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Temporal changes in mental response and prevention patterns, and their impact from uncertainty stress during the transition in China from the COVID-19 epidemic to sporadic infection

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ABSTRACT

An epidemic of a highly lethal disease can overwhelm people emotionally and physically. Little is known about how public mental and preventive patterns changed during the transition from the COVID-19 epidemic to sporadic infection. This study examined changing trends of metal response and behavioral variables, and their impact from uncertainty stress in this process in China. A prospective longitudinal observation design was utilized. There were 7 waves of surveys from COVID-19 epidemic status to the sporadic infection period. Sixty-two participants completed all observation points and were included in the study. The Mann–Kendall Test was used to assess changing trends across the seven observation points. The nonparametric linear mixed effects model was used to examine the association between uncertainty stress and mental and behavioral responses.

The mean uncertainty stress did not change significantly over the observation period (Z: −0.911, $p > 0.05$). This trend was also true for perceived risk, perceived severity, self-efficacy for prevention, and prevention behavior. There was a statistically significant downward trend in irrational beliefs about prevention (Z: −4.993, $p < 0.01$), sleep (Z: −2.499, $p < 0.05$), emotions (Z: −5.650, $p < 0.01$), and lifestyle (Z: −5.978, $p < 0.01$). The results showed that uncertainty stress was positively associated with irrational beliefs (β: 0.16298, $p < 0.01$), their sleep (β: 0.02070, $p < 0.05$), emotions (β: 0.03462, $p < 0.01$), and lifestyle (β: 0.02056, $p < 0.05$). High levels of uncertainty stress were negatively associated with self-efficacy for prevention and prevention behavior, β was −1.33210 ($p < 0.01$) and −0.82742 ($p < 0.01$). These results may have important policy and disease prevention in post-epidemic times.

1. Introduction

The COVID-19 pandemic is a public health emergency that caused unprecedented disruption to the way most people live and work.

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The disease induced a strong mental and behavioral response that may lead to significant mental and physical health disorders among large segments of the population. According to SCM theory, any stimulus, which in turn may make became aware of the serious threat the disease poses (Cognition) and mental response, ultimately lead to people's mental and behavioral problems(M) [1,2]. COVID-19 is a strong stimulus that plausibly induces people to perceive a high risk of infection with potentially severe health consequences [3]. Many studies found that the potential to contract highly lethal disease, such as COVID-19, can overwhelm people emotionally and physically, and induce strong mental and behavioral responses [4–7]. Given the importance of human mental and behavioral functioning to disease control, it is crucial to study these factors during and after an outbreak [8–10]. Currently, COVID-19 changes from epidemic status to a sporadic infection status in many countries around the world. It is of special significance to understand the impact of time on mental and behavioral reactions to COVID-19 as this may have implications on policy and possible behavioral interventions. However, most studies of COVID-19 were only implemented in a period of the COVID-19 epidemic, were cross-sectional, and few previous empirical studies utilized longitudinal observation [10,11]. A prior prospective observational study examined changing trends in mental and behavioral responses during the epidemic phase of COVID-19 infection in China. At the time of this study, COVID-19 was causing sporadic infections in China. It was not known how a person's mental and behavioral responses, including prevention beliefs and behavior might change as the incidence of the disease decreased. The main purpose of this research is to evaluate changing trends in mental responses and prevention patterns during this period in China. This is urgently needed to inform disease prevention specialists, especially those who work with the most vulnerable populations.

Firstly, this study will include perceived susceptibility and perceived severity of COVID-19 infection. The Health belief model (HBM) specifies that individuals' perceptions can predict their behavior. The four key constructs of the HBM are identified as perceived susceptibility and perceived severity, perceived benefits and perceived barriers. The HBM provided a useful framework for investigating COVID-19, Perceived susceptibility and perceived severity were especially useful about COVID-19. Studies found that perceived susceptibility and perceived severity (also known as perceived risk) were related to social distancing, vaccination, and other suggested COVID-19 preventive behaviors [12–14]. However, few studies explored how perceived risk changed during different periods of the COVID-19 epidemic [15]. This study will examine how perceived risk and uncertainty stress in China was impacted during the transition from the COVID-19 epidemic to sporadic infection. Self-efficacy is defined as "the conviction that one can successfully execute a behavior and achieve behavioral goals. Self-efficacy is a predictor of behavior and has been added as a separate construct to this study [16]. During the COVID-19 pandemic, studies found that self-efficacy was related to practicing preventive behavior and mental health problems [17–20].

Secondly, this study will include mental stress, and uncertainty stress. SCM theory postulates that a contextual stimulus produces a mental response, which, in turn, may influence behavioral and mental problems [1,21]. An outstanding characteristic of the COVID-19 epidemic is uncertainty. It is a new virus, and much information is unknown or imperfect. There is much ambiguity surrounding the disease, including frequent mutations in the pathogen itself. A host of evidence supports the assertion that uncertainty is a powerful stressor [2,22,23]. Obviously, the uncertainty regarding COVID-19 may form strong levels of uncertainty and stress for people. Some authors have noted that uncertainty stress has hurt COVID-19 epidemic control and has created challenges for disease prevention [24]. One recent study found that uncertainty stress was an independent stimulus in the SCM theoretical framework [15]. Uncertainty stress has been at persistently high levels throughout the COVID-19 epidemic, and it has been positively associated with disease fear, and negatively associated with self-efficacy and prevention behaviors [15]. Currently, it is not known if these higher levels of uncertainty stress will be maintained as COVID-19 enters into a more sporadic infection period. Will it still contribute to mental and behavioral responses, especially, prevention patterns? This study will seek to answer these questions.

Thirdly, this study will include prevention behaviors and irrational beliefs about prevention. COVID-19 is ferocious, spreads quickly, and poses a great threat to society and the health of its population. It is widely believed that prevention is the key to stopping the epidemic [25]. Many studies have been conducted on COVID-19 prevention behaviors [25,26]. Currently, it is need to be known whether prevention behavior changes from the COVID-19 epidemic to sporadic infection.

Another issue closely related to preventive behavior is irrational beliefs about prevention (irrational beliefs). Irrational beliefs as a cognitive vulnerability factor are dogmatic, non-pragmatic, maladaptive, unhealthy, dysfunctional, lack empirical support and produce maladaptive emotions and behaviors [27]. The ABC model assumes that psychological disturbances often result from the evaluation of experiences rather than actual experiences. In the ABC model, A represents the activating event we experience; B represents rational or irrational beliefs that guide our interpretation or perception of the event; C represents our emotional and behavioral responses arising from our rational or irrational beliefs [28].Some studies found that during the COVID-19 epidemic, people showed more irrational beliefs than would be typical [27].Unusual environmental threats cause higher stress levels in people which is associated with impaired reality and strange thinking patterns [29,30]. This may lead to irrational beliefs about prevention with increased levels of perceived risk and severity associated with COVID-19 [27,31,32]. These beliefs are self-defeating, unconditional, conflict with reality, and unlikely to find empirical support. This study addressed irrational beliefs about effective COVID-19 prevention measures in China that were not founded upon reality and science.

Finally, this study will include sleep, emotional, and lifestyle problems. According to SCM, COVID-19 is a strong stimulus that plausibly induces people to perceive high risk of infection which could lead to severe mental and behavior problems [3]. Many studies found that the potential to contract a highly lethal disease, such as COVID-19, can overwhelm people emotionally and physically, and induce strong mental and behavioral responses [4,5,7,33,34]. Sleep, emotional, and lifestyle problems are common manifestation of mental and behavioral problems [35]. This study will examine changing trends of sleep, emotion, and lifestyle from the COVID-19 epidemic to sporadic infection, and there impact on uncertainty stress.

The study may yield information to assist in formulating evidence-based public policy decisions, directing prevention efforts and implementing health education initiatives aimed at mental and behavioral problems in post-epidemic time. The information may also be of significance for future epidemics and pandemics that may occur.

2. Methods

2.1. Study design

A prospective longitudinal observation study was designed to examine temporal trends and changes in mental and behavioral responses as COVID-19 transitioned from epidemic status to a period of more sporadic infections, and their associations with uncertainty stress in China.

2.2. Participants

Participants were recruited via a survey advertisement in the social media groups WeChat and Douban, two of the most popular social media platforms in China. Inclusion criteria were membership in a common community; being between 20 and 60 years of age; having access to a Smartphone; knowing the Chinese language; and being willing to participate in the panel study and provide follow-up information at seven scheduled observation points. Participants were excluded if they refused to provide this information or had a medical condition that could limit or preclude their participation. Within the registration system, potential participants were screened to ascertain eligibility. Upon consent, participants received an electronic questionnaire and instructions on how to proceed. After reading the instructions, they were asked to provide an e-consent by tapping the "Confirmation and Authorization" button and then directed to the questionnaire. A special administrative WeChat group was established to manage the follow-up data collection, using a unique QR code for each respondent. The QR code was the vehicle, not only for identifying unique participants, but prohibiting non-participants from taking the survey. After scanning the QR code, survey participants could enter the investigation group without further preconditions.

This panel study includes seven waves of data collected from COVID-19 epidemic status to the sporadic infection period. The data collection time interval of each wave was 7 days. Data were collected at two different times; early in the year February and March 2020 and later in the year, December 2020. The actual dates of the data collection were as follows: wave 1(5/Feb/2020), wave 2(12/Feb/2020), 3(19/Feb/2020), wave 4 (26/Feb/2020), and wave 5(4/March/2020) in the first period. The corresponding number of reported newly confirmed patients in this period in China respectively numbered 3,887, 2,015, 394, 433, and 133(National Health Commission of People's Republic of China, 2021). The second period of data collection was:wave 6 (23/December 2020) and wave 7 (30/December 2020). The corresponding number of reported new confirmed patients in this period respectively numbered 17 and 25 [36].

2.3. Data collection

Data was obtained by an online survey, to ascertain mental and behavioral responses to COVID at that time. An online survey was implemented on *Wenjuanxing* (www.wjx.cn), a survey service website similar to Qualtrics or Survey monkey, but tailored to Chinese users. Each wave of the survey had a dedicated electronic questionnaire access link. The online questionnaire link was posted to the respondent group, centrally managed in a WeChat group, and accessible every Wednesday from 10:30 a.m. to 4:30 p.m. Data were collected from 9.00 to 11.00 a.m. every Monday. Data collectors and facilitators were third-year doctoral students enrolled in a university public health program. All responses were anonymous. The questionnaire took approximately 10 min to complete, and the same survey protocol was used for each wave of the survey to assure homogeneity of data administration and collection. As appropriate, a token of appreciation, 30 RMB (approximately $5.00 US dollars) was given to those participants who completed all 7 questionnaires. The study was approved by the Ethics Committee of Zhejiang University (2014:1–017).

2.4. Measurement

In this study, basic individual demographic characteristics were recorded as age, sex, ethnicity, education level, marital status and occupation.

Mental and behavioral variables about prevention in this study included several factors, as described below:

Perceived risk and severity, emotional, sleep, and lifestyle problems are common mental responses and behavioral problems [35]. (1) Perceived risk was measured by a question "Do you always feel that you may be infected? Responses were on a 5-point Likert-type scale ranging from "strongly disagree" to "strongly agree." Perceived severity was measured by the question "If you were infected with COVID-19 it would be a serious misfortune." Responses were again on a 5-point Likert-type scale ranging from "strongly disagree" to "strongly agree". (2) Emotional status, sleep and lifestyle status were measured by three questions, that asked, "how is your current (emotional, sleep, lifestyle) status as compared to before COVID-19 epidemic?" Respondents were to select one of four options: "same as before" "less worse than before" or "much less worse than before" or "better than before". Code "better than before" as 1, "same as before "as 2, "less worse than before" as 3, "much less worse than before" as 4.

Uncertainty stress. COVID-19 is an unfamiliar, infectious disease associated with high mortality rates ([2,22,23]. Uncertainty stress is most common and strongest among different types of mental stresses (Peng et al., 2021). Uncertainty stress was measured utilizing a scale designed by Yang and colleagues (Yang et al., 2019), which has demonstrated acceptable validity, and has since been used extensively in Chinese research (Yang et al., 2019; Wu et al., 2020). It covered 4 items; current life uncertainty ("life is unstable and cannot be controlled"), social change uncertainty ("uncertain about what will happen in the future"), goals uncertainty ("uncertain about how to achieve goals") and social values uncertainty ("cannot follow social values"). Respondents rated these items on a 5-point scale from feel no stress (0), a little stress (1), some stress (2), considerable stress (3), and very strong stress (4). A total stress score was obtained by adding up the responses to the individual questions. The higher the total score, the greater the perceived level of uncertainty stress [37,38]. In this study we examined 'the reliability and validity of the uncertainty stress questionnaire at the seven different observation time points. The Cronbach's α coefficient was 0.83, 0.788 0.92, 0.93, 0.86, 0.92, and 0.90, respectively, suggesting acceptable reliability. Fact analysis was conducted in the following steps. For the Kaiser-Meyer-Olkin measure of sampling adequacy, the lowest of the values at each of the seven survey waves was 0.79, Bartlett's test of sphericity for all was significant ($P < 0.001$), suggesting the samples were factorable. One factor was extracted at each wave, accounting for 67% (the lowest value in the seven waves) of the variance. The lowest value of factor loading of these items was 0.66, 0.75.0.78, and 0.76 at the seven observation time points—indicating the scale has good construct validity (Table 4).

We refer to irrational beliefs about COVID-19 prevention as an umbrella term that covers beliefs that lack a solid evidence base or defy principles of normative rationality [27]. They included, (1) smokers are not susceptible to COVID-19, (2) consuming alcohol can prevent the spread of the virus, (3) people should avoid people from Hubei province, where COVID-19 first manifested in China to prevent contraction of the disease, (4) employees from Hubei should be dismissed to prevent the spread of the novel virus, and (5) people who move away from an affected area should be deported back to their place of origin. Items were rated on a 5-point Likert-type scale, ranging from 1 (strongly disagree) to 5 (strongly agree). Item scores were summed to attain a total score for belief in COVID-19 prevention myths. The Cronbach's α coefficient the questionnaire was 0.68, 0.70, 0.69, 0.71, 0.73, 0.72, and 0.75 at the seven observation time points, respectively, suggesting acceptable reliability. Fact analysis was conducted in the following steps. For the Kaiser-Meyer-Olkin measure of sampling adequacy, the lowest of the values at each of the five survey waves was 0.68, Bartlett's test of sphericity for all were significant ($P < 0.001$), suggesting the samples were factorable. One factor was extracted at each wave, accounting for 63% (the lowest value in the seven waves) of the variance. The lowest value of factor loading of these items was 0.63, 0.53.0.51, 0.45, and 0.49 at the seven observation time points—indicating the scale has good construct validity.

Self-efficacy for prevention and prevention behavior. Self-efficacy is commonly defined as the belief in one's capabilities to achieve a goal or an outcome [16]. Self-efficacy for preventing COVID-19 infection was measured by asking, 'Do you think that you can avoid the disease through your current prevention behaviors?' Responses were provided on a 5-point Likert type scale ranging from 'no confidence I can avoid the disease' to 'much confidence I can avoid the disease'. Prevention behaviors against COVID-19 infection were measured by a question, "I feel my precautions against infection by Covid-19 were", with options on a 5-point scale ranging from "very weak" to "very strong".

2.5. Data analysis

All data were entered into a database using Microsoft Excel. They were then imported into SAS (9.4version) for statistical analysis. Across survey waves mean scores were calculated for the various variables at different observation points. As most of the variables included in this study were not normally distributed we used nonparametric testing methods to examine changing trends in mental and behavioral responses, and their associations. The Mann–Kendall Test was used to assess changing trends across the seven observation

Table 1
Characteristics of sample.

Group	N (62)	%
Sex		
Male	19	30.6
Female	43	69.4
Age (years)		
<30	26	41.9
30–49	15	24.2
50+	21	33.9
Education		
High school or junior college	32	51.6
College and more	30	48.4
Ethnicity		
Han	57	91.9
Minority	5	8.1
Marital status		
Never married	28	45.2
Married	29	46.8
Divorce or widowed	5	8.0
Occupation		
Manager	15	24.2
Professional	12	19.4
Commercial or service	13	21.0
Operator	7	11.3
Retired	15	24.2

Table 2
Means and their change trend across time in metal response and behavioral variables.

Group	Uncertainty stress (Mean < 95% C.I)	Perceived risk (Mean < 95% C. I)	Perceived severity (Mean < 95% C.I)	Self-efficacy for prevention (Mean < 95% C.I)	Prevention behavior (Mean < 95% C.I)	Irrational beliefs about prevention (Mean < 95% C.I)	Sleep (Mean < 95% C.I)	Emotion	Lifestyle (Mean < 95% C.I)
Time1	9.40(8.52,10.27)	2.19(1.90,2.48)	3.45(3.08,3.83)	4.09(3.88,4.30	3.11(2.91,3.31)	11.44(10.64,12.22)	1.30 (1.12,1.48))	1.47 (1.30,1.63)	1.51 (1.30,1.71)
Time2	10.29(9.31,11.28)	2.24(1.99,2.48)	3.27(2.92,3.63)	3.96(3.75 k,4.17)	3.173.02,3.33)	11.43(10.65,12.21)	1.25 (1.11,1.40)	1.35 (1.20,1.51)	1.47 (1.30,1.64)
Time3	10.02(8.99,11.05)	2.18(1.93,2.43)	3.40(3.05,3.75)	3.94(3.70,4.18)	3.20(2.99,3.41)	11.96(11.09.12.83)	1.28 (1.10,1.46)	1.14 (1.03,1.25)	11.36 (1.20,1.52)
Time4	9.60(8.55,10.64)	2.10(1.83,2.36)	3.39(3.12,3.68)	4.04(3.82,4.26)	3.34(3.18,3.51)	11.65(10.81,12.50)	1.27 (1.111.43))	1.21 (1.10,1.35)	1.31 (1.16,1.46)
Time5	9.16(8.10,10.22)	2.04(1.84,2.23)	3.34(3.00,3.69)	4.10(3.89,4.31)	3.36(3.16,3.56)	11.52(10.66,12.44)	1.20 (1.05,1.35)	1.14 (1.04,1.24))	1.30 (1.15,1.46)
Time6	9.37(8.29,10.45)	2.02(1.78,2.25)	3.39(3.07,3.71)	4.13(3.93,4.34)	3.10(2.85,3.34)	9.10(8.26,9.94)	1.09(.01,1.18)	1.08 (1.00,1.15)	1.02 (0.98,1.06)
Time7	9.60(8.55,1.063)	2.09(1.88,2.31)	3.27(2.94,3.60)	4.02,3.82,4.29)	3.22(2.99,3.44)	9.53(8.69,10.37)	1.12 (1.01.1.22)	1.07 (1.00,1.14)	1.06 (0.99,1.13)
Mann–Kendall test (Z)	−0.911	−0.141	1.010	0.129	0.728	−4.993**	−2.499 *	−5.650**	−5.978**

*p < 0.05; **p < 0.01.

points [39]. The nonparametric linear mixed effects model was used to examine the association between uncertainty stress and several mental and behavioral response variables [40]. Regression parameters in fixed effects were estimated using the Theil-Sen test [41,42].

Statistical power was estimated for repeated measures for each variable in STATA 15.0 [43]. This analysis provides statistical power(1-β) at a given sample size ($n = 62$), 5% significance level, and effect size which used a parameter in the model. 0.8 and over of statistical power was judged as acceptable [44]. As effect size of various variables may be different their statistical powers are different (Table 4).

3. Results

One hundred-and-fifty participants were recruited at baseline. The baseline was linkable to five intermediate and a final observation point, with 102 participants completing the survey during the COVID-19 epidemic period, 62 completing the survey during the COVID-19 sporadic infection period. Sixty-two participants completed both the baseline and final observation points and were included in the analysis. Of the study sample, 69.4% were female and 91.9% were Han Chinese. Those less than 30 years old comprised 41.9% of the sample and 33.9% were more than 50 years of age. 45.2% were never married. High school or junior college graduates made up 51.6% of participants while 48.4% had completed an undergraduate degree or higher. As to occupation, 24.2% were managers, 19.4% were professionals, 21.0% were commercial or service workers, 11.3 were operators, and 24.2% were retired. (Table 1).

Table 2 depicts the means and change trend across time in metal response and behavioral variables. The mean uncertainty stress score at baseline was 9.40 and it was 9.60 at the end of the study, which did not change significantly over the observation period (Z: −0.911, $P > 0.05$). This trend was also the same for perceived risk (Z: −0.141, $P > 0.05$), perceived severity (Z: 1.010, $P > 0.05$), self-efficacy for prevention (Z: 0.129, $P > 0.05$), and Prevention behavior (Z: 0.728, $P > 0.05$). There was a statistically significant downward trend in irrational beliefs about prevention (Z: −4.993, $p < 0.01$), sleep (Z: −2.499, $p < 0.05$), emotion (Z: −5.650, $p < 0.01$), and lifestyle (Z: −5.978, $p < 0.01$).

Table 3 indicates that uncertainty stress was positively associated with irrational beliefs (β: 0.16298, $p < 0.01$). The more uncertainty stress, the worse their sleep (β: 0.02070, $p < 0.05$), emotion (β: 0.03462, $p < 0.01$), and lifestyle(β: 0.02056, $p < 0.05$). Higher uncertainty stress levels were negatively associated with self-efficacy for prevention and prevention behavior, βvalue was = -1.33210 ($p < 0.01$) and −0.82742 ($p < 0.01$), respectively.

4. Discussion

Addressing a gap in the literature, this study found temporal trends in mental response and behavioral variables from the COVID-19 epidemic to the sporadic infection period. There was a statistically significant downward trend in sleep, emotion, and lifestyle problems. This phenomenon may be explained by SCM theory. COVID-19 is a strong stimulus that plausibly induces mental and behavioral responses during an epidemic. Studies have reported on high mental and behavioral responses during the COVID-19 epidemic [4–7]. It might be expected that some mental and behavioral responses, sleep, emotion, and lifestyle problems, would be reduced. As COVID transitioned from the epidemic phase to the sporadic infection phase. Further, irrational beliefs were common during the COVID-19 epidemic. Irrational beliefs are self-defeating, unconditional, in conflict with reality, and are not supported by empirical data. They may exacerbate the epidemic by negatively impacting preventive behaviors [31,45]. Irrational beliefs appeared very quickly when COVID-19 infections began, and dropped rapidly as the epidemic declined and the sporadic infection phase was apparent.

Perceived risk and severity did not show significant downward trends in this transition period. This indicates that people still maintained a high alert status for COVID-19 infection. Self-efficacy is commonly defined as the belief in one's capabilities to achieve a goal or an outcome. This construct also remained relatively stable during the study period. This study found no significant temporal changes in preventive behavior. Overall these data seem to indicate that people were still concerned about COVID-19 and their ability to prevent it even as the disease moved from an epidemic status to a sporadic infection status.

This study did find that the high levels of uncertainty stress persisted from the COVID-19 epidemic phase to the sporadic infection period. Uncertainty occurs when an event or a situation causes ambiguity, inconsistency, or unpredictability. The COVID-19 outbreak created a great deal of uncertainty. High uncertainty stress would be expected and was documented during the COVID-19 epidemic phase [15]. It might be expected that uncertainty stress would be reduced as the epidemic progressed and would especially be reduced

Table 3
Association of Uncertainty Stress and irrational beliefs about prevention, self-efficacy for prevention, prevention behavior, sleep, emotion, and lifestyle.

Group	Estimate(β)	Standard Error (S.E)	P
Irrational beliefs about prevention	0.16298	0.06080	0.00778
Self-efficacy for prevention	−1.33210	0.23269	<0.0001
Prevention behavior	−0.82742	0.25419	0.0001
Sleep	0.02070	0.00815	0.0115
Emotion	0.03462	0.00644	<0.0001
Lifestyle	0.02056	0.00821	0.0127

in a sporadic infection period when infection risk is reduced. This was not the case. High levels of uncertainty stress in the sporadic infection phase indicate that there are other challenges besides COVID-19 infection numbers in this process. Although the disease itself declined, the epidemic has had a strong negative impact on economic activity and production. This has created much uncertainty in employment, work and life. Moreover, this study found that uncertainty stress was positively associated with "instantaneous" responses, and was negatively associated with "stable" responses. This indicates uncertainty stress remains a large challenge to prevention in the COVID-19 sporadic infection period. This would imply that COVID-19 interventions should focus attention on decreasing uncertainty stress and on improving production and economic recovery.

There are several limitations to this study. First, our sample size was small. Nevertheless, this is a prospective longitudinal panel study, and the variables included were repeatedly measured for each participant. So that statistical power for the tests used in this study was high. The result found that statistical powers all variables achieved accepted level except perceived severity, see Table 4. This indicates that the sample size in this study was large enough to make appropriate inferences. Second, sample attrition may introduce "cluster" bias because many longitudinal studies likely over-represent some of these characteristics, such as high educational attainment. A more sophisticated design and representative sample would be necessary to resolve this problem. Third, a high non-response rate (39.2%) occurred in the second stage follow up. This could, in part, be due to the long period from the first stage to the second stage. But, demographic characteristic comparisons between the first and second stage samples [15]. Further studies are necessary to reduce the bias. Fourth, this study covered from 5/Feb/2020 to 30/December 2020, which reflects form the COVID-19 epidemic to sporadic infection in China in this period. However, after China officially announced that COVID-19 management was open on December 5, 2022, the COVID-19 pandemic, then return to the sporadic state. Our study did not capture the later events related to COVID-19 in China. This may be different from our observation period in this study, it is worth further exploring. Fifthly, measurement instruments may lack robustness. Especially measure of some variables used a single questionnaire item to measure the variable. This has been used in previous literature, and especially in other COVID-19 studies [46–48]. There is also anecdotal evidence to suggest the validity of using one question measures of these variables. Previous studies have shown that those responding positively to these questions were more likely to take precautionary action [46–48]. Sixthly, since there are lack of similar follow-up studies on COVID-19 in the world we can compare with what is happening internationally with COVID-19.

As the virus spreads around the globe, COVID-19 already moves from epidemic to sporadic infection status in many countries. This study provides new information on changing trends of mental responses and prevention patterns from the COVID-19 epidemic phase to the sporadic infection period. The study may have important implications for policy and disease prevention for many countries of the world.

Ethical statement

The study was approved by the Ethics Committee of Zhejiang University (2014:1–017).

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Informed consent

All participants received an electronic questionnaire and instructions on how to proceed. After reading the instructions, they were asked to provide an e-consent by tapping the "Confirmation and Authorization" button and then directed to the questionnaire.

Author contribution statement

Tingzhong Yang: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.
Sihui Peng: Conceived and designed the experiments; Performed the experiments; Wrote the paper.
Weifang Zhang: Performed the experiments; Contributed reagents, materials, analysis tools or data.

Table 4
Results of statistical power analysis.

Variables	1-β
Uncertainty stress	0.93
Perceived risk	0.81
Perceived severity	0.45
Self-efficacy for prevention	0.83
Prevention behavior	0.88
Irrational beliefs about prevention	0.94
Sleep	0.82
Emotion	0.89
Lifestyle	0.96

Randall R Cottrell: Analyzed and interpreted the data; Wrote the paper.

Data availability statement

Data will be available upon request.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests.

Tingzhong Yang reports administrative support and statistical analysis were provided by Zhejiang University.

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