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## Longitudinal trajectories of insomnia symptoms among college students during the COVID-19 lockdown in China

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### ABSTRACT

**Purpose:** This study aimed to examine the patterns and predictors of the trajectories of college students' insomnia symptoms across different stages of the COVID-19 pandemic.

**Methods:** A total of 35,516 college students completed three online surveys during the COVID-19 outbreak period (3–10 February 2020), initial remission period (24 March–3 April 2020), and effective control period (1–15 June 2020), respectively. These surveys measured the participants' socio-demographic and pandemic related factors, insomnia symptoms, mental health status, and psychosocial factors. Multivariate logistic regressions were used to examine predictors for trajectory membership.

**Results:** The prevalence of insomnia symptoms increases during home quarantine. Five insomnia symptoms trajectories were observed: resistance (82.8% of the sample), recovery (5.0%), delayed-dysfunction (5.8%), chronic-dysfunction (1.8%), and relapsing/remitting (4.6%). Female gender, residence location in urban, has history of sleep problems, smoking, alcohol use, community or village has confirmed COVID-19 cases, current poor mental health, higher negative coping were related to higher risk of developing insomnia symptoms in at least one time point, whereas better family function increased the possibility of recovery relative to chronic dysfunction. Lower social support and positive coping could also cause insomnia chronicity.

**Conclusion:** Adolescents have different trajectories of insomnia symptoms during pandemic lockdown. Although most adolescents did not experience insomnia or recovered over time, some adolescents, especially those with the risk factors noted above, exhibit delayed or chronic symptoms. These findings could inform mental health professionals regarding how to provide individualized and appropriate intervention for college students after their return to school.

### 1. Introduction

The 2019 novel coronavirus (COVID-19) disease has spread globally since winter 2019, which has caused various impacts on the individual's well-being. In response to this highly contagious virus, many countries, including China, have taken confinement measures, including contact restrictions, self-isolation, and closure of schools, and colleges/universities [1]. Although social distancing measures were effective in controlling the spread of the pandemic, as its side-effect, home-quarantine

may increase daytime stress, anxiety, depressive symptoms [2,3]. Due to strict pandemic prevention and control measures, lack of physical activity level [4,5], increased electronic screen time [6,7], and decreased regular social interaction [8,9] were disrupt individual' sleep quality.

A recent meta-analysis reported pooled prevalence of de insomnia of the global population was 23.87% [10]. Evidence from China, compared with a pooled prevalence estimate of insomnia (315%) absent of pandemic [11], pooled prevalence from a recent meta-analysis conducted during the COVID-19 was more than two times higher (39.1%)

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[12], which to a certain extent reflects a significant impact of the COVID-19 pandemic on sleep. Meanwhile, younger people are more vulnerable to stress during COVID-19 pandemic [13]. Previous study also point out that high levels of stress may be influencing their sleep quality [14]. Data shows that adolescent sample showed a high prevalence of insomnia during pandemic lockdown. Compared to junior school students (18.0%), high school students (25.3%) and college students (25.7%) reported higher rates of insomnia symptoms during the COVID-19 outbreak [15]. This study also revealed that college students were more likely to experience declines in sleep quality, increased sleep times, later bedtimes, and sleep disturbances [15]. Prior evidence suggested that college students have poorer sleep habits [16], such as staying up late, mobile phone use at bed, playing online games, or online shopping. Therefore, as home-quarantine gave college students more free time from school, it may worsen their already poor sleep habits, leading to sleep problems. However, only few COVID-19 related studies have focused on college students' insomnia symptoms. What's more, college students' sleep quality was correlated to their perceptions of COVID-19 [17] and their sleep problems may evolve with the development of the pandemic. To date, most studies on sleep problems during the pandemic focused on the pandemic outbreak period through cross-sectional survey design.

In China, COVID-19 first broke out in the city of Wuhan at the end of December 2019, which then spread across the country. During January 23–March 10, 2020, COVID-19 had spread across China rapidly, with the total number of confirmed cases of COVID-19 had increased to 80,905. Thus, all provinces and autonomous regions in mainland China had activated the level 1 public health emergency response in order to prevent the spread [18]. The China government also implemented social distancing measures (e.g., home quarantines and national school closures) to slow down the spread of the infection. Since March 2020, the pandemic in China has been initial remission, with a consistent downward trend of newly confirmed cases nationwide and newly confirmed cases in the Hubei Province zero. Starting in May 2020, COVID-19 under effective control in China, and schools have gradually begun to open with students returning to school in batches [19]. However, little is known about changes of college students' sleep problems across different stages of the COVID-19 pandemic. Accordingly, this study focused on insomnia symptoms over the home-quarantine period among college students from Guangdong province, China. Guangdong Province was one of pandemic moderate-risk area as assessed by the World Health Organization in early 2020, with the cumulative COVID-19 confirmed cases ranged from 1000 to 9999 [20]. All schools in Guangdong province were closed during the pandemic, students were required to staying at home and completing their studies online. The first aim of this study is to explore the trajectories of insomnia symptoms across different stages of the COVID-19 pandemic.

Meanwhile, potential predictors of mental health during pandemic have been extensively investigated. Well-documented influential factors can be divided into the following categories. First, COVID-19 related factors, such as confirmed COVID-19 cases in the community or village and relatives or friends being infected with COVID-19, are proven critical for the development of depression and anxiety [21,22]. Second, pre-existing individual characteristics such as female gender, in their senior year, history of physical illness are also associated with elevated risk of poor mental health during pandemic [23]. Furthermore, factors that occur after the trauma and thus may affect the individual's responses post-pandemic, such as perceived social support, family function, coping style, and other psychological resources, exert considerable influence on the onset and severity of mental health symptoms as well [21,23,24]. In addition, several psychological symptoms are also closely related to insomnia, such as depression [25], anxiety [26] and posttraumatic stress symptoms (PTS) [27]. Therefore, the second aim of this study attempted to explore the potential predictors of insomnia and its changes during the pandemic and to identify those who were at a high risk of showing exacerbating insomnia symptoms during this period.

## 2. Methods

### 2.1. Participants and procedure

Participants surveyed for sleep insomnia were college student of the adolescent's behavior and health cohort during COVID-19 pandemic, which were sampled from 22 colleges/universities in Guangdong province, China. Detailed sampling and data collection have been described elsewhere [21]. In brief, this study was supported and helped by the local education bureau and psychological counseling center of each university. All participants received an electronic informed consent form before survey, for those who confirmed their participation. The self-built information website and the official WeChat was accounted to push the electronic questionnaire to target college students. All students were required to provide their anonymized student number, which was assigned based on their registration status at school, to complete the test. They were also informed that they could feel free to withdraw from the study at any time. Our study was approved by the Human Research Ethics Committee of South China Normal University (Ethics\_No\_SCNU-PSY-2020-01-001).

Using a repeated cross-sectional study design, our study investigated 185,901, 155,563, and 166,052 participants online during COVID-19 outbreak period (Time 1, T1: 3–10 February 2020), initial remission period (Time 2, T2: 24 March–3 April 2020), and effective control period (Time 3, T3: 1–15 June 2020), respectively (see Fig. 1). A small part of participants was excluded for exclusion criteria (missing data information >25% and response time < 5 min), leaving 164,101, 145,875, and 146,102 college students, respectively. Among participants, a total of 35,516 college students both provided complete responses on measurement questions at all three surveys. We compare the insomnia prevalence rates at each wave between participants who provided complete data across all waves and those who had missing data in at least one wave. There was no significant difference in insomnia prevalence rates between these two groups at any wave.

### 2.2. Measures

#### 2.2.1. Socio-demographic and pandemic related factors

Socio-demographic and pandemic related factors were collected by the self-made questionnaire. Socio-demographic variables include gender (1 = male, 2 = female), grade (freshman to postgraduate), age (years), residence location (1 = rural, 2 = urban), only single-child status (1 = yes, 2 = no), history of physical illness (1 = yes, 2 = no), history of mental illness (1 = yes, 2 = no), history of sleep problems (1 = yes, 2 = no), ever smoking (1 = yes, 2 = no), ever alcohol use (1 = yes, 2 = no). Pandemic related factors include weather have confirmed COVID-19 cases in the community or village (1 = yes, 2 = no), and weather have relatives or friends being infected with COVID-19 (1 = yes, 2 = no).

#### 2.2.2. Insomnia symptoms

Three sleep items based on criteria of the Diagnostic and Statistical Manual of Mental Disorders [28] were used to assess participants' insomnia symptoms over the past two weeks at three surveys (T1 to T3), including difficulty initiating sleep (DIS), difficulty maintaining sleep (DMS), and early morning awakening (EMA). Responses to items range from 1 = never, 2 = 1 time/week, 3 = 1–2 times/week, 4 = 3–5 times/week, to 5 = 5–7 times/week. If any of these items were rated as "4 = 3–5 times/week" or "5 = 5–7 times/week" (more than three times a week), the participants were classified as having insomnia symptoms. This definition has been used in previous publications using the same survey question on insomnia symptoms [29,30]. The internal consistency of these items in the three surveys was acceptable, and Cronbach's  $\alpha$  were 0.70, 0.74, and 0.74, respectively.

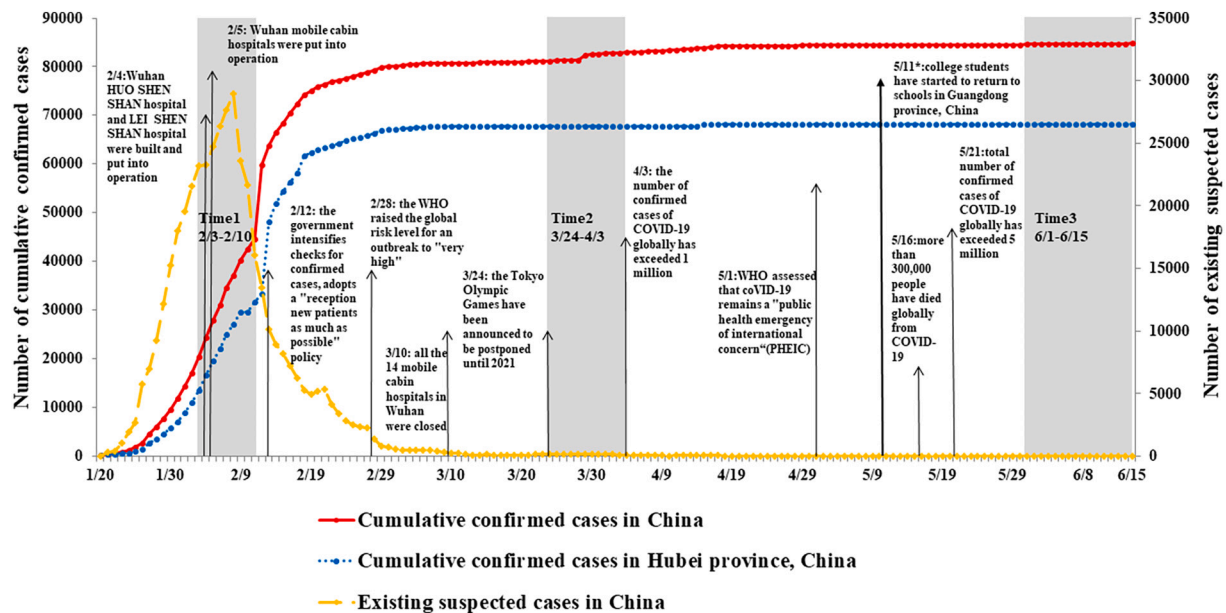


Fig. 1. The national pandemic trend of the 2019 coronavirus disease (COVID-19) in China from January 20 to June 15, 2020.

Note: First data collection period (Time 1): February 3 to February 10; Second data collection period (Time 2): March 24 to April 3; Third data collection period (Time 3): June 1 to June 15.

### 2.2.3. Mental health status

Depressive symptoms, anxiety symptoms and posttraumatic stress symptoms (PTS) measured at T1. Depressive symptoms were assessed by the Chinese of 9-item Patient Health Questionnaire (PHQ-9) [31] and anxiety symptoms were assessed by the Chinese of 7-item Generalized Anxiety Disorder Scale (GAD-7) [32]. Responses to items both were recorded from 0 (not at all) to 3 (nearly every day), with higher total score indicating a greater tendency of having depressive and anxiety symptoms over past two weeks. A score 10 and above could be considered for potential clinical depression [33] or anxiety [34]. In the current sample, the Cronbach's  $\alpha$  were 0.87 for PHQ-9, and 0.91 for GAD-7. PTS were measured by 6-item Impact of Event Scale (IES-6). According to previous studies [35], the Chinese of IES-6 originating from the Chinese version of Impact of Event Scale-Revised (CIES-R) [36]. Five response options are available on a scale of 0 (not at all) to 4 (extremely). Higher total score indicates higher levels of potential PTS over past one week, and a summed score of 9 indicating probable clinical PTS [37]. In this study, Cronbach's  $\alpha$  for IES-6 was acceptable ( $\alpha = 0.79$ ).

### 2.2.4. Psychosocial factors

Several psychosocial factors that are of interest to us have been taken into consideration in this study, i.e., social support, coping, and family function. Social support refers to functions that individuals' significant others play for them [38]. The Perceived Social Support Scale (PSSS) was used to measure individual perceptions of the available support from their family, friends, and other sources at T1. Twelve items were rated from 1 (very strongly disagree) to 7 (very strongly agree), with a higher total score indicating a stronger perception of social support [39], and Cronbach's  $\alpha$  was 0.94 in this study. Coping style is the cognitive and behavioral effort to manage the internal and external demands of stressful events [40], which was assessed by Simplified Coping Style Questionnaire (SCSQ) in our study at T1. Two factors (positive coping and negative coping) showed good reliability and validity in previous studies [41,42], and the Cronbach's  $\alpha$  for total scale (8 items), positive coping (12 items) and negative coping (8 items) subscales were acceptable (0.87, 0.91 and 0.78, respectively). Family function was measured by APGAR-family scale at T2 [43]. This scale consists of 5 items, with each item scored from 0 (never/ rarely) to 2 (most/ all the time), and a total score of 7–10 indicates a highly functional family, 4–6

indicates a moderately dysfunctional family and 0–3 indicates a severely dysfunctional family. In this study, the Cronbach's  $\alpha$  was 0.90.

### 2.3. Data analysis

All analyses were performed using SPSS version 23.0. First, the repeated measures analysis was used to compare the differences in the prevalence rate of insomnia symptoms at three time periods. The repeated measures analysis corrected with bonferroni. Second, any of insomnia symptoms  $\geq 3$  times per week was defined as having insomnia symptoms in this study. The percentage was used to reflect the detection rate of insomnia symptoms in each time point. According to time-varying changes of positive detection rate, we established the different patterns of insomnia symptoms during the pandemic.

We refer to previous studies [44] to further summarize five trajectories of insomnia symptoms, i.e., resistance, recover, delayed-dysfunction, chronic-dysfunction, and relapsing/remitting: (1) resistance: symptoms of insomnia were absent at all three time points, (2) chronic-dysfunction: insomnia symptoms is both positive at three time points; (3) recover: insomnia symptoms is positive at T1 but negative at T2 and T3, or insomnia symptoms is positive at T1 and T2 but negative at T3; (4) delayed-dysfunction: insomnia symptoms is negative at T1 but positive at T2 and T3, or insomnia symptoms is negative at T1 and T2 but positive at T3; (5) relapsing/remitting: insomnia symptoms is negative at T1 and T3 but positive at T2, or insomnia symptoms is positive at T1 and T2 but negative at T3.

Finally, the multivariate logistic regressions were used to examine predictors for the occurrence and changes of insomnia symptoms. Our major interest was to explore the risk factors associated with increased likelihood of developing non-resistance. We set the resistance group as the referent group and compared it with a 'non-resistance' group composed of the rest of the four groups (recover, delayed-dysfunction, chronic-dysfunction, and relapsing/remitting). We also explore the risk factors associated with decreased likelihood of developing recover. Thus, we set the chronic dysfunction group as the referent group and compared it with recovery group. Considering the sample size was very large in the presents study, all statistical significance was set to be  $p < 0.001$  (2-sided tests), and adjusted odds ratios in 1.2–1.5 (or 0.7–0.9) and  $>1.5$  (or  $<0.7$ ) were considered to demonstrate weak/ moderate

and strong associations, respectively [45,46].

### 3. Results

#### 3.1. Sample characteristics

Among the 35,516 Chinese college students who took part in all three surveys, 9244 were male students, and 26,272 were female students. The age of this sample ranged from 16 to 25 years old, with a mean age of 20.29 (SD = 1.85) years. Other detailed sample demographic and health behavior for both time points shown in Table 1.

#### 3.2. Prevalence of insomnia symptoms

As shown in Fig. 2, the prevalence rates of insomnia symptoms at three time points were 7.8%, 8.7%, and 8.5%, respectively. Compared to Time 1, DIS and EMA symptoms were significantly increased at Time 2 and Time 3, while DMS was stable at three surveys.

#### 3.3. Trajectories of insomnia symptoms

The overall trajectories of insomnia symptoms were presented in Fig. 3, and we have also identified five groups of insomnia symptoms trajectories in Fig. 4. 82.8% ( $n = 29,395$ ) of the cohort met the criteria for sleep problems at neither of the three waves, and these students were classified as resistance group. 1.8% ( $n = 649$ ) met the criteria at all three waves and were classified as chronic-dysfunction group. Meanwhile, 11.3% ( $n = 4004$ ) met criteria at only one wave, 4.1% ( $n = 1468$ ) at any combinations of two waves (T1 and T2, T1 and T3, or T2 and T3). Among these participants, 5.8% was delayed-dysfunction group, 5.0% was recovery group. In addition, 4.6% was relapsing/remitting group:

**Table 1**  
Sample characteristics ( $N = 35,516$ ).

Characteristics		N	%
Gender	Male	9244	26.0
	Female	26,272	74.0
Grade	Freshman	12,726	35.8
	Sophomore	10,447	29.4
	Junior	7258	20.4
	Senior	3147	8.9
	Postgraduate	1938	5.5
Residence location	Rural	14,347	40.4
	Urban	21,169	59.6
Only single child status	Yes	7266	20.5
	No	28,250	79.5
History of physical illness	Yes	174	0.5
	No	25,342	99.5
History of mental illness	Yes	296	0.8
	No	35,220	99.2
History of sleep problems	Never	2378	6.7
	Sometimes	9513	26.8
	Often	23,625	66.5
Ever smoking	Yes	1613	4.5
	No	33,903	95.5
Ever alcohol use	Yes	11,758	33.1
	No	23,768	66.9
Confirmed COVID-19 cases in the community or village	Yes	2352	6.6
	No	33,164	93.4
Relatives or friends being infected with COVID-19	Confirmed/suspected	400	1.1
	No	35,116	98.9
Depression <sup>a</sup>	Yes	2448	6.9
	No	33,068	93.1
Anxiety <sup>b</sup>	Yes	906	2.6
	No	34,610	97.4
PTS <sup>c</sup>	Yes	12,438	35.0
	No	23,078	65.0

<sup>a</sup> Depression calculated using the PHQ-9, with a clinical cutoff score of 10.

<sup>b</sup> Anxiety calculated using the GAD-7, with a clinical cutoff score of 10.

<sup>c</sup> PTS calculated using the IES-6, with a clinical cutoff score of 9.

3.7% of the sample showed no sleep problems at T1 and onset at T2, while remission at T3; 0.9% showed insomnia symptoms at T1 with remission at T2, while relapse at T3.

#### 3.4. Predictors of sleep problems trajectory membership

As shown in Table 2, the likelihood of developing insomnia symptoms in at least one wave (non-resistance) would increase if the participants were females (OR = 1.31, 95%CI = 1.21–1.42), living in urban environment (OR = 1.31, 95%CI = 1.22–1.40), having history of sleep problems (OR for sometimes v. never = 3.32, 95%CI = 3.10–3.55; OR for often v. never = 11.32, 95%CI = 10.22–12.53), ever smoking (OR = 1.49, 95%CI = 1.29–1.72), ever using alcohol (OR = 1.26, 95%CI = 1.18–1.35), having depression (OR = 2.98, 95%CI = 2.67–3.31), anxiety (OR = 1.69, 95%CI = 1.42–2.01), PTS (OR = 1.37, 95%CI = 1.29–1.46), and higher level of negative coping (OR for medium v. low = 1.24, 95%CI = 1.14–1.36; OR for high v. low = 1.44, 95%CI = 1.31–1.59) at baseline. Higher level of social support (OR for medium v. low = 0.89, 95%CI = 0.82–0.96; OR for high v. low = 0.74, 95%CI = 0.66–0.82), positive coping (OR for medium v. low = 0.91, 95%CI = 0.84–0.98; OR for high v. low = 0.88, 95%CI = 0.80–0.97), family function (OR for fair v. poor = 0.59, 95%CI = 0.53–0.65; OR for good v. poor = 0.44, 95%CI = 0.39–0.49) might decrease the likelihood of developing insomnia symptoms in at least one of the non-resistance waves.

Meanwhile, we also set the chronic dysfunction group as the referent group and compared to the recovery group. The risk factors that cause persistent insomnia symptoms include having history of sleep problems (OR for sometimes v. never = 0.68, 95%CI = 0.50–0.92; OR for often v. never = 0.31, 95%CI = 0.23–0.41), and higher depression at baseline (OR = 0.62, 95%CI = 0.50–0.78). Meanwhile, compared with poor family function, fair or good family function (OR for fair v. poor = 1.60, 95%CI = 1.25–2.05; OR for good v. poor = 2.11, 95%CI = 1.57–2.82) can help with insomnia symptoms remission among college students.

### 4. Discussion

To our knowledge, this study is the first cohort study that investigated the heterogeneous trajectories and predictors of insomnia symptoms among college students across different stages of the COVID-19 pandemic. Our results showed that the overall severity of insomnia symptoms increased during initial remission period (T2: 24 March–3 April 2020) and effective control period (T3: 1–15 June 2020). The study presented five trajectories of insomnia symptoms, i.e., resistance, recovery, delayed-dysfunction, chronic-dysfunction, and relapsing/remitting. Gender, grade, residence location, history of sleep problems, smoking, alcohol use, COVID-19 community exposure, mental health status, and several psychosocial factors were significant predictors of distinct trajectories.

Our data showed increased insomnia among college students during home isolation, with the prevalence during the outbreak period, initial remission period and effective control period was 7.8%, 8.7%, and 8.5%, respectively. The result was similar to previous studies [21,47], social distancing, reduced physical activity, and increased screen exposure [47], which might have played a major role in disturbing sleep patterns. However, these rates were lower than those in other surveys investigating college students' sleep problems during pandemic. For example, Zhou and colleague investigated 11,835 adolescents and young adults using the P Pittsburgh Sleep Quality Index (PSQI), and the rates of sleep problems (PSQI score > 5) in the early stage of the pandemic were reported to be 25.7% [15]. Studies by Wang et al. (2019), sleep problems were measured using the Self-Rating Scale of Sleep (SRSS), indicated that prevalence of sleep problems (SRSS  $\geq$  23) was 13.5% among 3092 Chinese college students during COVID-19 lockdown [48]. The discrepant results may be attributed to different sleep assessments. Another possible reason is that varying degree of stress perception of COVID-19 owing to different sample source. Specifically, individuals living in high-

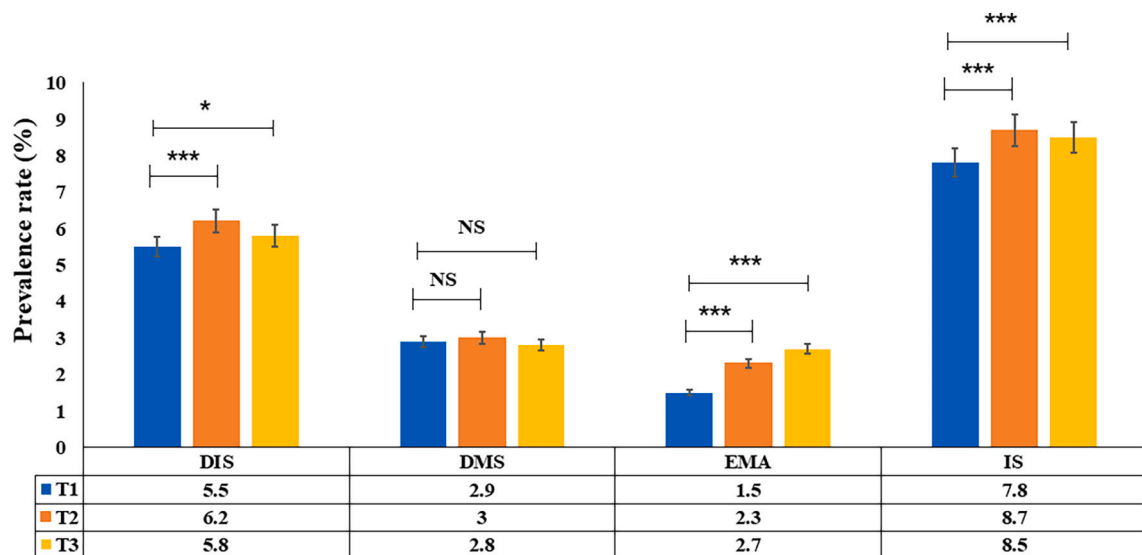


Fig. 2. Prevalence rates of insomnia symptoms.

Note: DIS: T1:Time1; T2:Time2; T3:Time3; DIS: difficulty initiating sleep; DMS: difficulty maintaining sleep; EMA: early morning awakening; IS: insomnia symptoms, any one of the DIS, DMS, or EMA is positive.

NS: no significant; \* $P < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$ .

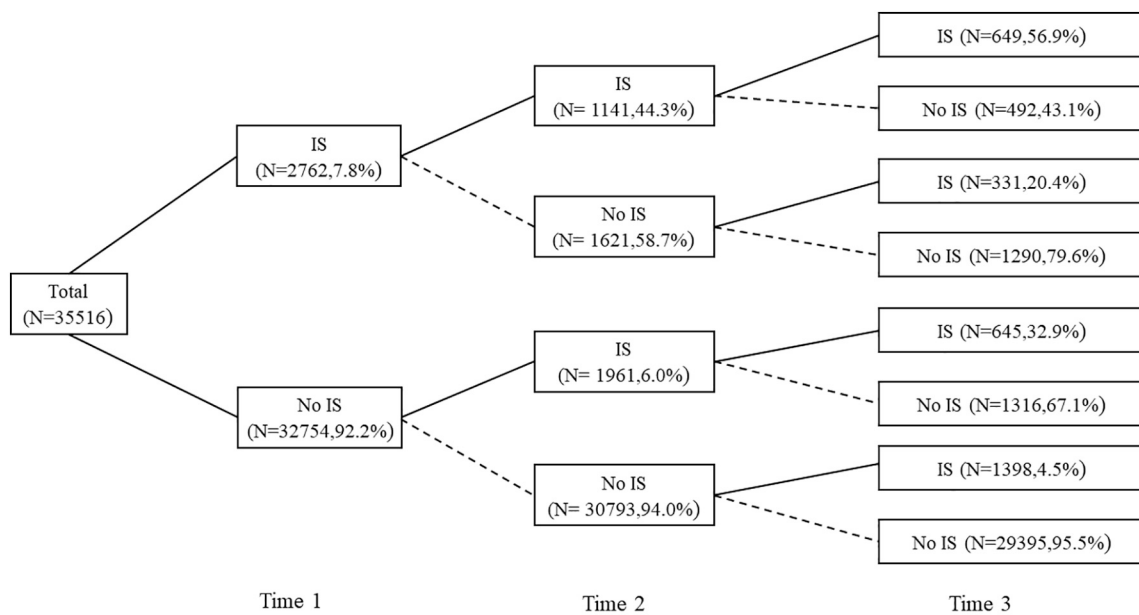


Fig. 3. Change patterns of insomnia symptoms (IS).

Note: Values represent numbers and percentages of students screened as having IS at each wave.

risk areas may be more likely to perceive the stress of the COVID-19, leading to more adverse psychological consequences. There is sufficient evidence for the people living in Hubei Province (high-risk areas) have approximately twice the risk of insomnia compared to other areas [49].

The insomnia symptoms trajectories showed that majority of the college students (82.8% for resistance) exhibited very mild or no insomnia symptoms throughout the 4-months home isolation period post-pandemic. A small percentage of this sample exhibited the trajectories of recovery (5.0%), delayed-dysfunction (5.8%), chronic-dysfunction (1.8%). These symptoms changes are similar to a previous study on depression, anxiety, and acute stress of college students during COVID-19 lockdown [21]. In fact, most students are in home quarantine,

and the risk of being infected by the epidemic is very low. We speculated that although the pandemic had negative impacts on students' academic and daily life, most of the students may cope well with these pressures and maintain a relatively healthy functioning. For most adolescents, reduced school stress and more time spent with family have a certain protective effect on sleep during pandemic lockdown. Besides, 4.6% students displayed a relapsing/ remitting trajectory. This proportion seemed lower than those reported by other studies that observed relapsing/ remitting sleep problems following a natural disaster [50], such as 12.5% in adolescent survivors of the 2008 Wenchuan earthquake over a 2-year follow-up. These differences may be explained by the differences in sample size, participants' age, measurement tools, and the nature of traumatic events experienced.

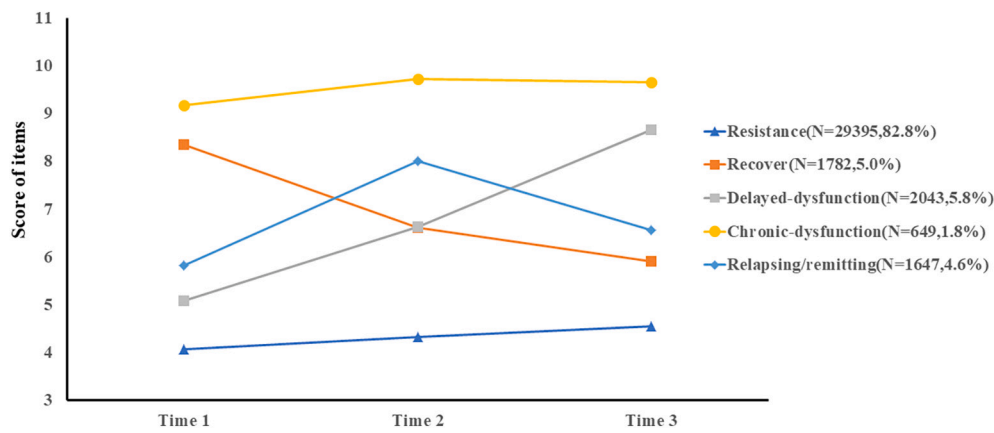


Fig. 4. Trajectories of insomnia symptoms.

Our data showed socio-demographic characteristics including gender, residence location, smoking, alcohol use, and confirmed COVID-19 cases in the community or village being weak or moderate predictors of insomnia symptoms ( $OR = 1.2-1.5, p < 0.001$ ). Female students were found to be more susceptible to having insomnia symptoms than males. Prior research also supports that female gender as a risk factor for sleep problems during pandemics [15,51]. One possible explanation that females are more reactive to stress and have stronger perceptions of threat than males [52], so that they could be more prone to the impacts of public health emergency. In line with a previous study [53], urban residence was found to be associated with higher risk of developing insomnia symptoms in our study. A possible explanation to this may be due to the fact that urban communities are more densely populated and exert higher risk of community infection, which may increase residents' anxiety and stress, leading to ones' insomnia symptoms. This study showed that ever smoking and alcohol use were also risk factors for sleep problems, which is consistent with the results of previous studies [54,55]. In addition, we found that students living in communities or village with confirmed cases of COVID-19 reported more "non-resistant" trajectory of insomnia symptoms. Under the context of community infection, psychological impact of home confinement may be exacerbated and in turn, worsen person' feelings of fear, frustration, and hopelessness during the quarantine, resulting in greater psychiatric symptoms [56]. Furthermore, In terms of the effect of the previous sleep status, our data has suggested that it is a strong predictor of sleep problems following the risk of sleep problems in our study. Whereas insomnia in those without sleep problems history is more likely to be relieved over time. This result may indicate that people with a history of sleep problems should be given special attention during sleep intervention, as they are more likely to be affected by negative life events, which may lead to the relapsing or persisting insomnia.

This study also examined the predictive effect of several mental health/ psychosocial factors on the insomnia symptoms trajectory membership. Consistent with previous studies [15,57], increasing depression, anxiety, or PTS symptoms contributed to the onset or persistence of insomnia symptoms. Our results also suggested that social support has the potential to predict distinct insomnia symptoms trajectories. In line with prior studies [15], greater social support was found to decrease the likelihood of insomnia symptoms. These findings pinpointed the importance of social support in facilitating adolescents' positive adaptation to public health emergencies. Numerous studies have confirmed that high quality social support predicts better mental health functioning [58,59]. Social support can also be regarded as a protective factor against the onset of mental health problems, for example, greater social support can enhance resilience to stress and help protect against developing trauma-related psychopathology [60]. Grey and colleagues have also found that social support was significantly

associated with elevated risk for depression and poorer sleep quality during the COVID-19 pandemic [24]. Furthermore, our study evidenced the importance of coping skills in moderately predicting insomnia symptoms, which is also consistent with related previous studies [61]. Specifically, positive coping was found to increase the likelihood of high-quality sleep. In contrast to the protective effect of positive coping, negative coping was a significant risk factor for insomnia symptoms. According to previous studies [62,63], negative coping style refers to dealing with problems by neglecting, avoidance and denial, in contrast, positive coping style tends to take direct and rational ways to solve problems. Coping style was found may play a mediating or moderating role in the relationship between stress and insomnia [64,65]. On the one hand, high stress can cause individuals to be more inclined to negative coping styles, thereby increasing the symptoms of insomnia; on the other hand, positive coping styles can weaken the catalytic effect of stress on insomnia. In addition, a dysfunctional family was also a vital psychosocial factor that increased the risk of developing insomnia symptoms. Better family function was found to significantly increase the likelihood of the recovery trajectory relative to the chronic dysfunction one. The positively role of family function in one's sleep problems has already been evidenced in many studies [66]. Better family function means more family support, better quality of family communication, affective expression or parental involvement [67], which have important protective effects on mental health among adolescents [68]. Findings in the current study also highlight the importance of support (e.g., family support) in facilitating college students' positive adaptation to the pandemic of COVID-19.

Regarding our results, we attempt to explain a resilience hypothesis of insomnia after exposure to a special public health emergency. The interaction of the susceptibility traits and the related stresses of public health emergency may lead to the individual's transient insomnia disorder. The protection of external resources (e.g. social support) and regulation of internal resources (e.g. use of positive coping style, resilience) may help individuals resist the impact of crisis events and adjust their homeostasis, thereby improving sleep quality and avoiding the persistent and deterioration of insomnia. Therefore, providing more social support to adolescents after exposure to a special public health emergency, as well as instructing them to adopt positive coping styles through individualized and appropriate intervention may help them improve their sleep quality. For instances, internet cognitive behavior therapy (I-CBT) may be an effective intervention measure to treat insomnia during pandemic lockdown [69].

Several limitations need to be considered in our study. First, due to the rapid development of the COVID-19 pandemic and Chinese government's effective public health measures, the interval between each survey was about 2 months, this short follow-up may limit the understanding of the trajectory of sleep problems. Second, as our

**Table 2**  
Risk and protective factors of insomnia symptoms trajectory groups.

		Non-resis v. Resis	Recov v. Chron
Gender (Male as Ref.)	Female	1.31(1.21,1.42) ***	1.14 (0.91,1.44)
Grade (Freshman as Ref.)	Sophomore	0.97(0.89,1.05)	0.99 (0.78,1.26)
	Junior	1.03(0.94,1.12)	0.82 (0.78,1.26)
	Senior	1.12(1.00,1.26) *	1.00 (0.64,1.05)
	Postgraduate	0.98(0.84,1.14)	1.00 (0.71,1.40)
Residence location (Rural as Ref.)	Urban	1.31(1.22,1.40) ***	1.05 (0.85,1.30)
Only single child status <sup>a</sup>	Yes	1.08(0.99,1.17)	0.85 (0.68,1.30)
History of physical illness <sup>a</sup>	Yes	1.06(0.69,1.63)	0.65 (0.22,1.88)
History of mental illness <sup>a</sup>	Yes	1.16(0.86,1.56)	0.70 (0.41,1.16)
History of sleep problems (Never as Ref.)	Sometimes	<b>3.32</b> <b>(3.10,3.55)***</b>	0.68 (0.50,0.92)*
	Often	<b>11.32</b> <b>(10.22,12.53)***</b>	<b>0.31</b> <b>(0.23,0.41)***</b>
Ever smoking <sup>a</sup>	Yes	1.49(1.29,1.72) ***	1.13 (0.80,1.60)
Ever alcohol use <sup>a</sup>	Yes	1.26(1.18,1.35) ***	0.96 (0.79,1.17)
Confirmed COVID-19 cases in the community or village <sup>a</sup>	Yes	1.33(1.19,1.49) ***	0.95 (0.72,1.26)
Relatives or friends being infected with COVID-19	Confirmed/suspected	0.94(0.71,1.23)	0.90 (0.48,1.67)
Depression at T1 <sup>a</sup>	Yes	<b>2.98</b> <b>(2.67,3.31)***</b>	<b>0.62</b> <b>(0.50,0.78)***</b>
Anxiety at T1 <sup>a</sup>	Yes	<b>1.69</b> <b>(1.42,2.01)***</b>	0.78 (0.59,1.04)
PTS at T1 <sup>a</sup>	Yes	1.37(1.29,1.46) ***	1.13 (0.93,1.36)
Social support at T1 (Low as Ref.)	Medium	0.89(0.82,0.96) **	1.06 (0.85,1.32)
	High	0.74(0.66,0.82) ***	1.25 (0.88,1.77)
Positive coping at T1 (Low as Ref.)	Medium	0.91(0.84,0.98)*	1.11 (0.89,1.37)
	High	0.88(0.80,0.97)*	1.06 (0.78,1.43)
Negative coping at T1 (Low as Ref.)	Medium	1.24(1.14,1.36) ***	0.84 (0.62,1.14)
	High	1.44(1.31,1.59) ***	0.81 (0.59,1.11)
Family function at T2 (Poor as Ref.)	Fair	<b>0.59</b> <b>(0.53,0.65)***</b>	<b>1.60</b> <b>(1.25,2.05)***</b>
	Good	<b>0.44</b> <b>(0.39,0.49)***</b>	<b>2.11</b> <b>(1.57,2.82)***</b>

Note: Data are given as odds ratio (95% confidence interval).

Non-resis = Non-resistance (including all other groups except the resistance group); Resis = resistance group; Relap = relapsing/ remitting group; Recov = recovery group; Delay = delayed dysfunction group; Chron = chronic dysfunction group.

T1 = measured at Time 1; T2 = measured at Time 2.

Bold:  $p < 0.001$  and OR  $> 1.5$  were considered to have scientific and public health significance.

\* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$ .

<sup>a</sup> No as Ref.

investigations of insomnia symptoms were in the form of self-report items, which potentially threatens the validity of the results. The better way to determine insomnia symptoms is to implement clinical diagnostic interviews. Third, a repeated cross-sectional research design used in this survey, so the sample loss rate relatively high, which may lead to selection bias. Fourth, other potential confounding factors were

neglected in the survey, such as sleep medications. Finally, although our sample is large, all participants were originally sampled from colleges/universities in Guangdong province, China. It is uncertain whether our findings could be generalized to general population and other countries.

## 5. Conclusion

In conclusion, this study made a unique contribution to the current literature by examining insomnia symptoms developmental trajectories and related predictors in a large sample of college students during the COVID-19 pandemic. The overall prevalence of insomnia symptoms increased during home quarantine. Gender, grade, residence location, history of sleep problems, smoking, alcohol use, COVID-19 community exposure, mental health status, social support, coping style, and family function were also found to be significant predictors of distinct trajectories for insomnia symptoms occurrence and trajectory membership. These findings could inform mental health professionals regarding how to provide individualized and appropriate intervention for college students post-pandemic.

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## Data availability statement

Proposals to access data from this study can be submitted to the corresponding author and may be made available upon data sharing agreement.

## Ethical approval

Ethical approval was obtained from the Human Research Ethics Committee of South China Normal University, Guangzhou, China.

## Declaration of Competing Interest

No conflict of interest declared.

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