainty about COVID-19 ( $r=0.360$ ,  $p<0.001$ ) also positively related to perceived stress.

The Structural Equation Modeling analysis in Figure 1 showed the hypothesized model fitted the data adequately across the whole samples ( $\chi^2/df = 2.377$ , AGFI=0.995, NFI = 0.999, TLI = 0.995, RMSEA = 0.025, FMIN=0.001). Specifically, uncertainty about COVID-19 had a weak direct effect on poor sleep ( $\beta=0.043$ ,  $p<0.05$ ). uncertainty about COVID-19 had an indirect effect on poor sleep through intolerance of

uncertainty ( $\beta=0.506$ ,  $p<0.001$ ) and perceived stress ( $\beta=0.479$ ,  $p<0.001$ ). Further, uncertainty about COVID-19 also had another indirect pathway impacting poor sleep via perceived stress ( $\beta=0.118$ ,  $p<0.001$ ).

## Discussion

The COVID-19 brings the unprecedented uncertainty to individual and society at the initial stage of outbreak. Uncertainty is an ever-present feature when people face the COVID-19 outbreak. This study investigated the Chinese residents' cognitive and behavioral response especially sleeping behavior towards the uncertainty about COVID-19 at the third week of lockdown.

Our study showed that this kind of uncertainty caused by COVID-19 might have influenced on the public's sleeping behaviors and sleep quality. The Illness Uncertainty Theory explains how patients cognitively process an illness-related stimulus, as well as how they structure the meaning of such an event, and proposes that high uncertainty is associated with diminished capacity to process new information, predict outcomes, and adapt to the illness [30]. Not only the illness uncertainty and fear of disease progression affect psychosocial adjustment and the quality of life [31], but the uncertain social situation caused by COVID-19 would also disrupt the people's routine sleep schedule.

However, we found an effect size smaller than expected for the correlation between uncertainty about COVID-19 and poor sleep status. For possible potential explanation, its key mechanism of the relationship between uncertainty about COVID-19 and poor sleep might be mediated by intolerance of uncertainty and corresponding stress indirectly. Sleep research has shown that stress uniquely predict poor sleep quality, while IU has been less studied with sleep problems [20]. Previous research has overlooked the role of cognitive dispositions that might exacerbate stress, thus contributing to the continuation of sleep problems [14]. Perceived uncertainty and IU might be such dispositions. Our study found uncertainty about COVID-19 had a highly positive association with IU. To our knowledge, only limited studies examined IU as antecedents of sleep problems. One study showed IU was strongly associated with anxiety sensitivity, in turn influencing both insomnia severity and sleep quality via depression and anxiety [14]. IU might be involved in the process that links personality to sleep problems as well [14]. The Uncertainty and Anticipation Model of Anxiety identified that individual differences in IU are related to physiological indicators of responses to uncertainty, that are associated with increased risk for anxiety [32, 33]. Another study demonstrated that worry partially mediated the relationship between IU and poor sleep quality in adolescent sample [20].

Along with previous study, our study has found a positive correlation between IU and perceived stress [15, 22, 34]. The link between uncertainty and stress theoretically suggested that IU could increase the negative impact of stressors [22, 35]. Given the great impact of the individual ability to tolerate uncertainty on the residents' level of perceived stress, it would be worth paying particular attention to such a skill when facing the COVID-19. It would be crucial to introduce or to empower tools and strategies that could increase residents' ability to tolerate uncertainty and cope with related stress, further to

improve the sleep status. Recently, work by our group has focused on disseminating mind-body resiliency skills aimed at reducing intolerance of uncertainty and improving stress management skills using synchronous, virtual platforms that can be accessed while engaging in social distancing [36]. Among cancer survivors, another population facing illness uncertainty, training in relaxation, meditation, cognitive-behavioral coping techniques, and positive psychology skills (e.g., gratitude, using humor) have been associated with favorable improvements in tolerance of uncertainty [37]. Similar resiliency training approaches may thus yield downstream benefits on improving sleep during the COVID-19 pandemic, although to the best of our knowledge this remains unexamined.

## **Strengths and Limitations**

This study has several strengths and limitations. First, sleep quality was assessed via self-report, which may be susceptible to recall bias. Still, the Pittsburgh Sleep Quality Index is psychometrically strong, and objective sleep measures (e.g., actigraphy) have been critiqued for not accounting for perceived sleep disturbances. Second, this report included a large sample of over 2500 Chinese residents. While the cross-sectional analyses precluded our ability to draw causal conclusions, our use of structural equation modeling capitalized on the large sample size to test multiple indirect pathways from COVID-19 uncertainty to sleep quality. Finally, while we were able to collect surveys during the early stages of the pandemic, we recognized this sample in China may not generalize to the experiences of uncertainty in other nations whose governments responded differently to managing COVID-19.

## **Conclusions**

The current study suggested that the Chinese residents' uncertainty about COVID-19 is directly associated with poor sleep but also indirectly correlated through the mediating role of IU and perceived stress. Specific strategies targeting in reducing greater IU and excessive stress might be effective for improving the public's sleep quality during the stage of COVID-19 pandemic.

## **Declarations**

### **Ethics approval and consent to participate**

The study protocol was approved by the Ethics Committee of Shenzhen University, and all methods were carried out in accordance with relevant guidelines and regulations. The written informed consent was obtained from all participants prior to administration of the questionnaire.

### **Consent for publication**

Not applicable.

### **Data availability statement**

Data available on request from the corresponding author.

## Funding

This study was partially supported by Natural Science Foundation of Guangdong Province of China (Grant No. 2018A030307002), Key Research Projects of Colleges and Universities in Guangdong Province (2018WZXDM015); and Shenzhen Basic Research Grant (2019SHIBS0003).

## Competing interests

The authors declare that they have no conflict of interest with respect to the research, authorship, and/or publication of this article.

## Authors' Contribution

DW and TY designed the study, DW, GJ and CJ collected and analysed the data, DW drafted the manuscript, and DH, CJ, and TY revised the manuscript.

## Acknowledgements

The authors would like to thank the research assistants to help us collect data and the residents who participated in this study.

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## Tables

**Table 1 Demographic characteristics and total score of poor sleep**

<b>Variables</b>	<b>N</b>	<b>%</b>	<b>Mean (SD)</b>	<b>F/t</b>	<b>p</b>
<b>Age</b>				6.800	<0.001**
<20	411	18.6	4.49 (2.64)		
20-24	1113	50.2	5.00 (2.77)		
25-29	240	10.8	5.28 (2.74)		
30-39	209	9.4	4.55 (2.66)		
40+	242	10.9	4.36 (2.53)		
<b>Gender</b>				0.235	0.628
Male	726	32.8	4.86 (2.80)		
Female	1489	67.2	4.80 (2.68)		
<b>Place of residence</b>				12.910	<0.001**
Urban	1522	68.7	4.96 (2.74)		
Rural	683	31.3	4.52 (2.64)		
<b>Ethnicity</b>				8.269	0.004**
Han	2155	97.3	4.79 (2.71)		
Minority	60	2.7	5.82 (2.87)		
<b>Marital status</b>				4.253	0.014*
Unmarried	1699	75.3	4.88 (2.73)		
Married	517	23.3	4.57 (2.67)		
Divorced/widowed	29	1.3	5.72 (2.52)		
<b>Education</b>				2.075	0.101
Junior high school or less	196	8.8	4.68 (2.82)		
High school	233	10.5	5.04 (2.86)		
Junior college	263	11.9	5.13 (3.02)		
College or higher	1523	68.8	4.76 (2.63)		
<b>Occupation</b>				0.621	0.648
Public official /professionals	257	11.6	4.71 (2.69)		
Enterprise personnel	238	10.7	4.91 (2.90)		
Commerce/service/operations	215	9.7	5.03 (2.61)		

Students	1311	59.2	4.78 (2.70)		
Others	194	8.8	4.91 (2.80)		
<b>Household annual income (RMB)</b>				0.750	0.522
Less than 20,000	475	21.4	4.78 (2.70)		
20,000-60,000	832	37.6	4.74 (2.67)		
60,000-100,000	516	23.3	4.90 (2.74)		
More than 100,000	392	17.7	4.95 (2.82)		

\*<0.05; \*\*<0.01

**Table 2 The sleep status of participants during the early stage of COVID-19 outbreak**

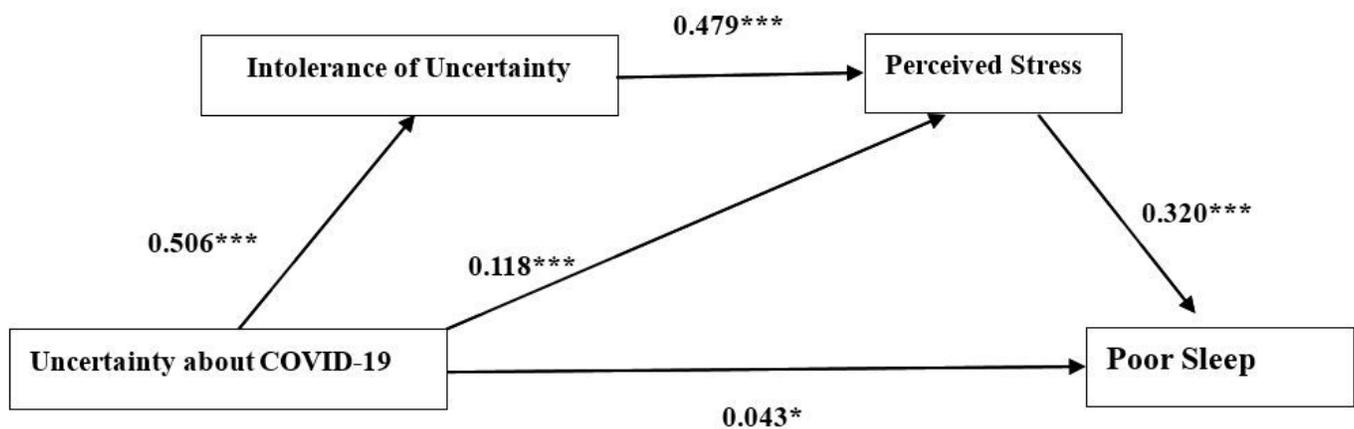
<b>Variables</b>	<b>n</b>	<b>%</b>	<b>Variables</b>	<b>n</b>	<b>%</b>
<b>Bedtime</b>			<b>Subjective Sleep quality</b>		
Before 11:00pm	550	24.8	Very good	527	23.8
11:00pm-12:00am	622	28.1	Good	1226	55.3
12:00am-1:00am	589	26.6	Bad	411	18.6
After 1:00am	454	20.5	Very Bad	51	2.3
<b>Sleep latency</b>			<b>Use of sleeping medication</b>		
≤15 mins	855	38.6	None	2026	91.5
16-30 mins	851	38.4	<1 /per week	90	4.1
31-60 mins	284	12.8	1-2 /per week	81	3.7
≥60 mins	225	10.2	≥3 / per week	18	0.8
<b>Sleep duration</b>			<b>Daytime dysfunction</b>		
<5 hours	58	2.6	None	1108	50.0
5-6 hours	187	8.4	<1 /per week	515	23.3
6-7 hours	426	19.2	1-2 /per week	347	15.7
≥7 hours	1544	69.7	≥3 / per week	245	11.1

**Table 3 Inter-correlations and descriptive statistics of study variables**

Variables						Total Score		Item Score	
		1	2	3	4	M(SD)	95% C.I.	M(SD)	95% C.I.
1	Intolerance of uncertainty	1.00				36.40 (8.19)	36.06- 36.74	3.03 (0.68)	3.00- 3.06
2	Uncertainty about COVID-19	0.506**	1.00			30.77 (6.47)	30.50- 31.04	3.08 (0.65)	3.05- 3.10
3	Perceived Stress	0.538**	0.360**	1.00		40.87 (6.81)	40.58- 41.15	2.92 (0.49)	2.90- 2.94
4	Poor sleep	0.218**	0.159**	0.336**	1.00	4.82 (2.72)	4.71- 4.94	/	/

\*\*<0.01

## Figures



\*<0.05; \*\*<0.01; \*\*\*<0.001

( $\chi^2/df=2.377$ , AGFI=0.995, NFI = 0.999, TLI = 0.995, RMSEA = 0.025, FMIN=0.001)

Figure 1

Uncertainty-Stress-Sleep Model during the early stage of COVID-19 outbreak