Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Longitudinal associations between multiple mental health problems and suicidal ideation among university students during the COVID-19 pandemic

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ABSTRACT

Background: Recent research suggested that COVID-19-related multiple mental health problems were associated with an increased risk for suicidal ideations (SIs), but population-based data demonstrating these associations are scarce. This study aimed to estimate the cumulative effects of psychological risk factors on SIs during the outbreak and remission periods of COVID-19 using a cumulative risk model, as well as sex differences.

Methods: A total of 68,685 college students in China participated in the survey during two phases of the pandemic (T1 and T2). Mental health risks (acute stress, depression, anxiety, insomnia, and obsessive-compulsive symptoms) and sociodemographic characteristics were measured at T1, and SIs were assessed at T1 and T2. Hierarchical regression analysis was used to determine the combined effect of multiple mental health problems on SIs at T1 and T2.

Results: The prevalence of SIs increased from the early periods of the COVID-19 pandemic (7.6%) to the later periods (10.0%). Depression was a powerful risk factor for SIs during the COVID-19 pandemic. Individuals with >3 mental risks would be most likely to experience rapidly increasing SIs during the early periods of the COVID-19 pandemic. Sex exerted different effects on the cumulative risk model of SIs.

Conclusions: Interventions, such as mental health education and improving utilization of student support services, should be implemented. There is a crucial need for early intervention and prevention efforts aimed at males with greater than three mental health problems.

1. Introduction

Suicide is a major public health concern, especially during the pandemic (Gunnell et al., 2020). Historically, the suicide rate was 40.35 per 100,000 during the 2003 severe acute respiratory syndrome (SARS) pandemic in Hong Kong, which peaked between 1993 and 2004 (Cheung et al., 2008). This study indicated that suicide is likely to become a more pressing concern during the coronavirus disease 2019 (COVID-19) because the pandemic spread rapidly across the globe and the imposition of the lockdown and quarantine (Gunnell et al., 2020). Growing evidence suggested that SIs were prevalent among university students during the COVID-19 pandemic (Crisol-Deza et al., 2022; Tasnim et al., 2020; Zhou et al., 2021). The prevalence of SIs during the COVID-19 pandemic were 12.8% among 3366 Bangladeshi university students (Tasnim et al., 2020) and 7.3% among 11,133 Chinese university students (Zhou et al., 2021). Moreover, medical students reported a higher rate of SIs (17.9%) during the COVID-19 pandemic in Peru (Crisol-Deza et al., 2022). Given that a suicidal ideation (SI) is the first step toward suicide (Wang et al., 2019), paying more attention to SIs during a pandemic is urgently needed to reduce the risk of suicide

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among university students during the COVID-19 pandemic.

Previous studies have demonstrated that an increased risk of SIs during the COVID-19 pandemic was significantly associated with mental health problems, including depression (Crisol-Deza et al., 2022; Papadopoulou et al., 2021; Sahimi et al., 2021; Tasnim et al., 2020), anxiety (Crisol-Deza et al., 2022; Papadopoulou et al., 2021; Tasnim et al., 2020; Zhu et al., 2021), acute stress (Shi et al., 2021; Tasnim et al., 2020), obsessive-compulsive symptoms [OCS] (Khosravani et al., 2021), and insomnia (Wang et al., 2021; Zhu et al., 2022). For example, Tasnim et al. (2020) reported that individuals with depression were 4.1 times (95% CI: 2.5–6.7) more likely to report SIs than individuals without depression. Individuals with anxiety had a 1.8-fold (95% CI: 1.2–2.7) higher likelihood of SIs, and these with acute stress were 2.7 times (95% CI: 1.8–4.1) more likely to have SIs. Wang et al. (2021) suggested that individuals with three core insomnia symptoms (difficulty initiating sleep, difficulty maintaining sleep, and early morning awakening) were 3.5–4.0 times more likely to report SIs than individuals without insomnia symptoms. Although the aforementioned studies confirmed that mental health problems increased the risk of SIs during the COVID-19 pandemic, the studies only focused on the adverse effect of single and specific mental health problems on SIs, which overestimated the harmful impact of a singular risk factor (Evans et al., 2013). Individuals with co-occurring psychological risk factors are more likely to have SIs than individuals with any specific risk factor (Appleyard et al., 2005; Evans et al., 2013). There are no studies that have investigated the total accumulation of these risk factors on SIs. Additionally, previous studies have shown that sleep disturbances and anxiety during the early period of the COVID-19 pandemic also predicted the possibility of SIs during the later period (Wang et al., 2021; Zhu et al., 2021), indicating that mental health problems during the outbreak period may not only affect SIs in the current periods, but continue to affect SIs in later periods. Unfortunately, the relationship between the co-occurrence of mental health problems during the current period of the COVID-19 pandemic and SIs during the later period has not been established.

In recent decades, the cumulative risk model has been advanced as an alternative method to estimate the cumulative effect of multiple risk factors (Appleyard et al., 2005; Chang et al., 2019; Evans et al., 2013; Li et al., 2016). This approach forms a composite index by standardizing each risk factor for the original units of measurement that usually differ for each factor (Evans et al., 2013). More specifically, each risk factor is first recoded as dichotomous or binary variables (1 = risky, 0 = risk-free). Then, the values of all risk factors are summed to yield an overall cumulative risk index. The cumulative effect of risk factors is finally conducted on this basis (Evans et al., 2013). Notably, the cumulative risk model produces better statistical power for multiple and correlated influencers compared with the general linear model (Li et al., 2016). Given the aforementioned limitations and advantages of the cumulative risk model, the first aim of this study was to estimate the cumulative effects of psychological risk factors on SIs during the outbreak and remission periods of COVID-19 using the cumulative risk model.

Furthermore, significant sex differences in SIs have been reported (Chen et al., 2021; Zhou et al., 2021; Zhu et al., 2022). The prevalence of SIs in females (3.6%) was higher than the prevalence of SIs in males (2.4%) during the COVID-19 pandemic (Zhu et al., 2022), while another study suggested that the prevalence of SIs in males (7.9%) was higher than the prevalence of SIs in females [4.6%] (Chen et al., 2021). In addition, distinct risk factors for SIs were also confirmed in previous studies (Chen et al., 2021; Zhu et al., 2022). Based on the above studies, we speculated that significant sex differences might exist with respect to the total accumulation of mental health problems and SIs. Hence, the second aim of this study was to determine the differences in the cumulative risk model between the cumulative effect of mental health problems and SI during the COVID-19 pandemic based on sex.

2. Methods

2.1. Participants and procedure

Data were extracted from the University Students Health Survey during the COVID-19 Pandemic that was conducted in Guangdong, China via three large-scale cross-sectional online surveys. Detailed information on the COVID-19 pandemic in China and sampling can be found in our previously published studies (Li et al., 2021; Ma et al., 2020; Wang et al., 2022). A total of 185,901 college students (valid questionnaires = 164,101) were recruited during the COVID-19 outbreak (T1, February 3, 2020 to February 10, 2020). After the spread of COVID-19 in China was effectively brought under control, 155,563 students (valid questionnaires = 147,643) voluntarily participated in this survey during the COVID-19 remission stage (T2: March 24, 2020 to April 3, 2020). Among 70,387 students (valid questionnaires = 68,685) participated in both surveys and Supplementary Table 1 provided the information regarding participant characteristics among those who were lost to attrition from T1 to T2. Seven hundred eighty students fell outside the target age range of 16–25 years [overall, mean ± standard deviation (SD) = 20.23 ± 1.63 years; males: mean ± SD = 20.32 ± 1.60 years; females: mean ± SD = 20.19 ± 1.64 years] in the present study, resulting in a final sample of 67,905 (21,270 males [31.3%]).

The target universities supported these surveys and a survey invitation letter was sent to all students via a network platform. For the target population, participation in the survey was voluntary. All participants gave electronic informed consent before starting the online survey and had the right to withdraw freely at any time. The online questionnaire was used to assess demographic characteristics (sex and age), the severity of the pandemic, and the mental health problems. The severity of the pandemic was divided into three levels (severe, moderate, and mild) based on the cumulative cases of each province before March 1, 2020 (https://www.who.int/emergencies/diseases/novelcoronavirus-2019/situation-reports). Additionally, we ensured that responses to the survey were kept confidential and provided the contact information of mental health services (https://mp.weixin.qq.com/s/Lh2AD9HZ5JKkgP5SS9zekQ). This study was approved by the Human Research Ethics Committees of South China Normal University (Ethics_No._SCNU-PSY-2020-01-001) and carried out in accordance with the Helsinki Declaration as revised in 1989.

2.2. Measurements

The two-item Patient Health Questionnaire (PHQ-2), two-item Generalized Anxiety Disorder Scale (GAD-2), six-item Impact of Event Scale (IES-6), and eight-item Youth Self-Rating Insomnia Scale (YSIS) were used to assess depression (Risk 1), and anxiety (Risk 2), acute stress, and insomnia at T1 (Hinz et al., 2017; Kroenke et al., 2003; Liu et al., 2019; Thoresen et al., 2010). Each PHQ-2 and GAD-2 item is rated on a four-point Likert scale from 0 (not at all) to 3 (nearly every day). Each IES-6 and YSIS item is answered on a dive-point Likert scale (IES-6: 0–4; YSIS: 1–5). In this sample, Cronbach's α for items in the four scales was 0.71, 0.80, 0.80, and 0.89, respectively.

Three self-made items were used to measure obsessive-compulsive symptoms (OCS) at T1 as follows: Item 1: “Do you still want to continue washing your hands after washing your hands 2 or 3 times?”; Item 2: “Do you still feel uneasy after cleaning and disinfecting the room and other items every day?”; Item 3: “Are you always thinking about things related to COVID-19 and not willing to do other things?”. Responses were recorded using a two-point Likert scale (yes = 1, no = 0). In the current sample, Cronbach's α for these items was acceptable (α = 0.61).

One item extracted from PHQ-9 was used to measure SI at T1 and T2 (Kroenke et al., 2001). The item is “Have you ever had thoughts that you would be better off dead or hurting yourself in some way?”, which was rated on a four-point Likert scale from 0 (not at all) to 3 (nearly every

day).

2.3. Statistical analyses

First, the sum of the subscale for depression, anxiety, acute stress, OCS, and insomnia with multiple items were calculated. Then, according to the previous study (Evans et al., 2013), the above five risk scores of mental health problems were standardized to obtain a *Z*-score. A Z-score ≥ 1 was considered risky and coded as 1, and a Z-score < 1 was considered risk-free and coded as 0. Finally, the cumulative risk index was calculated by adding up the five risk scores.

The independent-sample *t*-test was used to compare the differences in age and any mental risk factors based on sex. Pearson's correlation analysis was used to examine the relationships among the main study variables. Subsequently, we examined the independent influence of a single mental risk on SIs before and after controlling the other four mental risk factors (Mackenzie et al., 2011). The hierarchical regression analysis was used to investigate the cumulative effect of mental risk on SIs at T1 and T2. Sex, age, and severity of the pandemic were first considered as covariates in Step 1. Then, the linear term of cumulative risk index was entered as the influencer in Step 2. The quadratic term of cumulative mental risk index was finally entered as the influencer in Step 3 (Cohen et al., 2003).

All statistical analyses were performed using IBM SPSS 23.0 software for Windows. A two-sided *p*-value $< .05$ was considered statistically significant.

3. Results

3.1. Mental risk among university students

Table 1 shows the mean (SD) and rates of mental health problems among university students. Overall, anxiety had the highest rate among university students at T1 (20.7%), followed by acute stress (15.5%) and insomnia (14.1%). The SI rates were 7.6% (males: 7.64%; females: 7.62%) at T1 and 10.0% (males: 11.16%; females: 9.51%) at T2. In addition, the rates of 0-, 1-, 2-, 3-, 4-, and 5-mental health risks were 59.3%, 22.8%, 10.7%, 4.9%, 1.9%, and 0.4%, respectively.

3.2. The independent influence of single mental risk on SI

Each mental health risk was significantly associated with SIs at T1 ($r = 0.08$–0.36, all $p < .01$) and T2 ($r = 0.08$–0.22, all $p < .01$). As shown in Table 2, depression was the strongest factor affecting SIs at T1 and T2 before controlling other mental risks. After controlling other mental risks, anxiety was the strongest factor for SIs at T1, while depression was the strongest influencers of SIs at T2. Additionally, we found that the impact of a single mental health risk on SIs at T1 and T2 decreased after controlling the other four mental risk factors.

Table 2
The independent influence of single mental risk on SI before and after controlling other four mental risk factors.

	T1_SI			T2_SI		
	r	*β*	*β′*	*r*	*β*	*β′*
Risk1_Depression	0.26**	0.32**	0.21**	0.19**	0.14**	0.09**
Risk 2_Anxiety	0.36**	0.27**	0.23**	0.22**	0.10**	0.06**
Risk 3_ASS	0.13**	0.12**	**0.01**	0.12**	0.08**	0.03**
Risk 4_OCS	0.08**	0.09**	0.03**	0.08**	0.06**	0.04**
Risk 5_Insomnia	0.23**	0.22**	0.12**	0.19**	0.11**	0.08**

Note: ASS: Acute stress symptoms; OCS: Obsessive-compulsive symptoms; T1: Time1; SI: suicidal ideation; β is standardized regression coefficient.
β' is standardized regression coefficient after controlling other mental risks.
* $p < .05$.
** $p < .01$.

3.3. The mental cumulative risk model of SI

The regression model showed that the relationships between the linear term of cumulative risk index and SIs were significant and positive (Table 3; T1, $\beta = 0.36$, $p < .01$; T2, $\beta = 0.16$, $p < .01$). The associations between the quadratic term of the cumulative risk index and SIs are illustrated in Table 4 and Fig. 1. After controlling the effects of sex, age, and severity of the pandemic, we found that the quadratic term of the cumulative risk index was significantly and positively associated with SIs at T1 ($\beta = 0.19$, $p < .01$), but not significantly related at T2 ($\beta = -0.01$, $p = .24$).

3.4. Moderating effect of sex

As shown in Table 5 and Fig. 2, the interaction between sex and the cumulative risk index had a significant effect on SIs at T1 (quadratic term; $\beta = 0.07$, $p < 0.01$) and T2 (linear term; $\beta = 0.01$, $p < 0.01$). More specifically, when the number of mental risks was two, the prevalence of SIs in males increased significantly faster than the prevalence of SIs in females.

4. Discussion

To our best knowledge, this is the first study to determine the cumulative effect of multiple mental health problems on SIs among university students from the early periods of the COVID-19 pandemic to the later periods. There were several main findings as follows: (1) The prevalence of SIs increased from the early periods of the COVID-19 pandemic (7.6%) to the later periods (10.0%). (2) Depression was a powerful risk factor for SIs during the COVID-19 pandemic. (3) The influence of mental cumulative risks was the greatest compared to single mental risks. More specifically, individuals with >3 mental risks were more likely to experience a rapid increased in SIs during the early

Table 1
Mean (SD) and rates of mental health problems among university students.

	Overall ($n = 67{,}905$)		Male ($n = 21{,}270$)	Female ($n = 46{,}635$)	*t*	*p*	*d*
	Mean (SD)	Risky (%)	Mean (SD)	Mean (SD)			
T1_Risk1_Depression	1.09(1.12)	7.5	0.93(1.10)	1.16(1.12)	−25.64	<0.01	−0.21
T1_Risk 2_Anxiety	0.63(0.99)	20.7	0.50(0.93)	0.69(1.01)	−24.47	<0.01	−0.20
T1_Risk 3_ASS	7.30(3.99)	15.5	7.28(4.14)	7.30(3.91)	−0.88	0.381	–
T1_Risk 4_OCS	0.38(0.73)	10.5	0.37(0.75)	0.38(0.73)	−2.70	<0.01	–
T1_Risk 5_Insomnia	13.20(5.09)	14.1	12.70(5.01)	13.43(5.11)	−17.42	<0.01	−0.14
T1_T1_SI	0.09(0.32)	7.6	0.09(0.33)	0.09(0.32)	0.82	0.413	–
T2_SI	0.11(0.36)	10.0	0.13(0.38)	0.11(0.35)	6.21	<0.01	0.05
T1_MCR score	0.68(1.01)	–	0.62(0.96)	0.71(1.03)	−10.67	<0.01	−0.10
Cumulative risk index	0	1	2	3	4	5	
Rates (%)	59.3	22.8	10.7	4.9	1.9	0.4	

Note: SD: standard deviation; ASS: Acute stress symptoms; OCS: Obsessive-compulsive symptoms; SI: suicidal ideation;MCR: Mental cumulative risk.
Range of total scores: Depression, 0–6; Anxiety, 0–6; ASS: 0–24; OCS: 0–3; Insomnia: 8–40; SI: 0–3.

Table 3
The associations between linear term of cumulative risk index and SI among college students at T1 and T2.

	T1_SI				T2_SI			
	R^2	*F(df)*	*β*	*95% CI*	R^2	*F(df)*	*β*	*95% CI*
Step 1	0.01	4.93(3)			0.13	2554.44(4)		
Gender			0.004	[−0.003, 0.01]			0.03**	[0.02,0.03]
Age			−0.01**	[−0.004, −0.001]			−0.002	[−0.002,0.001]
SOE			−0.004	[−0.004, 0.01]			−0.01	[−0.02, 0.002]
T1_SI							0.30**	[0.33, 0.35]
Step 2	0.13	2591.01(4)			0.15	2444.89(5)		
T1_MCR (X)			0.36**	[0.11, 0.12]			0.16**	[0.05, 0.06]

Note: T1: Time1; SOE: Severity of the pandemic; MCR: Mental cumulative risk; SI: suicidal ideation.
β is standardized regression coefficient; CI: Confidence interval.
* $p < .05$.
** $p < .01$.

Table 4
The associations between quadratic term of cumulative risk index and SI among college students at T1 and T2.

	T1_SI				T2_SI			
	R^2	*F(df)*	*β*	*95% CI*	R^2	*F(df)*	*β*	*95% CI*
Step 1	0.001	4.93(2)			0.13	2554.44(4)		
Gender			0.02**	[0.01, 0.02]			0.03**	[0.02,0.03]
Age			−0.02**	[−0.01, −0.003]			−0.002	[−0.002,0.001]
SOE			−0.001	[−0.01, 0.01]			−0.005	[−0.02, 0.001]
T1_SI							0.30**	[0.33, 0.35]
Step 2	0.13	2591.01(4)			0.15	2444.89(5)		
T1_MCR (X)			0.19**	[0.05, 0.07]			0.17**	[0.05, 0.07]
Step 3	0.14	2179.97(5)			0.15	2037.65(6)		
T1_MCR (X^2)			0.19**	[0.017, 0.021]			−0.01	[−0.003, 0.001]

Note: T1: Time1; SOE: Severity of the pandemic; MCR: Mental cumulative risk; SI: suicidal ideation.
β is standardized regression coefficient; CI: Confidence interval.
* $p < .05$.
*** $p < .001$.
** $p < .01$.

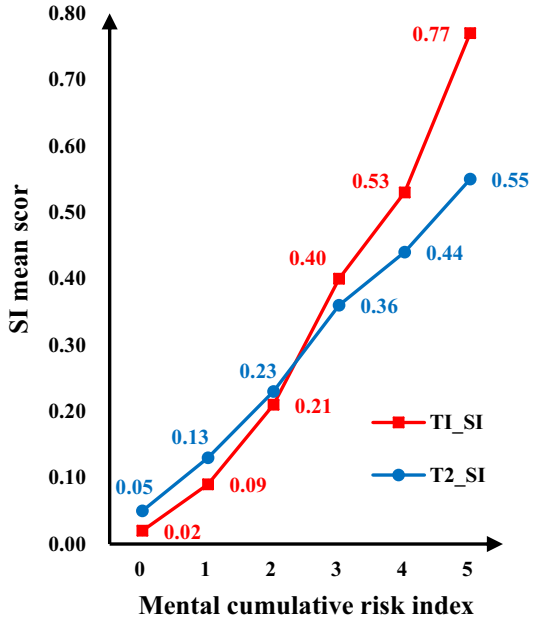

Fig. 1. Relationship model between mental cumulative risk index and SI scores among university students during the COVID-19 pandemic (T1 and T2).
Note: X-axis, mental cumulative risk index (0–5); Y-axis, SI mean scores; Red line, the cumulative risk model at T1; Blue line, the cumulative risk model at T2. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

periods of the COVID-19 pandemic. (4) Sex exerted different effects on the cumulative risk model of SIs.

First, we found that the SI rates increased from 7.6% (the COVID-19 outbreak in China) to 10.0% (the remission periods of the COVID-19 pandemic) among university students during the COVID-19 pandemic. An increase in SIs during the pandemic was also reported in an employee cohort study in Japan and an adult longitudinal study in the UK (O'Connor et al., 2021; Sasaki et al., 2021). A possible explanation was that university students might feel fear of future career or academic development due to long-term isolation and quarantine during the COVID-19 pandemic (Tasnim et al., 2020). To summarize, the aforementioned findings illustrated that SI became a more significant and urgent public health concern due to the COVID-19 pandemic (Sasaki et al., 2021). Therefore, it will be necessary to improving suicide prevention strategies during the COVID-19 pandemic.

Second, our findings suggested that depression was a stronger risk factor for SIs than anxiety, acute stress, OCS, and insomnia, whether in the outbreak or initial remission period of the COVID-19 pandemic, which is consistent with previous studies (Crisol-Deza et al., 2022; Papadopoulou et al., 2021; Sahimi et al., 2021). Evidence suggested that moderate-to-severe depression was the strongest risk factor significantly associated with SIs during the COVID-19 pandemic (OR = 55.983, 95% CI = 9.015–347.671), followed by mild depression [OR = 15.984, 95% CI = 2.977–85.804] (Sahimi et al., 2021). Several causes could explain the above findings. Depression and SIs have been linked to decreased dopamine release in the striatal circuit (Ducasse et al., 2018). In contrast, individuals with depression lack motivated behavior to obtain a reward and decreased pleasure from obtaining a reward. As a result, SIs increase within months (Ducasse et al., 2018). To summarize, depression may be the target area of early intervention to reduce SIs among university students during the COVID-19 pandemic.

Table 5
The moderating effect of gender on the mental cumulative risk model among university students at T1 and T2.

	T1_SI				T2_SI			
	R^2	*F(df)*	*β*	*95% CI*	R^2	*F(df)*	*β*	*95% CI*
Step 1	0.001	6.95(2)			0.13	3389.72(3)		
Age			−0.02**	[−0.01, −0.003]			−0.002	[−0.002,0.001]
SOE			0.001	[−0.01, 0.01]			−0.01	[−0.02, 0.002]
T1_SI							0.30***	[0.33, 0.35]
Step 2	0.13	2601.82(4)			0.15	2444.89(5)		
Gender			−0.01**	[−0.01, −0.001]			0.02**	[0.01, 0.03]
T1_MCR (X)							0.15**	[0.05, 0.06]
T1_MCR (X^2)			0.33**	[0.032, 0.033]				
Step 3	0.14	2145.50(5)			0.15	2039.12(6)		
Gender× T1_MCR (X)							0.01**	[0.003, 0.01]
Gender× T1_MCR (X^2)			0.07**	[0.01, 0.02]				

Note: T1: Time1; SOE: Severity of the pandemic; MCR: Mental cumulative risk; SI: suicidal ideation.
β is standardized regression coefficient; CI: Confidence interval.
* $p < .05$.
** $p < .01$.

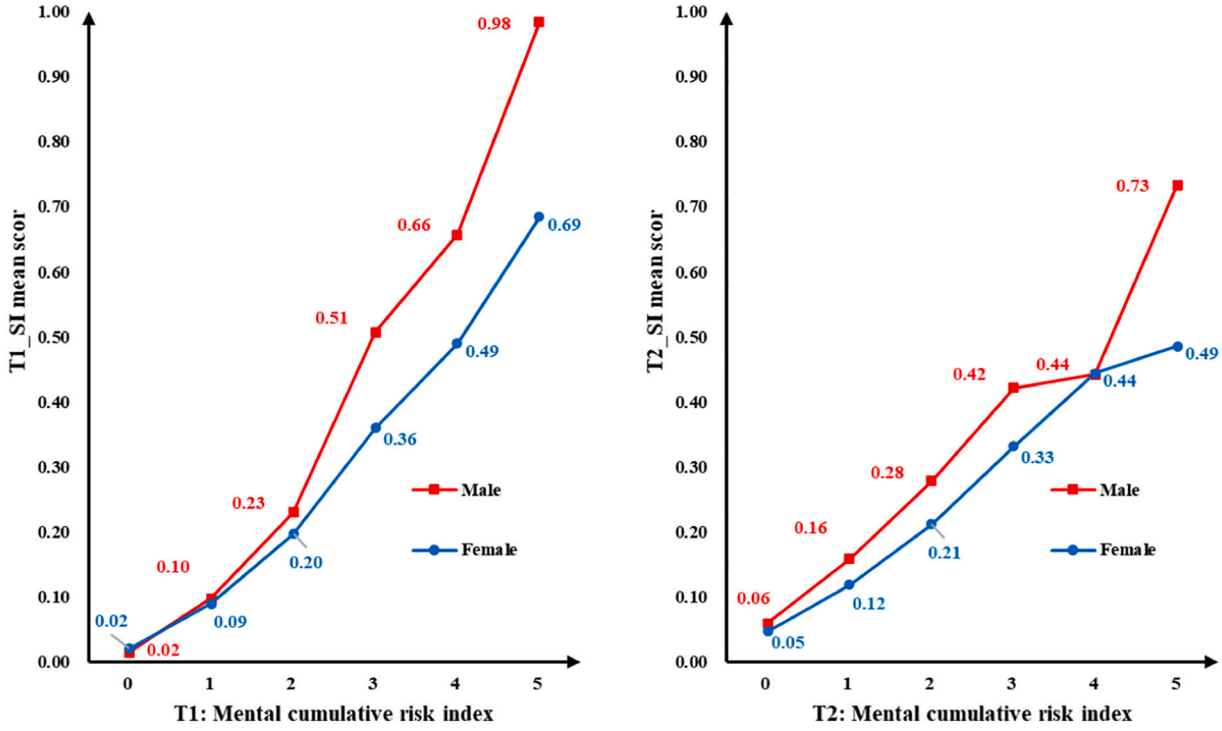

Fig. 2. The of interaction between sex and mental cumulative risk index on SI during the COVID-19 pandemic (T1 and T2).
Note: X-axis, mental cumulative risk index (0–5); Y-axis, SI mean scores; Red line, males' cumulative risk model; Blue line, females' cumulative risk model; Left panel, the cumulative risk model at T1; Right panel, the cumulative risk model at T2. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Another finding to note was that the influence of mental cumulative risks is the greatest compared to a single mental risk, including depression, anxiety, acute stress, OCS, and insomnia, especially in individuals with greater than three mental health problems, in whom SIs would most likely increase during the early periods of the COVID-19 pandemic. The above findings could be partially supported by the view that co-morbidity increases the likelihood of SIs (Bantjes et al., 2016; Lawrence et al., 2021). For example, compared to individuals without any mental health problems, those with two mental health problems were approximately two times more likely to have SIs, and those with more than two problems were approximately six times more likely to report SIs (Bantjes et al., 2016). A possible reason for these findings is that individuals with more mental health problems would be more likely to decompose their ability to manage interpersonal and academic stressors, which potentially contributes to SI onset (Akram et al., 2020). An alternative explanation was that greater distress or psychological distress may directly lead to SIs to escape this pain (Ducasse et al., 2018; Lawrence et al., 2021). Hence, possible university-based interventions, such as mental health education and improving utilization of student support services, should be implemented to help students be aware of symptoms of psychopathology and cognizant of support services. These findings also highlighted the crucial need for early intervention and prevention efforts aimed at individuals with more than three mental health problems.

Furthermore, we found different effects of sex on the cumulative risk model. Males reported a higher rate of SIs than females during the COVID-19 pandemic, which is in agreement with previous studies (Chen et al., 2021; Zhou et al., 2021). In addition, relative to females, males

with more than two mental risks were susceptible to sharply increased SIs during the COVID-19 outbreak. A possible explanation for sex differences is that females are usually more likely to express their distress and have more types of emotion regulation strategies to relieve psychological distress. In contrast, males tended to withhold their feelings and only occasionally seek support from friends to deal with their emotional distress (Nolen-Hoeksema, 2012). During the COVID-19 pandemic, males were more likely to suppress or avoid both the experience and expression of emotions due to the implementation of lockdowns, school closures, and social distance (Nolen-Hoeksema, 2012), which might cause a higher risk to experience SIs and mental health problems. Notably, the current explanations are tentative, and future research is needed to clarify the mechanisms underlying the sex-specific reasons between cumulative mental risk and SIs.

The key strengths of this study included a larger sample, a longitudinal study, and a novel approach to estimate the cumulative effect of multiple risk factors. Additionally, this was the first study to examine the cumulative effect of mental risk factors on SIs among university students from the outbreak of the COVID-19 pandemic to the remission periods. There were also several limitations in this study. First, the findings may not be generalizable to all university students across the globe as the survey was conducted in China. Second, self-reported measures were used to identify the clinical symptoms instead of clinical assessments, which may over- or under-estimate outcomes. Third, the cumulative indices for risk factors were created with equal weight; however, different symptoms may offer various levels of risk. A more in-depth examination of this issue can help address the question. In addition, there was a certain loss of other psychiatric symptoms. Research examining specific socio- demographic factors of SIs is warranted because it is beneficial to identify very specific targets for intervention programs. Finally, we have unexplained variation in the proportions, and the moderating effect of sex remained in our model.

In conclusion, the rates of SIs significantly increased over time among university students in China from the outbreak periods of the COVID-19 pandemic to the remission periods. The mental cumulative risks had the greatest influence on SIs compared to a single mental risk, including depression, anxiety, acute stress, OCS, and insomnia. Depression was a powerful risk factor for SIs during the COVID-19 pandemic. Males with greater than two mental health problems were more likely to have sharp increases in SIs during the COVID-19 outbreak. Interventions, such as mental health education and improving utilization of student support services, should be implemented. There is a particular need for early intervention and prevention efforts aimed at males with more than three mental health problems.

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CRediT authorship contribution statement

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Conflict of interest

All authors declare no conflict of interest.

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