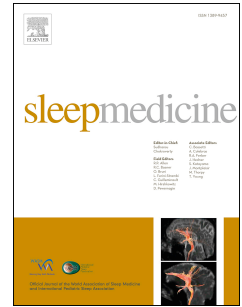


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Shuang-Jiang Zhou, Lei-Lei Wang, Rui Yang, Xing-Jie Yang, Li-Gang Zhang, Zhao-Chang Guo, Jin-Cheng Chen, Jing-Qi Wang, Jing-Xu Chen



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Shuang-Jiang Zhou^{a1}, Lei-Lei Wang^{a1}, Rui Yang^b, Xing-Jie Yang^a, Li-Gang Zhang^a, Zhao-Chang Guo^c,
Jin-Cheng Chen^d, Jing-Qi Wang^e, Jing-Xu Chen^{a*}

^a Beijing HuiLongGuan Hospital, Peking University HuiLongGuan Clinical Medical School, Beijing, China

^b Beijing Anding Hospital, Capital Medical University, Beijing, China

^c The First High School of Juxian, Rizhao, Shandong Province, China

^d The Experimental Middle School of Chengde, Hebei Province, China

^e Binhai Eco-city School-Tianjin Nankai High School, Tianjin, China

* Corresponding author. Beijing HuiLongGuan Hospital, Peking University HuiLongGuan Clinical Medical School, Beijing 10096, China

E-mail address: chenjx1110@163.com

¹ Joint first authors: These two individuals contributed equally to the manuscript.

Abbreviations: COVID-19, coronavirus disease-2019; OR, odds ratio, CI, confidence interval; PSQI, Pittsburgh Sleep Quality Index; PHQ-9, Patient Health Questionnaire; GAD-7, Generalized Anxiety Disorder scale; SARS CoV-2, severe acute respiratory syndrome coronavirus-2; SSRS, Social Support Rate Scale

Abstract

Objective: To assess the prevalence and sociodemographic correlates of insomnia symptoms among Chinese adolescents and young adults affected by the outbreak of coronavirus disease-2019 (COVID-19).

Methods: This cross-sectional study included Chinese adolescents and young adults 12–29 years of age during part of the COVID-19 epidemic period. An online survey was used to collect demographic data, and to assess recognition of COVID-19, insomnia, depression, and anxiety symptoms using the Pittsburgh Sleep Quality Index (PSQI), the Patient Health Questionnaire (PHQ-9), and the Generalized Anxiety Disorder (GAD-7) questionnaires, respectively. The Social Support Rate Scale was used to assess social support.

Results: Among 11,835 adolescents and young adults included in the study, the prevalence of insomnia symptoms during part of the COVID-19 epidemic period was 23.2%. Binomial logistic regression analysis revealed that female sex and residing in the city were greater risk factors for insomnia symptoms. Depression or anxiety were risk factors for insomnia symptoms; however, social support, both subjective and objective, was protective factors against insomnia symptoms. Furthermore, anxiety and depression symptoms were mediators of social support and insomnia symptoms.

Conclusions: Results of this study revealed a high prevalence of sleep problems among adolescents and young adults during the COVID-19 epidemic, especially senior high school and college students, which were negatively associated with students' projections of trends in COVID-19. The adverse impact of COVID-19 was a risk factor for insomnia symptoms; as such, the government must devote more attention to sleep disorders in this patient population while combating COVID-19.

Keywords: Insomnia; COVID-19; Prevalence; Adolescents; Young adults

1. Introduction

Sleep disorders represent an important public health problem, and affect individuals across several age groups, including adolescents and young adults, with severe consequences for both the individual and society. Previous studies have found that insomnia is the most prevalent sleep disorder among adolescents [1-4] and young adults [5]. The prevalence of insomnia symptoms in Chinese adolescents range from 3.4% to 12.2% [6], and the percentage of Chinese young adults experiencing insomnia symptoms is 20.3% [7]. Sleep disorders in adolescents and young adults are characterized by a lack of sleep, difficulty falling asleep, and/or remaining asleep [8].

Insomnia in adolescents and young adults is mainly related to demographic and psychosocial factors. Several studies have reported that insomnia symptoms are more common in girls [9,10] and older adolescents [10]. Stress and poor mental health are important psychosocial factors contributing to insomnia [10,11]. Intensive research has revealed that acute insomnia may be regarded as a physiological response to acute stressors or “threats” [12-15]. Stressful environmental events have been associated with insomnia [15] and, for individuals experiencing stress, research has shown that, to some extent, social support is a helpful resource for coping with stress and an important protective factor in ensuring sleep quality [16-18].

Coronavirus disease-2019 (COVID-19) first emerged in Wuhan, Hubei province, China, on December 31, 2019 and was later declared an international public health emergency by the World Health Organization [19]. COVID-19 has spread to 212 countries/territories outside of China and, the causative virus, severe acute respiratory syndrome coronavirus-2 (SARS CoV-2) has infected 3,018,681 patients globally [20] (82,862 in China [21]) as of April 30, 2020. Because so many individuals and countries have been affected so quickly, it has caused public panic and mental health stress [22]. Many individuals have developed symptoms of anxiety, depression, and insomnia due to COVID-19. However, previous studies have focused primarily on health care workers and adults, and little attention has been devoted to the relationship between mental health status and insomnia symptoms in adolescents and young adults [22-25]. In particular, adolescents and young adults are experiencing complex situations such as school suspension, online classes at home, and reduced activities during the COVID-19 epidemic. Therefore, it is necessary to quickly assess sleep disorders related to

emergencies induced by the epidemic.

The objective of the current study was to assess the prevalence of and factors influencing insomnia symptoms among adolescents and young adults in the Chinese population during part of the COVID-19 outbreak.

2. Material and methods

2.1. Study population and design

The present cross-sectional study was conducted using an online survey to assess mental health problems from March 8 to March 15, 2020. Junior and senior high school students, and college students in China 12–29 years of age were invited to participate in the online survey through the Wenjuanxing platform (<https://www.wjx.cn/app/survey.aspx>). In total, 12,299 participants participated in the survey. After removing individuals who submitted incomplete questionnaires, 11,835 subjects from 21 provinces and autonomous regions were included in the analysis.

Approval for the study was obtained from the Ethics Committee of Beijing HuiLongGuan Hospital (Beijing, China). All subjects provided informed online consent to participate in the study.

2.2. Measurement

A data collection sheet was designed to collect basic sociodemographic information, while student awareness of COVID-19 (including knowledge and projections of future trends in the disease), adverse impact(s) of COVID-19, and insomnia symptoms were assessed using an online survey. The surveys addressing awareness of COVID-19 and its adverse impact(s) asked participants to select responses using a self-administered questionnaire. The self-administered questionnaire mainly includes the following three questions: (1) How well do you know about COVID-19? (2) Do you think COVID-19 has an impact on your normal study and life? (3) Are you optimistic or pessimistic about the development trends of COVID-19? First, subjects were asked about their familiarity with information about prevention and control of COVID-19, with responses ranging from 1 (“very unfamiliar”) to 5 (“very familiar”). Second, subjects were asked about their attitudes toward projections of trends in COVID-19, ranging from 1 (“very pessimistic”) to 5 (“very optimistic”). Third,

subjects were asked whether the COVID-19 epidemic had seriously affected their normal study and life, with responses ranging from 1 (“none”) to 5 (“severe”).

Insomnia symptoms were assessed using the Pittsburgh Sleep Quality Index (PSQI) [7, 26,27]. The PSQI is a self-rated questionnaire that assesses seven components of sleep quality during the previous month: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. A total of 19 items were rated on a scale scored from 0–3 (0, not during the past month; 3, ≥ 3 times a week), with the total PSQI score ranging from 0 to 21 and a global score > 5 indicating poor sleep quality [26,28]. Previous studies have demonstrated that the scale has good reliability and validity in the Chinese adolescent and college population [29,30].

Depression symptoms were assessed using the Patient Health Questionnaire (PHQ-9) [31-34], which consists of nine items. The PHQ-9 is a simple, highly effective, self-assessment tool for depression. Participants are asked to report the presence of nine problems, including depression and declines in interest in the past two weeks on a four-point scale ranging from “nearly every day” (3 points) to “not at all” (0 points) [32,34]. The scores for symptom severity were 5–9 for mild, 10–14 for moderate, 15–19 for moderately severe, and 20–27 for severe. The PHQ-9 has good internal consistency, with a Cronbach’s alpha coefficient of 0.80–0.90 [31-34]. Reliability and validity of the PHQ-9 in the general population, as well as in patients with mental disorders, have been demonstrated [35,36].

Anxiety symptoms were assessed using the Chinese version of the Generalized Anxiety Disorder Scale (GAD-7) [37,38], which measures seven symptoms. Participants were asked how often they were bothered by each symptom during the past two weeks. The response options were “not at all”, “several days”, “more than half the days” and “nearly every day”, and scored as 0, 1, 2, and 3, respectively. The scores for symptom severity were 5–9 for mild, 10–14 for moderate, and 15–21 for severe [37,38]. Good retesting reliability and validity for the GAD-7 have been confirmed in Chinese individuals [39], with a Cronbach’s alpha of 0.90–0.92 [37,40].

Social support was assessed using the Social Support Rate Scale (SSRS) [41,42]. The scale was developed by Xiao Shuiyuan in 1968 and contains 10 items encompassing three dimensions: objective support, subjective support, and use of social support. A higher total

score indicates a higher level of social support. The Cronbach coefficient for the SSRS is 0.89–0.94. The present study mainly evaluated the two dimensions: objective support and subjective support [41,43].

2.3. Statistical analyses

Data were analyzed using SPSS version 24.0 (IBM Corporation, Armonk, NY, USA). The chi-squared test was used to compare sex, age, presence or absence of anxiety, and depression symptoms with the prevalence of insomnia symptoms in junior and high school students, college students, and the total sample. The same method was used to separately compare the incidence of insomnia symptoms in junior and senior high school students, college students, and the overall sample in terms of familiarity with COVID-19 knowledge, predicted/projected trends in COVID-19, and the extent to which individual learning and life was affected by COVID-19. Chi-squared tests were also used to compare the incidence of insomnia symptoms and the distribution of factors related to insomnia symptoms in different groups. At the same time, the incidence of insomnia symptoms and the proportion of insomnia symptom-related factors were calculated in the total sample. Binomial logistic regression was used to analyze the predictors of insomnia symptoms. With versus without insomnia symptoms represented dichotomous dependent variables; the level of statistical significance was set at 0.05 (two-sided).

The SPSS function “PROCESS macro” was used for mediation analysis. According to the results of linear regression, the mediating effect model was as follows: X represented the score of subjective support and objective support, Y represented the total score of PSQI, and M represented the scores of the PHQ-9 and GAD-7 questionnaires. The relationship between independent variables, mediating variables, and dependent variables is presented in the form of plots. Regression coefficients represent the magnitude and direction of the effect on another variable in each model. The bootstrap method was used to test the mediating effect, and the sample size was set to 5000. A 95% confidence interval for indirect effects without zero was statistically significant.

3. Results

A total of 12,299 junior and senior high school, and college students were invited to

participate in the online survey, 11,835 of whom (12–29 years of age [mean age, 17.41 ± 2.70 years]) fulfilled the study inclusion criteria and completed the assessments, corresponding to a response rate of 96.2%. Results revealed that the proportion of men with insomnia symptoms was lower than that of women among junior and senior high school students (15.9% versus [vs.] 20.0%; 22.4% vs. 27.5%, respectively); however, there was no significant difference among college students (Table 1). Among the total study population, the incidence of insomnia symptoms in male students was lower than that in female students. Results of chi-squared testing revealed that the proportion of insomnia symptoms among senior high school and college students in cities was lower than that in rural areas (37.7% vs. 47.5%; 22.4% vs. 27.5%, respectively). Among students with depression symptoms (42.9%), 44.8% experienced insomnia symptoms. Similarly, among students with anxiety symptoms (34.4%), 44.4% experienced insomnia symptoms.

The incidence of insomnia symptoms in students with different levels of COVID-19 knowledge is presented in Figure 1. The lesser the knowledge about COVID-19, the higher the rate of insomnia symptoms among students. The rate of insomnia symptoms in students with different levels of adverse impact from COVID-19 are shown in Figure 2. The more serious the influence of COVID-19 on students' study and life, the higher the incidence of insomnia symptoms. Figure 3 shows the incidence of insomnia symptoms in students with different levels of projections regarding trends in COVID-19. The more optimistic the projections about trends in COVID-19, the lower the rate of insomnia symptoms among students.

As shown in Table 2, 23.2% of the sample experienced insomnia symptoms, with 18.0%, 25.3%, and 25.7% of junior school students, high school students, and college students, respectively, experiencing difficulty in sleeping. The proportions of poor sleep quality, sleep disturbance(s), and use of sleep medication were higher in college students compared with junior and senior school students. Furthermore, the proportion of college students who went to bed after 24:00 was significantly higher than that of junior and senior high school students (43.8% vs. 7.9% and 4.5%, respectively). In addition, the sleep efficiency of college students was the worst, with 27.4% at $< 85\%$. For senior high school students, sleep duration was the worst, and more than one-half of high school students slept < 7 h per night. Daytime dysfunction caused by insomnia was also more prominent in high school students, 59.3% of

whom were affected. However, their sleep efficiency was best, with only 16.7% exhibiting an efficiency $\leq 85\%$. Generally speaking, junior school students slept better; however, the proportion of junior school students who slept > 9 h per night was higher.

Results of binary logistic regression analysis of the factors associated with insomnia symptoms are summarized in Table 3. In the logistic regression model, female sex was a stronger risk factor for insomnia symptoms (odds ratio [OR] 1.301 [95% CI 1.175–1.441]). With regard to the effect on grades, attending senior high school and college were risk factors for insomnia (OR 1.378 [95% CI 1.210–1.568]; OR 2.033 [95% CI 1.768–2.338], respectively). With regard to region, residing in a city was a risk factor for insomnia symptoms (OR 1.183 [95% CI 1.065–1.315]). Depression and anxiety were risk factors for insomnia (OR 6.361 [95% CI 5.599–7.227]; OR 2.059 [95% CI 1.835–2.310], respectively). Projections of trends in COVID-19 were protective factors against insomnia symptoms (OR 0.919 [95% CI 0.875–0.965]). The adverse impact of COVID-19 was a risk factor for insomnia (OR 1.165 [95% CI 1.112–1.222]). Regarding social support, subjective and objective support were protective factors against insomnia symptoms (OR 0.967 [95% CI 0.957–0.978]; OR 0.991 [95% CI 0.988–0.995], respectively).

Linear regression revealed that subjective and objective support were protective factors for insomnia symptoms, anxiety, and depression symptoms, and the total PHQ-9 and GAD-7 scores were risk factors for insomnia symptoms (Supplementary Material 2). As shown in Figure 4 (models 1 and 2), the indirect effects between subjective support, objective support, and PSQI total scores through the mediator (PHQ-9 total score) were significant, suggesting that models 1 and 2 were full mediation models. In models 3 and 4 (using the same format as model 1 and 2 to present the results; see Figure 5), the direct effects were also significant, suggesting that models 3 and 4 had partial mediating effects.

4. Discussion

The present large-scale, cross-sectional epidemiological study revealed that the prevalence of insomnia symptoms in adolescents and young adults in China during part of the COVID-19 epidemic period was 23.2%. Moreover, the prevalence of insomnia symptoms among senior high school and college students was higher. The prevalence of insomnia symptoms in adolescents was higher than that in the United States (9.4%) in the absence of epidemics [44]. The percentage of insomnia symptoms in young adults (25.7%) has been reported to be

higher than the incidence reported for the general population in China (18.3–23.6%) in the absence of epidemics [7,45].

Results of analysis revealed that, during part of the COVID-19 epidemic, college students were more likely to experience declines in sleep quality, increased sleep times, later bedtimes, and sleep disturbances. Previous studies have reported that college students have poor sleep habits [46], and the COVID-19 epidemic has further worsened sleep habits by allowing college students to have more hours free from school. Poor sleep habits, such as staying up late due to increased mobile phone use, playing online games, and online shopping, also lead to decreased sleep hygiene/quality, prolonged sleep latency, and shorter sleep time, which is consistent with previous studies [9,47]. Among these, a small number of college students need to use sleep medication to regulate sleep.

Regarding senior high school students, the percentage of insomnia symptoms was also higher (25.3%), which was higher than that in the students without COVID-19 in China or other countries [6]. Stress during academic examination season is known to compromise sleep quality in students [48], and senior high school students in China have a heavy academic burden. In particular, third-grade senior school students are facing college entrance examinations [49]. As a result of the COVID-19 epidemic, they cannot go to school normally, and college entrance examinations were also forced to be postponed. These problems can easily lead to sleep disorders. More than one-half of senior high school students (50.1%) had insufficient sleep (< 7 h per night), which was especially higher than college and junior high school students. In addition, sleep time was also generally later for senior high school students, with 80.4% going to sleep between 22:00 to 24:00. Less sleep and later sleep times lead to a decline in student daytime function, which also has an impact on learning efficiency and academic achievement [50,51]. Therefore, we should devote attention to sleep disorders among senior high school students. It should be ensured that they have sufficient rest and sleep time so that they can be in a good position to study during the daytime.

Moreover, insomnia was strongly associated with female sex. Previous studies have also shown that among those with insomnia, females predominated [44,52]. Anxiety and depression symptoms are risk factors for insomnia. As we know, there is a correlation and a cyclical relationship between anxiety, depression and insomnia. Anxiety and depression are risk factors for insomnia [53,54]. Many patients with anxiety disorders and depression are accompanied by insomnia, and some patients with anxiety disorders and depression disorder

even suffer from co-morbid insomnia [55]. And in a lot of insomnia sufferer, are also co-morbid with anxiety, depressed disorder [56]. In addition, the comorbidity rate of anxiety and depression symptoms and insomnia has been relatively high. Studies have shown that sleep problems are common in individuals with anxiety and depression [57,58]. Some studies also suggest that persistent insomnia may be a risk factor for anxiety and depression disorder [59]. During the COVID-19 epidemic, many people (including adolescents and young adults) had symptoms of anxiety and depression [23], which exacerbated the symptoms of insomnia. In addition, prolonged insomnia can also lead to increased anxiety and depression symptoms, so it is important to pay attention to students' psychological problems and insomnia symptoms during the COVID-19 epidemic. In addition, the proportion of anxiety and depression in the female population was higher [25,60,61], which also aggravated insomnia symptoms. Students residing in cities were more likely to experience insomnia, which was consistent with previous research [62].

The COVID-19 epidemic has had a significant impact and is a risk factor for insomnia [24]. It has disrupted the normal learning and living conditions of students and affected their sleep hygiene [23]. However, a positive and optimistic attitude toward the COVID-19 epidemic can reduce insomnia. Therefore, students should endeavor to gain more knowledge about COVID-19 and increase their confidence in fighting the disease.

As most provinces and cities in China are currently determining school re-opening times, sleep problems may be partially alleviated. Therefore, we suggest that teachers devote attention to students' sleep problems after schools open again. For students experiencing insomnia symptoms, we should actively promote counseling and intervention. Students who have not yet started school can survey their sleep status online in the form of a questionnaire at the same time as online classes.

In addition, our research has shown that good social support (subjective and objective support) can reduce insomnia symptoms as well as indirectly reduce insomnia symptoms by reducing anxiety and depression symptoms. Previous studies have reported similar results [18]. Therefore, it is particularly important for parents, teachers, and other social groups to provide support to students during the COVID-19 outbreak to reduce insomnia symptoms. We can also provide some sleep knowledge and videos of sleep intervention through mobile phones or computers, such as relaxation training and cognitive behavioral therapy for

insomnia, to alleviate or relieve insomnia symptoms [63]. COVID-19 remains widespread around the world. To date, nearly 3.0 million people globally have been infected with SARS CoV-2 [20]. Most of the world's schools are not open; as such, this may be an opportunity to devote attention to sleep problems.

This study had three limitations. First, possible bias could have led to the underestimation of the prevalence of insomnia symptoms. This sample was a non-probability sample, which is a sample of voluntary participants. For some areas with a severe epidemic, insomnia rates may be higher. However, due to the influence of anxiety and depression, students may not be willing to participate in a questionnaire survey [64], and there may be a certain deviation in the response population. Second, because the online questionnaire was a self-administered evaluation, the indicated levels of insomnia symptoms may not always be consistent with the evaluations of mental health professionals. Third, there were differences in the proportion of men and women in the study. Female students accounted for a relatively large proportion. The relatively high proportion of female students is mainly caused by the imbalance between male and female students in schools. In China, the proportion of female students in both high schools and universities is higher than that of male students on the whole, and the imbalance between male and female students among college students is more prominent. This is also the reason why the proportion of female students in this study is much higher than that of male students. Notably, this is also the limitation of this study, Gender matching should be carried out in future studies [65].

5. Conclusions

Results of the present study revealed a high prevalence of sleep problems among adolescents and young adults during part of the COVID-19 epidemic, especially among senior high school and college students, which were negatively associated with the level projection in trends in COVID-19. We have also found that social support can alleviate or reduce symptoms of insomnia by reducing symptoms of anxiety and depression, so parents, school organizations, and other groups should provide some social support to adolescents and young adults during the COVID-19 outbreak. These findings also suggest that the government needs to devote more attention to sleep problems among adolescents and young adults while combating COVID-19. Fortunately, the Chinese government has provided psychological

health services through various channels, including hotlines, online consultation, and outpatient consultations [66]. Nevertheless, more attention should be devoted to sleep disorders, especially among senior high school and college students.

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References

- [1] Johnson EO, Roth T, Schultz L, Breslau N. Epidemiology of DSM-IV insomnia in adolescence: lifetime prevalence, chronicity, and an emergent gender difference. *Pediatrics*. 2006;117:e247-56.
- [2] Kaneita Y, Ohida T, Osaki Y, Tanihata T, Minowa M, Suzuki K, et al. Insomnia among Japanese adolescents: a nationwide representative survey. *Sleep*. 2006;29:1543-50.
- [3] Roberts RE, Roberts CR, Duong HT. Chronic insomnia and its negative consequences for health and functioning of adolescents: a 12-month prospective study. *J Adolesc Health*. 2008;42:294-302.
- [4] Amaral MO, de Figueiredo Pereira CM, Silva Martins DI, de Serpa Cdo R, Sakellarides CT. Prevalence and risk factors for insomnia among Portuguese adolescents. *Eur J Pediatr*. 2013;172:1305-11.
- [5] Amaral AP, Soares MJ, Pinto AM, Pereira AT, Madeira N, Bos SC, et al. Sleep difficulties in college students: The role of stress, affect and cognitive processes. *Psychiatry Res*. 2018;260:331-7.
- [6] Zhang J, Chan NY, Lam SP, Li SX, Liu Y, Chan JW, et al. Emergence of Sex Differences in Insomnia Symptoms in Adolescents: A Large-Scale School-Based Study. *Sleep*. 2016;39:1563-70.
- [7] Li L, Wang YY, Wang SB, Zhang L, Li L, Xu DD, et al. Prevalence of sleep disturbances in Chinese university students: a comprehensive meta-analysis. *J Sleep Res*. 2018;27:e12648.
- [8] Yang CM, Wu CH, Hsieh MH, Liu MH, Lu FH. Coping with sleep disturbances among young adults: a survey of first-year college students in Taiwan. *Behav Med*. 2003;29:133-8.
- [9] Hysing M, Pallesen S, Stormark KM, Lundervold AJ, Sivertsen B. Sleep patterns and insomnia among adolescents: a population-based study. *J Sleep Res*. 2013;22:549-56.
- [10] Liu X, Uchiyama M, Okawa M, Kurita H. Prevalence and correlates of self-reported sleep problems among Chinese adolescents. *Sleep*. 2000;23:27-34.
- [11] Zhang SC, Yang R, Li DL, Wan YH, Tao FB, Fang J. Association of health literacy and sleep problems with mental health of Chinese students in combined junior and senior high school. *PLoS One*. 2019;14:e0217685.
- [12] Ellis JG, Gehrman P, Espie CA, Riemann D, Perlis ML. Acute insomnia: current conceptualizations and future directions. *Sleep Med Rev*. 2012;16:5-14.
- [13] McNamara P AS. *Evolutionary Medicine of Sleep Disorders: Toward a Science of Sleep Duration*. New York, NY: Cambridge University Press. 2010.
- [14] Riemann D, Spiegelhalder K, Feige B, Voderholzer U, Berger M, Perlis M, et al. The hyperarousal model of insomnia: a review of the concept and its evidence. *Sleep Med Rev*. 2010;14:19-31.
- [15] Nunn CL, Samson DR, Krystal AD. Shining evolutionary light on human sleep and sleep disorders. *Evol Med Public Health*. 2016;2016:227-43.

- [16] Geng F, Fan F, Mo L, Simandl I, Liu X. Sleep problems among adolescent survivors following the 2008 Wenchuan earthquake in China: a cohort study. *J Clin Psychiatry*. 2013;74:67-74.
- [17] Matsumoto S, Yamaoka K, Inoue M, Inoue M, Muto S. Implications for Social Support on Prolonged Sleep Difficulties among a Disaster-Affected Population: Second Report from a Cross-Sectional Survey in Ishinomaki, Japan. *PLoS One*. 2015;10:e0130615.
- [18] Nursalam N, Octavia M, Tristiana RD, Efendi F. Association between insomnia and social network site use in Indonesian adolescents. *Nurs Forum*. 2019;54:149-56.
- [19] WH O. WHO Director-General's statement on IHR Emergency Committee on Novel Coronavirus (2019-nCoV).
[https://www.who.int/dg/speeches/detail/who-director-general-s-statement-on-ihr-emergency-committee-on-novel-coronavirus-\(2019-ncov\)](https://www.who.int/dg/speeches/detail/who-director-general-s-statement-on-ihr-emergency-committee-on-novel-coronavirus-(2019-ncov)). 2020.
- [20] WH O. Coronavirus disease 2019 (COVID-19) Situation Report – 100.
https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200429-sitrep-100-covid-19pdf?sfvrsn=bbfbf3d1_6 Accessed 30 April 2020. 2020.
- [21] NHCotPsRo C. Latest Situation Report of Coronavirus disease 2019 (COVID-19).
<http://www.nhc.gov.cn/xcs/yqfkdt/202004/ce78f5575e0d4ef0b4543eb072acebc3shtml> Accessed 30 April 2020. 2020.
- [22] Bao Y, Sun Y, Meng S, Shi J, Lu L. 2019-nCoV epidemic: address mental health care to empower society. *Lancet*. 2020;395:e37-e8.
- [23] Wang C, Pan R, Wan X, Tan Y, Xu L, Ho CS, et al. Immediate Psychological Responses and Associated Factors during the Initial Stage of the 2019 Coronavirus Disease (COVID-19) Epidemic among the General Population in China. *Int J Environ Res Public Health*. 2020;17.
- [24] Zhang C, Yang L, Liu S, Ma S, Wang Y, Cai Z, et al. Survey of Insomnia and Related Social Psychological Factors Among Medical Staff Involved in the 2019 Novel Coronavirus Disease Outbreak. *Front Psychiatry*. 2020;11:306.
- [25] Zhou SJ, Zhang LG, Wang LL, Guo ZC, Wang JQ, Chen JC, et al. Prevalence and socio-demographic correlates of psychological health problems in Chinese adolescents during the outbreak of COVID-19. *Eur Child Adolesc Psychiatry*. 2020.
- [26] Buysse DJ, Reynolds CF, 3rd, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry Res*. 1989;28:193-213.
- [27] Mah CD, Kezirian EJ, Marcello BM, Dement WC. Poor sleep quality and insufficient sleep of a collegiate student-athlete population. *Sleep Health*. 2018;4:251-7.

- [28] Sing CY, Wong WS. Prevalence of insomnia and its psychosocial correlates among college students in Hong Kong. *J Am Coll Health*. 2010;59:174-82.
- [29] Wang Y YC, Yang XT, Li QQ, He XG, Zheng KJ, Yi M. Reliability and validity of Pittsburgh sleep quality index in adolescents with myopia. *Modern Preventive Medicine*. 2019;46:1062-9.
- [30] Liu XC TM, Hu L, Wang AZ, Wu HX, Zhao GF, Gao CN, Li WS. Reliability and validity of the Pittsburgh sleep quality index. *Chinese journal of psychiatry*. 1996;29:103-7.
- [31] Spitzer RL, Kroenke K, Williams JB. Validation and utility of a self-report version of PRIME-MD: the PHQ primary care study. *Primary Care Evaluation of Mental Disorders. Patient Health Questionnaire*. *Jama*. 1999;282:1737-44.
- [32] Kroenke K, Spitzer RL, Williams JB. The PHQ-9: validity of a brief depression severity measure. *J Gen Intern Med*. 2001;16:606-13.
- [33] Wittkamp KA, Naeije L, Schene AH, Huyser J, van Weert HC. Diagnostic accuracy of the mood module of the Patient Health Questionnaire: a systematic review. *Gen Hosp Psychiatry*. 2007;29:388-95.
- [34] Levis B, Benedetti A, Thombs BD. Accuracy of Patient Health Questionnaire-9 (PHQ-9) for screening to detect major depression: individual participant data meta-analysis. *Bmj*. 2019;365:11476.
- [35] Wang W, Bian Q, Zhao Y, Li X, Wang W, Du J, et al. Reliability and validity of the Chinese version of the Patient Health Questionnaire (PHQ-9) in the general population. *Gen Hosp Psychiatry*. 2014;36:539-44.
- [36] Zhang YL, Liang W, Chen ZM, Zhang HM, Zhang JH, Weng XQ, et al. Validity and reliability of Patient Health Questionnaire-9 and Patient Health Questionnaire-2 to screen for depression among college students in China. *Asia Pac Psychiatry*. 2013;5:268-75.
- [37] Spitzer RL, Kroenke K, Williams JB, Löwe B. A brief measure for assessing generalized anxiety disorder: the GAD-7. *Arch Intern Med*. 2006;166:1092-7.
- [38] Xu WF PY, Chen BQ, Peng ZY, Zhao JL, Yu GL. Assessment of Anxiety and Depression by Self-rating Scales of GAD-7 and PHQ-9 in Cardiovascular Outpatients. *World Latest Medicine Information*. 2018;18:12-4 (In Chinese).
- [39] He XY LC QJ, et al. Reliability and validity of a generalized anxiety scale in general hospital outpatients. *Shanghai Archives of Psychiatry*. 2010;22:200-3 (In Chinese).
- [40] Beck AT, Guth D, Steer RA, Ball R. Screening for major depression disorders in medical inpatients with the Beck Depression Inventory for Primary Care. *Behav Res Ther*. 1997;35:785-91.
- [41] Xiao Shuiyuan YD. The Influence of Social Support on Physical and Mental Health. *Chinese Mental Health Journal*. 1987;1:183-7.
- [42] Xiao H, Zhang Y, Kong D, Li S, Yang N. The Effects of Social Support on Sleep Quality of Medical

Staff Treating Patients with Coronavirus Disease 2019 (COVID-19) in January and February 2020 in China. *Med Sci Monit.* 2020;26:e923549.

[43] Wang XD WX, Ma H. Beijing: China Journal of Mental Health Press. Rating scales for mental health. 1999:127-30.

[44] de Zambotti M, Goldstone A, Colrain IM, Baker FC. Insomnia disorder in adolescence: Diagnosis, impact, and treatment. *Sleep Med Rev.* 2018;39:12-24.

[45] Jiang XL, Zheng XY, Yang J, Ye CP, Chen YY, Zhang ZG, et al. A systematic review of studies on the prevalence of insomnia in university students. *Public Health.* 2015;129:1579-84.

[46] Sivertsen B, Øverland S, Pallesen S. Trends in timing of sleep in the general population of Norway: 1980 to 20001. *Percept Mot Skills.* 2011;113:509-18.

[47] Gellis LA, Park A, Stotsky MT, Taylor DJ. Associations between sleep hygiene and insomnia severity in college students: cross-sectional and prospective analyses. *Behav Ther.* 2014;45:806-16.

[48] Zunhammer M, Eichhammer P, Busch V. Sleep quality during exam stress: the role of alcohol, caffeine and nicotine. *PLoS One.* 2014;9:e109490.

[49] Yuan F LZ, Yang YL, Mou Y. Prevalence of anxiety tested with Test Anxiety Scale(TAS) in senior three students: a Meta-analysis. *Chin J Sch Health.* 2018;39:1324-8 (In Chinese).

[50] Chan CS, Poon CYS, Leung JCY, Lau KNT, Lau EYY. Delayed school start time is associated with better sleep, daytime functioning, and life satisfaction in residential high-school students. *J Adolesc.* 2018;66:49-54.

[51] Kim SK, Kim JH, Jeon SS, Hong SM. Relationship between sleep quality and dizziness. *PLoS One.* 2018;13:e0192705.

[52] Perogamvros L, Castelnovo A, Samson D, Dang-Vu TT. Failure of fear extinction in insomnia: An evolutionary perspective. *Sleep Med Rev.* 2020;51:101277.

[53] Jansson M LS. The role of anxiety and depression in the development of insomnia: Cross-sectional and prospective analyses. *Psychology & Health* 2006;21:383-97.

[54] Lin RM XS, Yan YW, et al. Intolerance of uncertainty and adolescent sleep quality: The mediating role of worry. *Personality & Individual Differences.* 2017;108:168-73.

[55] Taylor DJ, Lichstein KL, Durrence HH. Insomnia as a health risk factor. *Behav Sleep Med.* 2003;1:227-47.

[56] Harvey AG. A transdiagnostic approach to treating sleep disturbance in psychiatric disorders. *Cogn Behav Ther.* 2009;38 Suppl 1:35-42.

[57] Benca RM, Peterson MJ. Insomnia and depression. *Sleep Med.* 2008;9 Suppl 1:S3-9.

- [58] Li YI, Starr LR, Wray-Lake L. Insomnia mediates the longitudinal relationship between anxiety and depressive symptoms in a nationally representative sample of adolescents. *Depress Anxiety*. 2018;35:583-91.
- [59] Baglioni C, Battagliese G, Feige B, Spiegelhalder K, Nissen C, Voderholzer U, et al. Insomnia as a predictor of depression: a meta-analytic evaluation of longitudinal epidemiological studies. *J Affect Disord*. 2011;135:10-9.
- [60] Lim GY, Tam WW, Lu Y, Ho CS, Zhang MW, Ho RC. Prevalence of Depression in the Community from 30 Countries between 1994 and 2014. *Sci Rep*. 2018;8:2861.
- [61] Putwain DW. Test anxiety in UK schoolchildren: prevalence and demographic patterns. *Br J Educ Psychol*. 2007;77:579-93.
- [62] Zhai K, Gao X, Wang G. The Role of Sleep Quality in the Psychological Well-Being of Final Year Undergraduate Students in China. *Int J Environ Res Public Health*. 2018;15.
- [63] Yang Y, Luo X, Paudel D, Zhang J, Li SX, Zhang B. Effects of e-aid cognitive behavioural therapy for insomnia (eCBTI) to prevent the transition from episodic insomnia to persistent insomnia: study protocol for a randomised controlled trial. *BMJ Open*. 2019;9:e033457.
- [64] Allgulander C. Psychoactive drug use in a general population sample, Sweden: correlates with perceived health, psychiatric diagnoses, and mortality in an automated record-linkage study. *Am J Public Health*. 1989;79:1006-10.
- [65] Zhang HZ ZX. The View Summary of College Students' Sex Ratio. *Journal of Higher Education in Science & Technology*. 2009;28:16-8.
- [66] NHCotPsRo C. Guideline for psychological crisis intervention during 2019-nCoV. http://www.gov.cn/xinwen/2020-01/27/content_5472433.htm. 2020.

Table 1

Socio-demographic characteristics, depression symptoms, anxiety symptoms and associations with insomnia symptoms (N = 11,835).

Variables	Junior high school		Senior high school		College		Total	
	No. (%)	Insomnia	No. (%)	Insomnia	No. (%)	Insomnia	No. (%)	Insomnia
	n (%)	<i>P</i>	n (%)	<i>P</i>	n (%)	<i>P</i>	n (%)	<i>P</i>
Sex		0.001		<0.001		0.16		<0.001
Male	1757(49.1)	279(15.9)	1818(43.8)	407(22.4)	1434(35.0)	350(24.4)	5009(42.3)	1036(20.7)
Female	1830(51.0)	366(20.0)	2331(56.2)	641(27.5)	2665(65.0)	740(26.4)	6826(57.7)	1711(25.1)
Region		0.706		0.002		0.016		0.185
City	1611(44.9)	294(18.2)	1339(32.3)	298(22.3)	1286(31.4)	362(28.1)	4236(35.8)	954(22.5)
Rural area	1976(51.0)	351(17.8)	2810(67.7)	750(26.7)	2813(68.6)	692(24.6)	7599(64.2)	1793(23.6)
Depression		<0.001		<0.001		<0.001		<0.001
Yes	1403(39.1)	534(38.1)	2069(49.9)	940(45.4)	1605(39.2)	801(49.9)	5077(42.9)	2275(44.8)
No	2184(60.9)	111(5.1)	2080(50.1)	108(5.2)	2494(60.8)	253(10.1)	6758(57.1)	472(7.0)
Anxiety		<0.001		<0.001		<0.001		<0.001
Yes	1261(35.2)	441(35.0)	1701(41.0)	769(45.2)	1112(27.1)	600(54.0)	4074(34.4)	1810(44.4)
No	2326(64.8)	204(8.8)	2448(59.0)	279(11.4)	2987(72.9)	454(15.2)	7761(65.6)	937(12.1)

Table 2

The incidence rate and patterns of insomnia symptoms (N = 11,835).

Variables	Junior high school		Senior high school		College		P	Total	
	n	(%)	n	(%)	n	(%)		n	(%)
Insomnia	645	18.0 ^{bc}	1048	25.3 ^a	1054	25.7 ^a	<0.001	2747	23.2
Subjective sleep quality							<0.001		
Excellent	1793	49.9 ^{bc}	1694	40.8 ^{ac}	1585	38.7 ^{ab}		5072	42.8
Good	1493	41.6 ^{bc}	1945	46.9 ^a	1925	47.0 ^a		5363	45.3
Bad	254	7.1 ^{ab}	436	10.5 ^{ac}	515	12.6 ^{bc}		1205	10.2
Poor	53	1.5	75	1.8	74	1.8		202	1.7
Sleep latency							<0.001		
≤ 15 minutes	2069	57.7 ^c	2390	57.6 ^c	2076	50.6 ^{ab}		6535	55.2
16–30 minutes	1167	32.5 ^c	1399	33.7 ^c	1538	37.5 ^{ab}		4104	34.7
31–60 minutes	251	7.0 ^c	280	6.7 ^c	349	8.5 ^{ab}		880	7.4
≥ 60 minutes	100	2.8 ^b	80	1.9 ^{ac}	135	3.3 ^b		316	2.7
Sleep duration (hours)							<0.001		
No more than 7	816	22.7 ^{bc}	2080	50.1 ^{ac}	1134	27.7 ^{ab}		4030	34.0
Greater than 7 and not greater than 9	2385	66.4 ^{bc}	1949	47.0 ^{ac}	2592	63.2 ^{ab}		6926	58.5
More than 9	392	10.9 ^{bc}	373	2.9 ^{ac}	373	9.1 ^{ab}		886	7.5
Sleep efficiency	837	23.3 ^{bc}	691	16.7 ^{ac}	164	27.4 ^{ab}		2651	22.4
Bedtime							<0.001		
Before 22 o'clock	1208	33.8 ^{bc}	286	6.9 ^{ac}	164	4.0 ^{ab}		1658	14.0
Greater than or equal to 22 o'clock and less than 24	2087	58.3 ^{bc}	3325	80.4 ^{ac}	2138	52.2 ^{ab}		7550	63.9
No less than 24 o'clock	282	7.9 ^{bc}	527	4.5 ^{ac}	1797	43.8 ^{ab}		2606	22.1
Sleep disturbance	1880	52.3 ^{bc}	2403	57.9 ^{ac}	2731	66.6 ^{ab}	<0.001	7015	59.2
Used sleep medication	23	0.6 ^{bc}	61	1.5 ^{ac}	99	2.4 ^{ab}	<0.001	183	1.5
Daytime dysfunction	1602	44.6 ^{bc}	2463	59.3 ^{ac}	2277	55.6 ^{ab}	<0.001	6342	53.6

^a Compared with junior high school, $P < 0.05$ ^b Compared with senior high school, $P < 0.05$ ^c Compared with college, $P < 0.05$

Table 3

Binary regression analyses of the factors associated with insomnia (N = 11,835).

Variables	B	SE	OR	95%CI	P
Gender					
Male			1		
Female	0.263	0.052	1.301	1.175–1.441	<0.001
Institution					
Junior high school			1		
Senior high school	0.320	0.066	1.378	1.210–1.568	<0.001
College	0.710	0.071	2.033	1.768–2.338	<0.001
Region					
Rural area			1		
City	0.168	0.054	1.183	1.065–1.315	0.002
Depression					
No			1		
Yes	1.850	0.065	6.361	5.599–7.227	<0.001
Anxiety					
No			1		
Yes	0.722	0.059	2.059	1.835–2.310	<0.001
COVID-19 knowledge	-0.013	0.02	0.987	0.964–1.010	0.255
Adverse impact of COVID-19	0.153	0.024	1.165	1.112–1.222	<0.001
Projections of COVID-19 trend	-0.085	0.025	0.919	0.875–0.965	0.001
Subjective support	-0.033	0.005	0.967	0.957–0.978	<0.001
Objective support	-0.009	0.002	0.991	0.988–0.995	<0.001

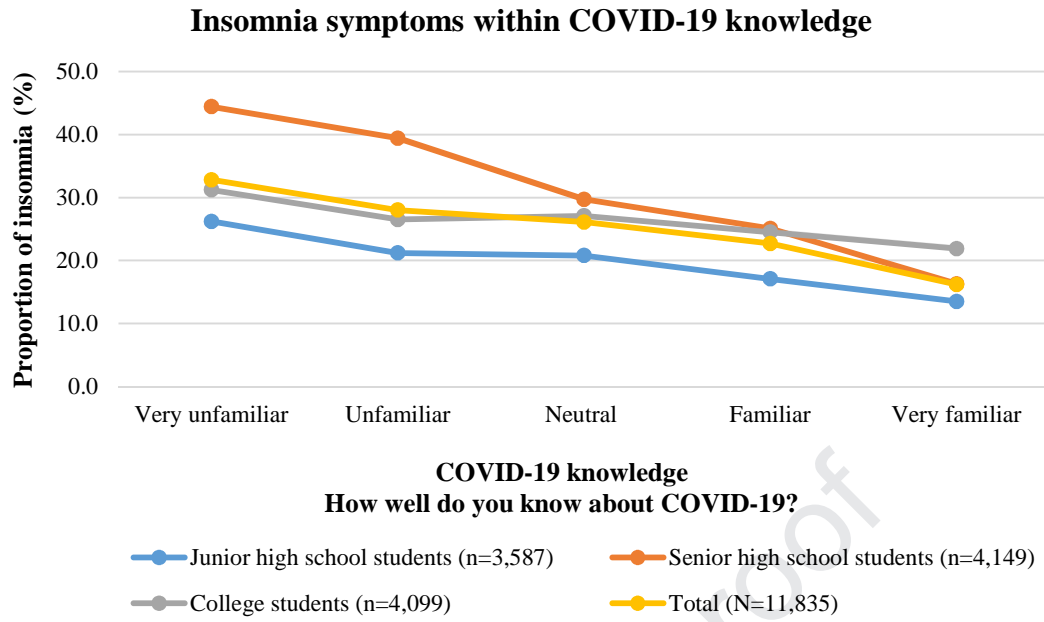


Figure 1. The incidence of insomnia symptoms in students with different levels of COVID-19 knowledge (N = 11,835).

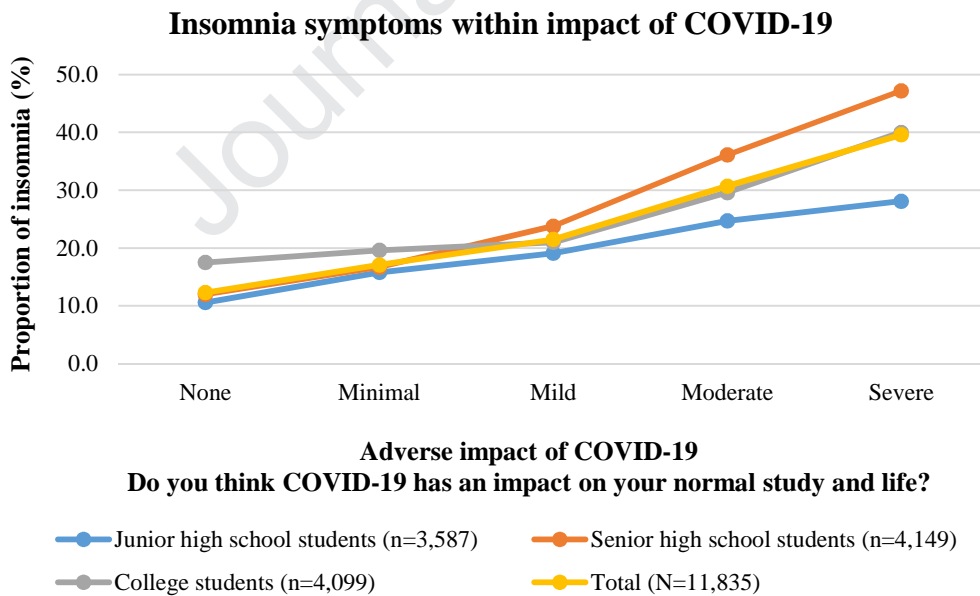


Figure 2. The incidence of insomnia symptoms in students with different levels of adverse impact of COVID-19 (N = 11,835).

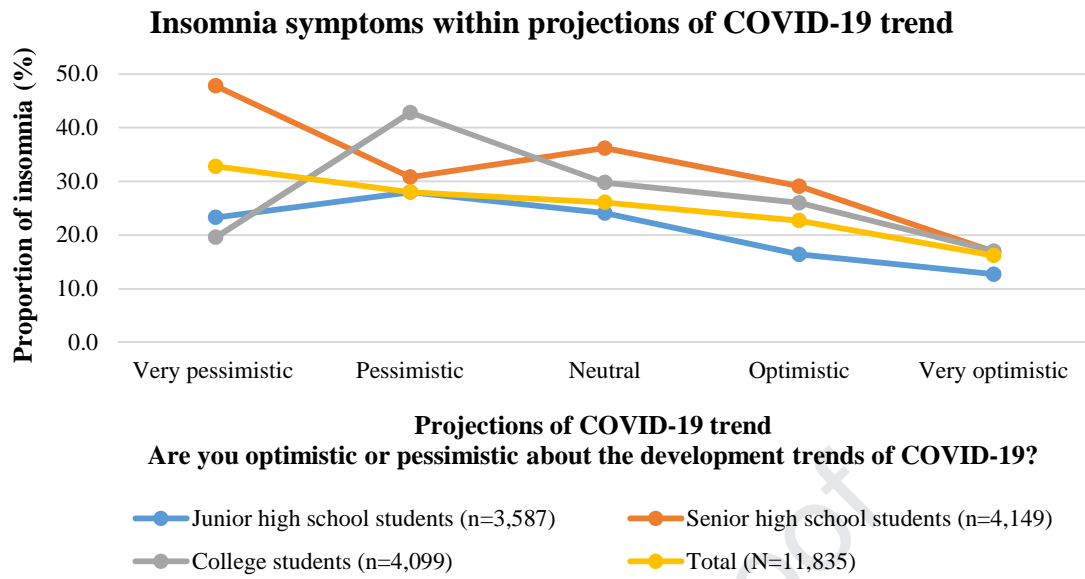


Figure 3. The incidence of insomnia symptoms in students with different levels of projections of COVID-19 trend (N = 11,835).

(All the figures above need to be printed in color.)

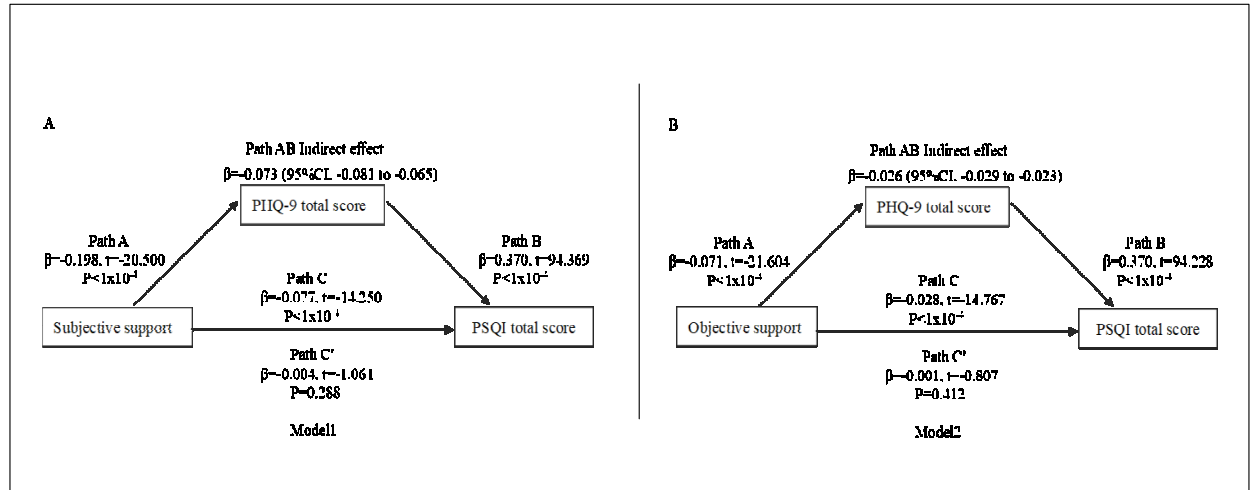


Figure 4. A shows model 1 path diagram of the mediation model (X=subjective support; Y= PSQI total score). Path C represent the variance in subjective support associated with PSQI total score. Path C' represent the association between subjective support and PSQI total score after taking into account PHQ-9 total scores. B shows model 2 path diagram of the mediation model (X=subjective support; Y= PSQI total score). Path C represent the variance in subjective support associated with PSQI total score. Path C' represent the association between subjective support and PSQI total score after taking into account GAD-7 total scores. Path AB is the mediation effect and is significant at $P < 0.05$ based on 95% CI from bias-corrected bootstrapping of 5000 samples.

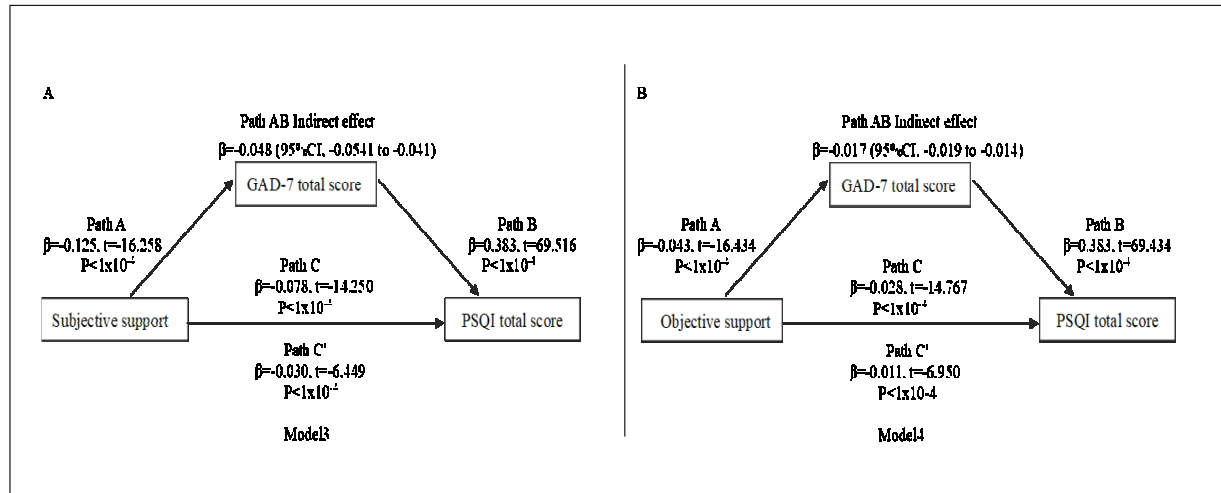


Figure 5. A shows model 3 path diagram of the mediation model (X=subjective support; Y= PSQI total score). Path C represent the variance in subjective support associated with PSQI total score. Path C' represent the association between subjective support and PSQI total score after taking into account PHQ-9 total scores. B shows model 4 path diagram of the mediation model (X=subjective support; Y= PSQI total score). Path C represent the variance in objective support associated with PSQI total score. Path C' represent the association between objective support and PSQI total score after taking into account GAD-7 total scores. Path AB is the mediation effect and is significant at $P < 0.05$ based on 95% CI from bias-corrected bootstrapping of 5000 samples.

Highlights

An online survey was used to conduct rapid assessment during the COVID-19 epidemic.

Sleep problems among adolescents and young adults were negatively associated with the level of projections of COVID-19 trend.

Social support (including subjective support and objective support) was a protective factor for insomnia symptoms.

Anxiety and depression symptoms were mediators between social support and insomnia symptoms.

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Authors' contributions

Shuang-Jiang Zhou and Lei-lei Wang were involved in interpretation of data and drafted the paper. Jing-Xu Chen conceived and designed the study. Lei-lei Wang did statistical analysis. Data acquisition: Shuang-Jiang Zhou, Rui Yang, Xing-jie Yang, Li-Gang Zhang, Zhao-Chang Guo, Jin-Cheng Chen, Jing-Qi Wang. All the authors have revised the manuscript for important intellectual content and have read and approved the final manuscript.

Conflict of interest

All authors declare no competing financial interest.

Availability of data and materials

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Ethics approval and consent to participate

Ethics Committee of Beijing HuiLongGuan Hospital approved the study.