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Sleep disturbance predicts suicidal ideation during COVID-19 pandemic: A two-wave longitudinal survey

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ABSTRACT

Background: This study aimed to examine the cross-sectional and longitudinal associations between sleep disturbance and suicidal ideation (SI) in a large cohort of adolescents experiencing the Coronavirus disease 2019 (COVID-19) crisis in China.

Methods: One two-wave longitudinal web-based survey of sleep, SI, and depression was conducted among 67,905 college students (mean age = 20.23 years, SD = 1.63 years; 31.3% male) during the COVID-19 outbreak (Time1, T1: Feb 3rd to 10th, 2020) and initial remission period (Time2, T2: March 24th to April 3rd, 2020).

Results: At T1 and T2, 8.5% and 9.7% of students reported sleep disturbance, 7.6% and 10.0% reported SI, respectively. The prevalence rates of SI at T1 and T2 increased significantly with sleep disturbance and short sleep duration. After adjusting for demographics, pandemic related factors, and depression at T1, sleep disturbance and short sleep duration at T1 were significantly associated with increased risk for SI at T2. Furthermore, sleep disturbance and short sleep duration predicted the new onset and persistence of SI.

Conclusion: These findings suggested that sleep disturbance predicts the development and persistence of SI. Early assessment and treatment of sleep disturbance may be an important strategy for prevention and intervention of SI in individuals after exposure to the special public health emergency of COVID-19.

1. Introduction

The COVID-19 crisis, as a public health emergency, has increased the risk of mental health problems. During COVID-19, many countries, including China, have introduced confinement measures, including self-isolation, contact restrictions, and closure of schools, colleges, universities and other educational institutions (Bedford et al., 2020). These measures can greatly affect the psychological status of students (Sahu, 2020). For example, Ma et al. reported depression, anxiety, and acute stress were 21.1%, 11.0%, and 34.9% among college students during COVID-19 outbreak, respectively (Ma et al., 2020). Meanwhile, from the past experience of the severe acute respiratory syndrome (SARS) in 2003, we can confirm that pandemics may increase the risk of suicide (Cheung et al., 2008). What is worrying is that this crisis may reappear

in the context COVID-19 (Gunnell et al., 2020). Suicidal ideation (SI) is defined as thoughts of ending one's life and is considered a strong predictor of suicide (Hubers et al., 2018). Recent evidence showed 19.56% of Chinese university students endorsed SI in quarantine during the COVID-19 pandemic (Sun et al., 2021a). Wang and colleagues carried out a study of the mental health status of 2031 undergraduate and graduate students in United States and found that 18.04% had SI during the COVID-19 pandemic (Wang et al., 2020a). Therefore, paying greater attention to individuals' SI during a pandemic is urgently needed. To decrease the risk of suicide during the COVID-19 pandemic, screening for SI and research into factors related to SI is imperative.

Sleep disturbance such as poor sleep quality, insomnia, and nightmares is a stand-alone risk factor for SI, suicide attempts (SA), and suicide death (SD) (Bernert et al., 2015). One retrospective study

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revealed that insomnia symptoms (difficulty initiating sleep, maintaining sleep, early morning awaking) positively and independently related to past SI and SA (Wojnar et al., 2009). Therefore, recognizing and treating sleep disturbances is especially important during stressful times such as the COVID-19 pandemic because it may effectively reduce suicides. If an individual's sleep disturbance can be measured during the early period of a pandemic, it may be possible to predict the possibility of suicide during home-isolation. However, few prospective studies have examined the extent to which disturbed sleep predicts suicide. The studies which have addressed this issue have also been limited by inadequate sleep assessment. For example, Wong and Brower used a single-item measure of sleep complaints across three assessment waves (Wong and Brower, 2012), and found that sleep disturbances significantly predicted SI and SA status among 6504 adolescents one year and six years later. They evaluated sleep disturbance as a long-term risk factor for suicidal thoughts and behaviors (i.e., SI, SA), but their study left unclear the degree to which disrupted sleep predicts short-term risk, a question of considerable clinical relevance, given that clinical risk assessments are more focused on determining whether one person will engage in suicidality in the near future (Liu et al., 2020).

In China, COVID-19 spread across the country rapidly at the initial outbreak phase between January to March 2020. As of late April 8, 2020, the pandemic in China has been brought under control, with very few newly confirmed cases per day. Although the pandemic was under control, it may not mean that SI have been in remission. Suicidal behavior is likely to be present for a long time and peak later than the actual pandemic (Sher, 2020). Therefore, sleep disturbance during the outbreak period may continue to affect SI in later periods, however, this remains unclear.

Accordingly, this study attempts to investigate sleep problems during COVID-19, as well as to enhance understanding of short sleep duration and sleep disturbance as risk factors for the onset and persistence of SI in a 2-month follow-up sample of college students. Our study aims to investigate: (1) the prevalence rates of sleep disturbance and SI in Chinese college students during COVID-19; (2) whether sleep disturbance and short sleep duration could be cross-sectional associated with the current and follow-up SI; and (3) whether previous sleep disturbance and short sleep duration could predict the change of SI.

2. Methods

2.1. Participants

Data was collected from a two-wave longitudinal web-based survey of mental health outcomes among college students during COVID-19. Since March 10, 2020, the infection rates in China has been mostly

under control, with zero newly confirmed cases in Hubei Province, and newly confirmed cases nationwide showing a consistent downward trend. The details of the study design and sample procedures, and development trend of the COVID-19 pandemic in China are shown in Fig. 1 and have also been described elsewhere (Li et al., 2021). In brief, using a repeated cross-sectional study design, participants were recruited from 22 colleges/universities in Guangdong province, China. Participants aged between 16 and 25, with a mean age of 20.23 (SD = 1.63). A total of 67,905 college students (31.3% male) were surveyed both during the initial COVID-19 outbreak (Time1, T1: Feb 3rd to 10th, 2020) and the remission period (Time2, T2: March 24th to April 3rd, 2020). This study was approved by the Human Research Ethics Committee of South China Normal University (SCNU-PSY-2020-01-001). Sample characteristics and COVID-19 related factors were presented in Table 1.

Table 1
Sample characteristics and COVID-19 exposure.

Characteristics	N	%	
Gender	Male	21,270	31.3
	Female	46,635	68.7
Grade	Freshman	23,921	35.2
	Sophomore	20,533	30.2
	Junior	14,540	21.4
	Senior	6206	9.1
	Postgraduate	2705	4.0
Residence location	Rural	27,192	40.0
	Unban	40,713	60.0
Ethnicity	Han ^a	66,517	98.0
	Others	1388	2.0
Only single child status	Yes	14,140	20.8
	No	53,765	79.2
History of physical illness	Yes	335	0.5
	No	67,570	99.5
History of mental illness	Yes	534	0.8
	No	67,371	99.2
The severity of the epidemic in the place of residence	Mild	6439	9.5
	Moderate	61,030	89.9
	Severe	436	0.6
Confirmed COVID-19 cases in the community or village	Yes	4679	6.9
	No	63,226	93.1
Relatives or friends being infected with COVID-19	Confirmed/suspected	753	1.1
	No	67,152	98.9

^b the mean (SD) age at baseline for the 67,905 college students was 20.23 (1.63) years.

Note.

^a Han is the ethnic majority in China.

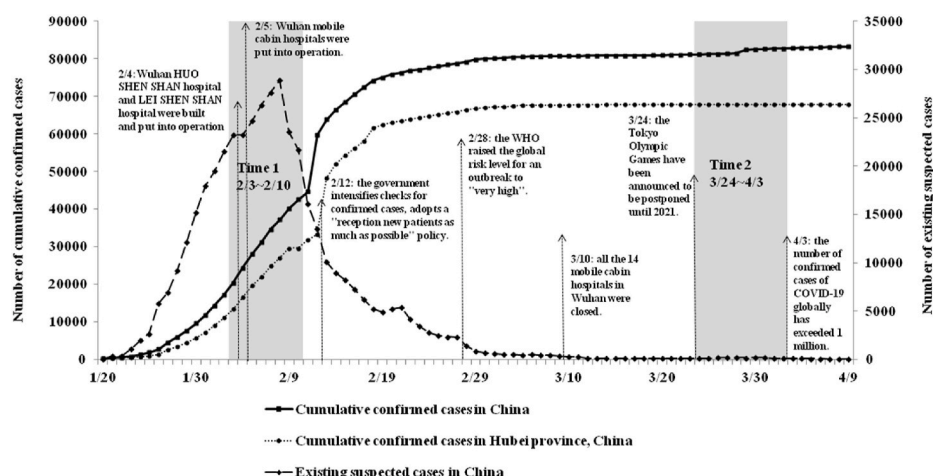


Fig. 1. The details of study design and sample procedures.

2.2. Measures

2.2.1. Sleep

Sleep related variables, including sleep duration, insomnia symptoms, and sleep quality, were assessed by five items adapted from the Pittsburgh Sleep Quality Index (PSQI) (Liu and Tang, 1996). Sleep duration was asked as such, “how many hours of actual sleep did you get at night over past two weeks?” College students answered a response option of 1 = < 5 h, 2 = 5–6 h, 3 = 6–7 h, 4 = 7–8 h, or 5=>8 h. Sleep time <6 h per night was considered as short sleep duration. Insomnia symptoms during the past two weeks were asked about difficulty initiating sleep (DIS), difficulty maintaining sleep (DMS), and early morning awakening (EMA). Insomnia symptoms item range from 1 (Never) to 5 (6–7 times/week). Sleep quality was measured by one question “How would you rate your sleep quality overall over past two weeks?” with a response option of 1 = Very good, 2 = Good, 3 = Fair, 4 = Poor, or 5 = Very poor. Overall sleep disturbance was defined as having any one of the following four sleep symptoms: DIS (≥3 times/week), DMS (≥3 times/week), EMA (≥3 times/week), or poor sleep quality (Fan et al., 2017, Wang et al., 2021). In this study the 4 items for insomnia and sleep quality showed good internal consistency in the two surveys, and the Cronbach’s alpha was 0.77 and 0.80, respectively.

2.2.2. SI

The 9th item of the 9-item Patient Health Questionnaire (PHQ-9) was used to assess SI (Schulberg et al., 2005). Participants were asked whether they have had “thoughts that you would be better off dead or hurting yourself in some way over the past two weeks?” This item ranges from 0 (Never) to 3 (nearly every day), and item responses >0 (not at all) is scored as a positive result of SI. Previous studies support the 9th item of PHQ-9 as a valid SI screening instrument (Bauer et al., 2013; Uebelacker et al., 2011).

2.2.3. Depression

In the current study, the 2-item Patient Health Questionnaire (PHQ-2) was used for screening and diagnosis of depression (Kroenke et al., 2003). PHQ-2 evaluates symptoms of depressed mood and little interest or pleasure in doing things over the past 2 weeks. Items are rated on a 4-point scale, ranging from 0 (not at all) to 3 (nearly every day), for a total score ranging from 0 to 6. A cut-off of 3 and greater represented the optimum specificity and sensitivity for detecting clinical level of depression (Arrieta et al., 2017). The Cronbach’s alpha was 0.71 at T1 and 0.78 at T2 in the current sample.

2.3. Statistical analyses

Analyses were performed using IBM SPSS Statistics for Version 23.0. Data were presented as mean (SD) for continuous variables and frequencies and percentages for categorical variables. McNemar’s test was used to examine the differences in the prevalence rates of sleep problems, SI, and depression between T1 and T2. Based on the cut-off scores (response >0) of the 9th item of PHQ-9 at T1 and T2, participants were categorized into four trajectories of SI: (1) Persistent group: scores at T1 and T2 both above the cut-off, (2) Remission group: score at T1 above the cut-off but below cutoff at T2; (3) New onset group: score at T1 below the cut-off but at T2 above the cut-off; (4) Resistance group: scores at T1 and T2 both below the cut-off. A series of logistic regression analyses were performed to examine the associations between each sleep variable and SI. Sleep disturbances and suicide are diagnostic features of major depression, and depression is a known and robust risk factor for death by suicide (Conwell and Brent, 1995). Adjustment for the confounding presence of a mood disorder diagnosis or depression is thus a necessary methodological step to delineate sleep disturbances as an independent risk factor for SI. Therefore, socio-demographics, pandemic related factors, and depression at T1 were included to adjust for their potential confounding effects in the multivariate

regression models. Odds ratio (OR) and 95% confidence interval (CI) were used to quantify the strength of the association.

3. Results

3.1. Prevalence of sleep disturbance, depression, and SI

Table 2 shows sleep duration, prevalence rates of sleep disturbance, depression, and SI at T1 and T2 after the pandemic outbreak. The prevalence of short sleep duration (<6 h per night) was determined to be 2.9% at T1 and 7.0% at T2. The prevalence of DIS, DMS, EMA, poor sleep quality, overall sleep disturbance, and SI at T1 were 5.6%, 2.9%, 1.6%, 2.7%, 8.5%, and 7.6% respectively, while rates of overall sleep disturbance and SI slightly increased at T2. Compared to T1, more students reported SI at T2, while depression did not change significantly at the two time points.

3.2. Cross-sectional associations of sleep with SI

As shown in Table 3, the prevalence rates of SI at T1 significantly increased with reduced sleep duration and increased sleep disturbance including DIS, DMS, EMA, and poor sleep quality at T1. Participants who reported having overall sleep disturbance were more likely to have SI (21.5% vs 6.3%; OR = 4.06; 95% CI = 3.79–4.36). After adjusting for demographics, pandemic exposure, and depression at T1, DIS (OR = 3.45; 95% CI = 3.21–3.72), DMS (OR = 3.51; 95% CI = 3.26–3.78), EMA (OR = 3.99; 95% CI = 3.67–4.33) ≥3 nights per week, poor/very poor sleep quality (OR = 3.50; 95% CI = 3.10–3.96), and overall sleep disturbance (OR = 2.47; 95% CI = 2.29–2.68) were all still significantly associated with increased odds of SI. Short sleep duration (OR = 3.78;

Table 2
Sleep, and SI during COVID-19 outbreak and remission.

Variable	During outbreak (T1)	During remission (T2)	p
Sleep duration			<0.001
<6 h	1915(2.9)	4881(7.0)	
6–7 h	6601(9.7)	15,761(23.2)	
7–8 h	26,339(38.8)	32,713(48.2)	
>8 h	33,050(48.7)	14,620(21.5)	
Difficulty initiating sleep			<0.001
Never	37,813(55.7)	30,949(45.6)	
<1 night/week	16,432(24.2)	19,996(29.4)	
1–2 nights/week	9887(14.6)	12,714(18.7)	
≥3 nights/week	3773(5.6)	4246(6.3)	
Difficulty maintaining sleep			<0.001
Never	46,663(68.7)	43,051(63.4)	
<1 night/week	12,992(19.1)	15,284(22.5)	
1–2 nights/week	6289(9.3)	7516(11.1)	
≥3 nights/week	1961(2.9)	2054(3.0)	
Early morning awakening			<0.001
Never	53,496(78.8)	48,211(71.0)	
<1 night/week	9455(13.9)	12,307(18.1)	
1–2 nights/week	3843(5.7)	5723(8.4)	
≥3 nights/week	1111(1.6)	1664(2.5)	
Subjective sleep quality			<0.001
Very good	27,055(39.8)	22,644(33.3)	
Good	25,149(37.0)	25,698(37.8)	
Normal	13,874(20.4)	17,180(25.3)	
Poor	1489(2.2)	1960(2.9)	
Very poor	338(0.5)	423(0.6)	
Sleep disturbance^a	5795(8.5)	6555(9.7)	<0.001
SI^b	5178(7.6)	6806(10.0)	<0.001
Depression^c	5518(7.5)	5038(7.4)	0.325

Note.

^a Sleep disturbance = difficulty initiating sleep (≥3 nights/week), difficulty maintaining sleep (≥3 nights/week), Early morning awakening(≥3 nights/week), or poor/very poor sleep quality.

^b SI calculated using the 9th item of the PHQ-9, its response>0 (not at all)is scored as a positive result.

^c Depression calculated using the PHQ-2, with a clinical cut-off score of 3.

Table 3
SI and its associations with sleep disturbance during COVID-19.

Sleep during outbreak (T1)	SI during outbreak (T1)		SI during remission (T2)	
	Crude OR (95% CI)	Adjust OR (95% CI) ^a	Crude OR (95% CI)	Adjust OR (95% CI) ^b
Sleep duration				
>8 h	1.00	1.00	1.00	1.00
7–8 h	1.22(1.14,1.30) [¶]	1.30(1.21,1.39) [¶]	1.18(1.02,1.14) [#]	1.11(1.05,1.18) [¶]
6–7 h	2.09(1.92,2.28) [¶]	2.03(1.86,2.22) [¶]	1.58(1.46,1.71) [¶]	1.50(1.38,1.63) [¶]
<6 h	4.74(4.22,5.32) [¶]	3.78(3.44,4.28) [¶]	3.25(2.91,3.63) [¶]	2.67(2.37,3.01) [¶]
Difficulty initiating sleep				
Never/<1 night/week	1.00	1.00	1.00	1.00
1–2 nights/week	2.32(2.15,2.50) [¶]	2.20(2.04,2.37) [¶]	1.84(1.73,1.96) [¶]	1.80(1.68,1.92) [¶]
≥3 nights/week	4.76(4.44,5.10) [¶]	3.45(3.21,3.72) [¶]	3.43(3.23,3.64) [¶]	2.77(2.60,2.95) [¶]
Difficulty maintaining sleep				
Never/<1 night/week	1.00	1.00	1.00	1.00
1–2 nights/week	2.47(2.30,2.65) [¶]	2.39(2.23,2.57) [¶]	1.84(1.73,1.96) [¶]	1.83(1.72,1.95) [¶]
≥3 nights/week	4.61(4.30,4.94) [¶]	3.51(3.26,3.78) [¶]	3.05(2.86,3.25) [¶]	2.53(2.37,2.71) [¶]
Early morning awakening				
Never/<1 night/week	1.00	1.00	1.00	1.00
1–2 nights/week	2.88(2.69,3.09) [¶]	2.72(2.53,2.92) [¶]	2.08(1.95,2.22) [¶]	2.00(1.87,2.14) [¶]
≥3 nights/week	5.48(5.07,5.91) [¶]	3.99(3.67,4.33) [¶]	3.64(3.38,3.91) [¶]	2.92(2.71,3.16) [¶]
Subjective sleep quality				
Very good/Good	1.00	1.00	1.00	1.00
Normal	3.56(3.35,3.78) [¶]	2.83(2.66,3.02) [¶]	2.74(2.60,2.90) [¶]	2.31(2.18,2.44) [¶]
Poor/Very poor	6.95(6.22,7.77) [¶]	3.50(3.10,3.96) [¶]	4.69(4.21,5.23) [¶]	2.87(2.55,3.23) [¶]
Sleep disturbance	4.06(3.79,4.36) [¶]	2.47(2.29,2.68) [¶]	3.18(2.97,3.40) [¶]	2.25(2.09,2.42) [¶]

*P < .05; [#]P < .01; [¶]P < .001.

Note.
^a Adjusting for age, sex, grade, residence location, ethnicity, only single child, history of physical/mental illness, COVID-19 related factors, and depression (PHQ-2) during outbreak (T1).

^b Adjusting for age, sex, grade, residence location, ethnicity, only single child, history of physical/mental illness, COVID-19 related factors, and depression (PHQ-2) during remission (T2).

95% CI = 3.44–4.28) remained also significantly associated with SI.

3.3. Longitudinal associations of sleep with SI

Table 3 also shows the predictive effects of sleep problems on SI at T2. The unadjusted odds of SI significantly increased with DIS, DMS, EMA, and poor sleep quality, and with reduced sleep duration. After adjusting for demographics, pandemic exposure, and depression at T2, DIS (OR = 2.77; 95% CI = 2.60–2.95), DMS (OR = 2.53; 95% CI = 2.37–2.71), EMA (OR = 2.92; 95% CI = 2.37–2.71) ≥3 nights per week, poor/very poor sleep quality (OR = 2.87; 95% CI = 2.55–3.23), and overall sleep disturbance (OR = 2.25; 95% CI = 2.09–2.42) at T1 also remained significantly associated with increased risk for SI at T2. Short sleep duration (OR = 2.67; 95% CI = 2.37–3.01) was also a significant predictor for SI.

3.4. Sleep disturbance predicting change of SI during COVID-19

Fig. 2 shows the self-report trajectories examined for SI. Most of the students (85.8%) have been in the resistance group during the pandemic; that is, no SI was reported. Approximately 3.4% of participants who had SI at T1 still had SI at T2, these students are classified in the persistent group. The other two trajectories included 6.6% students in new onset group, and 4.2% in the remission group.

As shown in Table 4, sleep duration and sleep disturbances (DIS, DMS, EMA, and poor sleep quality) were used to predict changes in SI. Demographics, pandemic exposure, and depression at T1 were adjusted for their potential confounding effects. Compared with resistance, adjusted OR of overall sleep disturbance was 2.13 (95% CI = 1.92–2.33; *p* < .001) for new onset SI. That is, the risk for new onset SI from T1 to T2 was more than doubled among adolescents who had sleep disturbance at T1 after the pandemic relative to those who did not. Meanwhile, compared to the remission group, adjusted OR of overall sleep disturbance was 1.27 (95% CI = 1.11–1.46; *p* < .01) for persistent SI. Short

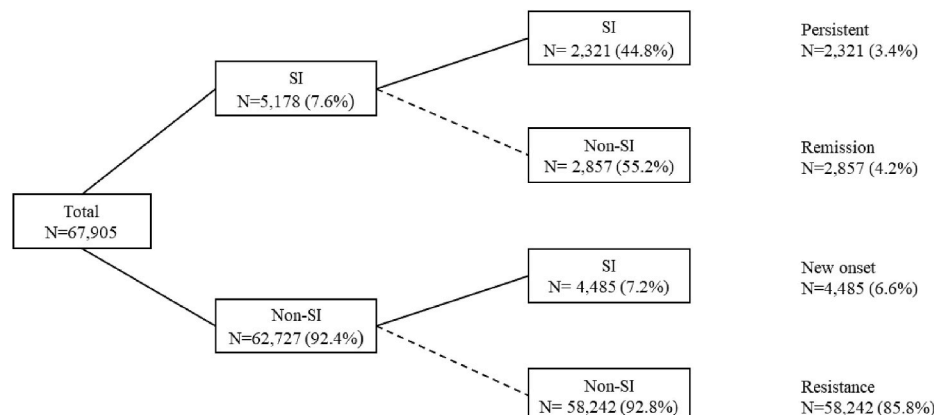


Fig. 2. The trajectory of SI.

Table 4
Sleep disturbance predicting change of SI during COVID-19.

Sleep during outbreak (T1)	New-onset v. Resistance		Persistent v. Remission	
	Crude OR (95% CI)	Adjust OR (95% CI) ^a	Crude OR (95% CI)	Adjust OR (95% CI) ^a
Sleep duration				
>8 h	1.00	1.00	1.00	1.00
7–8 h	1.04(0.97,1.11)	1.04(0.98,1.12)	0.97(0.86,1.11)	1.01(0.89,1.15)
6–7 h	1.35(1.22,1.50) ^o	1.31(1.19,1.46) ^o	1.17(0.99,1.38) ^s	1.15(0.97,1.36)
<6 h	2.47(2.13,2.88) ^o	2.24(1.93,2.61) ^o	1.51(1.23,1.85) ^o	1.35(1.10,1.66) [#]
Difficulty initiating sleep				
Never/<1 night/week	1.00	1.00	1.00	1.00
1–2 nights/week	1.67(1.55,1.80) ^o	1.68(1.56,1.81) ^o	1.20(1.03,1.39) [*]	1.16(1.00,1.34) ^{&}
≥3 nights/week	2.62(2.44,2.82) ^o	2.41(2.23,2.60) ^o	1.86(1.62,2.12) ^o	1.58(1.37,1.81) ^o
Difficulty maintaining sleep				
Never/<1 night/week	1.00	1.00	1.00	1.00
1–2 nights/week	1.56(1.44,1.68) ^o	1.58(1.46,1.70) ^o	1.34(1.17,1.53) ^o	1.31(1.15,1.50) ^o
≥3 nights/week	2.22(2.05,2.41) ^o	2.06(1.88,2.24) ^o	1.74(1.53,1.98) ^o	1.51(1.32,1.73) ^o
Early morning awakening				
Never/<1 night/week	1.00	1.00	1.00	1.00
1–2 nights/week	1.83(1.69,1.98) ^o	1.81(1.67,1.96) ^o	1.13(0.99,1.29)	1.09(0.95,1.25)
≥3 nights/week	2.56(2.32,2.82) ^o	2.28(2.06,2.52) ^o	1.81(1.58,2.08) ^o	1.55(1.35,1.80) ^o
Subjective sleep quality				
Very good/Good	1.00	1.00	1.00	1.00
Normal	2.23(2.09,2.39) ^o	2.07(1.93,2.22) ^o	1.61(1.43,1.81) ^o	1.43(1.27,1.62) ^o
Poor/Very poor	3.35(2.89,3.88) ^o	2.54(2.18,2.96) ^o	2.00(1.64,2.44) ^o	1.46(1.18,1.80) ^o
Sleep disturbance	2.54(2.33,2.78) ^o	2.13(1.94,2.33) ^o	1.61(1.41,1.83) ^o	1.27(1.11,1.46) [#]

* $P < .05$; [#] $P < .01$; ^o $P < .001$; [&] $P = .055$; ^s $P = .064$.

Note.
^a Adjusting for age, sex, grade, residence location, ethnicity, only single child, history of physical/mental illness, COVID-19 related factors, and depression (PHQ-2) during outbreak (T1).

sleep duration was also a significant predictor for new onset (OR = 2.24; 95% CI = 1.93–2.61) and persistent (OR = 1.35; 95% CI = 1.10–1.66) SI.

4. Discussion

To our knowledge, the present study is the first large-scale longitudinal study of sleep disturbances and SI among college students during the COVID-19 pandemic in China. Our findings showed that the prevalence of overall sleep disturbance and SI were 8.5% and 7.6% respectively, while rates increased from the start of the COVID-19 outbreak to the remission period in China. Meanwhile, sleep disturbance and short sleep duration were cross-sectional and longitudinally associated with an increased risk of SI. In addition, our data also revealed four trajectories for SI, i.e., resistance, persistent, new onset, and remission. Sleep disturbances were significant predictors of distinct SI trajectories.

Our study comprehensively investigated the sleep-related problems of college students during the pandemic. We found that 2.9% of college students reported nightly sleep duration of <6 h during the pandemic outbreak, which is similar to one previous study (2.7%) using a Chinese undergraduate student sample (Tang et al., 2020). However, with the development of the pandemic, the sleep time of students has obviously decreased. Students were going to bed and waking up later, and time to fall asleep increased during COVID-19 (Morin et al., 2020), and conversely, sleep duration increased only among those students with existing shorter sleep duration before the pandemic (Genta et al., 2021). The prevalence of sleep disturbance was 8.5% during pandemic outbreak, which is higher than results from Wang et al. (5.3%) (Wang et al., 2020b) yet lower than Zhou et al. (23.2%) (Zhou et al., 2020). The prevalence of SI was 7.6% in the current sample, which is also higher than results from Mamun et al. (5.0%) (Mamun et al., 2021) yet lower than Wang et al. (18.04%) (Wang et al., 2020a). These differences may be caused by variation in tools of measurement. In our study, sleep disturbances were found to have increased from the start of the COVID-19 outbreak to the remission period in China. Specifically, insomnia symptoms (e.g., difficulty initiating sleep, difficulty maintaining sleep, early morning awakening) became more severe during home isolation. Another novel view is that during the isolation period,

use of digital media (e.g., cellphones) among students increased greatly near bedtime, which has a negative effect on sleep continuity (Majumdar et al., 2020). What's more, consistent with several previous studies (Cellini et al., 2020; Morin et al., 2020), our data revealed that the sleep quality of college students declined during the pandemic (poor sleep quality rate increased from 2.7% to 3.5%).

Our data shows that with this increase in isolation time, the prevalence of SI among college students has increased significantly. Possible reasons include stress from the uncertainty of future career or academic opportunities (Tasnim et al., 2020) or the effects of confinement, social distancing, and atypical work schedules (Morin et al., 2020). The SI trajectories showed that the majority of the college students in the study (85.5% for resistance) exhibited no SI throughout the 2-month period post-pandemic. This result shows that the SI of most students is relatively low and very stable, which is in line with previous studies. For example, one research found 86.4% students presented with low and stable trajectories of SI during three years in early adolescence (Zhu et al., 2019). We speculated that people exposed to the public health emergency of COVID-19 exhibit acute stress responses only immediately after the public health emergency and maintain a stable trajectory of euthymia and healthy functioning. Moreover, a small percentage of the current sample exhibited the trajectories of persistence (3.4%), remission (4.2%) and new onset (6.6%). These changes are similar to our previous study on depression, anxiety, and states of acute stress of college students during COVID-19 (Li et al., 2021). We speculated that the presence or new onset of SI was largely related to secondary stressors (such as lifestyle and economic disruptions) during the COVID-19 pandemic lockdown (Shanahan et al., 2020). Meanwhile, a relatively similar proportion of remission of the current sample may suggest protective factors associated with pandemic lockdown, such as more time spent with family and reduced school stress (Sun et al., 2021b).

Controlling for socio-demographics, pandemic exposure, and depression, sleep disturbances have been cross-sectionally associated with SI during the pandemic. An increasing number of studies have suggested that people with sleep disturbances are at a higher risk of suicidality than those without sleep complaints (Liu et al., 2019). This study also demonstrated significant longitudinal associations between

sleep disturbances and SI, independent of depressive symptoms. These results were expected and consistent with several studies that prospectively demonstrated the association of previous sleep disturbances with later onset of SI (Wong et al., 2011; Wong and Brower, 2012). Most importantly, this is one of the few studies to examine the extent to which sleep disturbances are associated with changes of SI in a large cohort of adolescents exposed to a public health emergency. Sleep disturbance is risk factors for new onset of SI and good sleep quality is a protective factor for SI remission. However, different from the long-term risks identified in previous studies, this study confirmed the strong associations between sleep disturbances and SI within a short time-frame after exposure to a special public health emergency.

Meanwhile, while prior studies have found that short sleep duration was associated with increased risk for SI, most of these studies have been limited by cross-sectional design (Dolsen et al., 2020; Kim et al., 2020). A recent 2-year follow-up study found that shorter sleep duration at baseline was associated with an increased likelihood of suicidality in school-aged boys (Gong et al., 2020). Our data showed significant cross-sectional and longitudinal associations between short sleep duration and SI. Longitudinal analysis further demonstrated that short sleep duration could independently predict the new onset or persistence of SI, including after adjusting for demographics, pandemic exposure, and baseline depression. One possibility is that being awake at night creates a window of vulnerability with respect to suicidality. Specifically, both sleep deprivation and circadian effects compromise daytime and night-time frontal lobe function/executive function. Hypoactivation of the frontal lobe could diminish problem-solving abilities and increase impulsive behavior, both of which may increase the likelihood of suicide (Perlis et al., 2016). Insufficient sleep can also lead to disturbances in an individual's mood regulation, thereby increasing SI (Sarchiapone et al., 2014). Additionally, inadequate sleep is associated with thermoregulation difficulties, including lower body temperature; hypothalamus/hypothalamic-pituitary-adrenal (HPA) axis dysregulation has also been linked to thermoregulation difficulties as well as depression and risk of suicidality (Bao et al., 2008; Buckley and Schatzberg, 2005; Kirkcaldy, 2004).

Taken together, this study makes a unique contribution to the literature by examining the association between sleep disturbances and SI in college student sample during the COVID-19 pandemic. Our findings suggest that recognizing and treating sleep disturbance is especially vital during stressful periods such as the pandemic because it may significantly reduce risk of suicidality. It is important to identify and treat sleep disturbances not only among psychiatric patients but also among the non-clinical population. Individuals with sleep disorders need to be early evaluated early for SI and suicide intent after exposure to a special public health emergency. For groups in isolation at home, we can appropriately increase sleep duration and improve sleep quality (e.g. through do exercise (Yang et al., 2012) or by seeking help from cognitive behavioral therapy (Manber et al., 2011)) to address mental health problems and insomnia.

Finally, several limitations should be considered. First, all measures relied on self-report questionnaires, which may have led to reporting bias caused by people's own psychiatric states. In particular, we only use one item to measure SI, which may limit interpretation of the validity of the SI results (Na et al., 2018). Therefore, the research results need to be verified in conjunction with clinical diagnosis. Second, some students might have been receiving intervention (e.g. 'COVID-19 Psychological Resilience Model' intervention (He et al., 2020)) during the follow-up, which could affect their SI symptoms. In fact, almost all communities and universities opened free psychological hotlines during COVID-19. For example, our team (School of Psychology, South China Normal University) set up a 'Xinqing' hotline during the pandemic to provide free psychological assistance services to all residents across the country. Third, some important co-occurring risk factors that may have affected the study findings, such as acute stress, were not considered.

5. Conclusions

This is the first study to survey both cross-sectional and longitudinal associations of sleep disturbance with SI in a large cohort of college students exposed to a public health emergency. This study found that sleep disturbance not only was cross-sectional and prospectively associated with an increased risk of SI, but also predicted changes of SI. These findings suggest the causal role of sleep disturbance in the development and chronicity of SI. This study also pointed to the notion that assessing several simple symptoms related to sleep problems may be a quick and effective way to screen person at increased risk of SI. Therefore, we believed that assessment and treatment of sleep disturbance as early as possible may be an important strategy for prevention and intervention of SI in individuals after exposure to a public health emergency.

Author statement

Dongfang Wang: Conceptualization, Formal analysis, Writing – original draft. Brendan Ross: Formal analysis, Writing – review & editing. Xiuzhu Zhou, Dongjing Meng, Zhiyi Zhu: Formal analysis, Investigation. Jingbo Zhao: Methodology, Resources. Fang Fan: Conceptualization, Project administration. Xianchen Liu: Conceptualization, Writing – review & editing.

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Declaration of competing interest

All authors declare that they have no conflict of interest.

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