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The Influencing Factors of Sleep Quality Among Chinese Junior and Senior High School Adolescents During the COVID-19 Pandemic

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ABSTRACT

Background: Since coronavirus disease 2019 (COVID-19) outbreak, its terrible infectiousness has caused great panic, anxiety and poor sleep quality to the vulnerable adolescent populations.
Methods: This cross-sectional online survey recruited 10 569 Chinese junior and senior high school adolescents during 31 January to 9 February 2020. Basic socio-demographic information, Pittsburgh Sleep Quality Index (PSQI), Self-rating Anxiety Scale (SAS) and Fear of negative evaluation (FNE) were included in the survey. The χ^2 and logistic regression analyses were used to identify factors correlated with poor sleep quality.
Results: The prevalence of poor sleep quality was 18.6% in the Chinese adolescent population. The average score of PSQI was 3.39 (SD = 2.64), which was significantly correlated with scores for anxiety ($r = 0.50$, $p < 0.01$), and FNE ($r = 0.36$, $p < 0.01$). Adjusted logistic regression indicated that gender (females) and education (senior high school) were associated with poor sleep quality, while living in Hubei Province and time spent on the COVID-19 information were inversely associated with poor sleep quality. Having a family member or friend infected/suspected and spending time on electronics were associated with higher odds of having poor sleep quality. Adolescents with anxiety were 8 times, and those with FNE were three times more likely than ones without anxiety or FNE to have poor sleep quality. In addition, the number of meals, exercise time and diet quality were also significantly associated with sleep quality. ($p < 0.05$).

Conclusions: Poor sleep quality was common during the COVID-19 pandemic in Chinese adolescents. Understanding several factors associated with the poor sleep quality will offer some important insights into determining potential interventions to improve sleep quality during the COVID-19 pandemic.

INTRODUCTION

Adolescence is a critical period of transition in the life span, which is characterized by tremendous changes and growth [1]. Sleep is indispensable for the growth and development of adolescents and it is also necessary for maintaining their physical and psychological health [1]. According to the previous studies, prevalence of poor sleep quality in adolescents ranged from 3.4% to 40% in various countries [2, 3]. While, the prevalence of poor sleep quality in Chinese adolescent ranged from 3.4% to 25.7% [4, 5] before the COVID-19 pandemic. Compared with Chinese adolescents with good sleep quality, those with poor sleep quality were more likely to be girls, city residence, victims of bullying, with unstable personality, senior grades, with high academic pressure, lonely, anxious and depressed [4, 5]. The sleep theme of adolescents with poor sleep includes difficulties falling asleep, restless sleep, mid-sleep awakening for several times and waking up too early [1–5].

Adolescents, who are going through an immature psychological developing period, are easily affected by external adverse factors, especially the public health emergencies [6, 7]. The emergence of COVID-19 pandemic has exacerbated anxiety globally [7]. Recent studies have shown an increased prevalence of mental health disorders; such as anxiety, depression and post-traumatic stress symptoms with the rapid spread of and lock down caused by COVID-19 [8–10]. Among the various emergency measures taken to limit the COVID-19 outbreak, the temporary closure of schools and keeping the students at home, rendered lifestyle changes such as stopping the usual daily activities and spending more time on electronics [11]. Such lifestyle changes may bear risk to the adolescent physical and psychological health by hindering peer relationships and depriving opportunities for stress regulation [11]. However, since the morbidity and mortality of COVID-19 infection were lower in adolescents than in adults [12], the previous studies primarily focused on the mental and sleep outcomes associated with COVID-19 among the adult population [13], especially the health care medical staff [14], with insufficient attention on the adolescents' sleep quality [6, 7]. Therefore, it is necessary to timely evaluate adolescents' sleep quality and the related factors induced by the pandemic.

This study seeks to evaluate the prevalence and influencing factors of poor sleep quality among adolescents in junior and senior high schools during the COVID-19 pandemic, which could be helpful to screen the poor sleep quality among adolescents and explore potential interventions in the current or future pandemics.

METHODS

Data collection and participants

By the convenience sampling method, an online cross-sectional survey that recruited 10 569 participants from 32 provinces of China was conducted through the WenJuanxing platform, a large ecommerce and information service platform that provides online health products and services in China (https://www.wjx.cn/). The detailed geographic distribution of participants is shown in Fig. 1. The inclusion criteria for this study were as follow: (i) age between 12 and 20 years, (ii) adolescents in junior or senior high schools and (iii) volunteered to participate in the survey.

The online questionnaire was designed to collect basic socio-demographic information, Pittsburgh Sleep Quality Index (PSQI), Self-rating Anxiety Scale (SAS) and Fear of negative evaluation (FNE) questionnaire from 31 January to 9 February 2020. All adolescents provided informed consent. Participants had received explanation before signing the consent to participate and the analysis was entirely anonymous. This study was conducted anonymously and approved by the Ethics Committee

FIG. 1. The detailed geographic distribution of participants.

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INSTRUMENTS

Sleep quality

The sleep quality was assessed using the PSQI [15]. The PSQI scale is categorized into seven dimensions: (i) subjective sleep quality; (ii) sleep latency; (iii) sleep duration; (iv) habitual sleep efficiency; (v) sleep disturbances; (vi) use of sleeping medication and (vii) daytime dysfunction. Each dimension was graded on an integer score from 0 to 3, and accordingly, the PSQI score ranged from 0 to 21. Higher scores represented poorer sleep quality, and a PSQI total score > 5 defined the poor sleep quality group [6, 7, 15]. The reliability and validity of the Chinese version of PSQI were verified in previous studies in China and the Cronbach's alpha for this scale was 0.842 [16].

Anxiety

The SAS was wildly used to assess anxiety [17]. The SAS consists of 20 self-report items on anxiety and all items are rated on a 4-point Likert scale from 1 (never) to 4 (always). A standardized scoring algorithm was used to define symptoms of anxiety, and the total score ranged from 20 to 80. Higher scores indicated higher risk of anxiety. Anxiety symptoms were defined when the total SAS score was ≥ 50 [18]. The reliability and validity of the Chinese version of the SAS was verified and the correlation between test and retest within a 2-week period was 0.85 [19].

Fear of negative evaluation

The adolescents' levels of FNE were assessed by the Brief FNE Scale [20]. The BFNE is a 12-item self-reported questionnaire that assesses fear and distress related to negative evaluation from others, including

eight obverse-scored items and four reverse-scored items. A 5-point Likert scale ranging from 1 (not at all a characteristic of me) to 5 (extremely a characteristic of me) was used to rate each item. High FNE was defined when the total BFNE score was >30 [21]. The BFNE demonstrated adequate internal consistency in the current sample, and the Cronbach's alpha coefficient of the total scale was 0.813.

Statistical analysis

The Statistical Package of Social Science (SPSS 25.0) was used for data analyses. Continuous variables were presented as mean [standard deviations (SDs)] and categorical variables were presented as frequencies (percentages). For the purpose of our study, the number of confirmed COVID-19 cases in the adolescent's city was divided into none, ≤ 50, 51–100 and >100. Family members or friends infected/suspected were classified as none, confirmed and suspected. The time spent using electronics every day (h/d) was classified into five groups: <1, 1–4, 5–8, 9–12 and >12. The time spent on COVID-19 information per day was grouped into <0.5, 0.5–1 and >1 h/d. The number of meals every day, self-reported diet quality and exercise time every day were divided into three levels: decreasing, unchanged and increasing. The χ^2 test was used to compare the distributions of the characteristic variables between adolescents in the good with poor sleep quality groups. According to the findings of the previous studies and the established associations between sleep quality and a wide range of the collected variables [1, 2], univariate analyses were conducted to assess the associations between each of age, gender, education, being a single child, living in Hubei province, home quarantine, number of confirmed COVID-19 cases in the adolescents' city, having a family member or a friend infected/suspected, time spent on electronics per day, time spent on COVID-19 information per day, number of meals and exercise time, self-reported eating quality, anxiety level and FNE with poor sleep quality in our sample. Variables that showed significant associations with poor sleep quality in the univariate analyses were tested in multivariable-adjusted logistic regression models. Moreover, we conducted a stratified analysis by the level of education (junior high school versus senior high school) to explore potential differences in the influence of factors associated with sleep quality during COVID-19 outbreak among younger and older adolescents. Odds ratios (ORs) and 95% confidence intervals (95% CIs) were obtained from the logistic regression models. All statistical tests were two-tailed and values of $p < 0.05$ were regarded as statistically significant.

RESULTS

Demographic characteristics

The socio-demographic characteristics of the recruited Chinese adolescents according to binary categories of sleep quality are shown in Table 1. None of the 10 569 recruited adolescents reported symptoms of COVID-19. The number of respondents in Hubei (the epidemic area) and other regions (including Guangdong, Guangxi and other 29 regions) were 4402 (41.7) and 6167 (58.3%), respectively. The mean age of the recruited adolescents was 15.94 ± 1.45, and 50.3% were males. During the COVID-19 pandemic, 18.6% of adolescents had a poor sleep quality (PSQI >5). There were significant differences in all the studied factors between adolescents with and without poor sleep quality ($p < 0.05$).

Correlations

The mean, SD and Pearson correlation coefficients of the sleep quality-related variables are shown in Table 2. The PSQI total score was significantly correlated with the scores for anxiety ($r = 0.50$, $p < 0.01$) and FNE ($r = 0.36$, $p < 0.01$). Sleep latency was the highest PSQI domain score, and the use of sleeping medication was the lowest PSQI domain score. The mean score of the PSQI was 3.39, and the detailed seven domains' scores of sleep quality divided by age and gender are reported in Figs 2 and 3. Adolescents aged 16 years or more reported worse sleep quality, except for the sleep efficiency, compared with adolescents under 16 years. Furthermore, about the gender difference on sleep quality, females reported better performance at sleep efficiency, but worse performance at sleep quality,

TABLE 1. Distributions of socio-demographic characteristics according to the reported sleep quality

Variables	Total	Good sleep quality	Poor sleep quality n = 1966	p value
	(n = 10 569)	n = 8603 (81.4%)	(18.6%)	
Age (years)				<0.001
<16	3464 (32.8)	2937 (84.8)	527 (15.2)	
≥16	7105 (67.2)	5666 (79.6)	1439 (20.3)	
Gender				<0.001
Male	5319 (50.3)	4460 (83.9)	859 (16.1)	
Female	5250 (49.7)	4143 (78.9)	1105 (21.1)	
Education				<0.001
Junior high school	2110 (20.0)	1865 (88.4)	245 (11.6)	
Senior high school	8459 (80.0)	6738 (79.7)	1721 (20.3)	
Single child				0.060
No	5168 (48.9)	4169 (80.7)	999 (19.3)	
Yes	5401 (51.1)	4434 (82.1)	967 (17.9)	
Living in Hubei Province				<0.001
No	6167 (58.3)	4916 (79.7)	1251 (20.3)	
Yes	4402 (41.7)	3687 (83.8)	715 (16.2)	
Quarantine[a]				0.155
No	5319 (50.3)	4358 (81.9)	961 (18.1)	
Yes	5250 (49.7)	4245 (80.9)	1005 (19.1)	
Number of COVID-19 cases in your city				<0.001
None	649 (6.1)	566 (87.2)	83 (12.8)	
≤50	4567 (43.2)	3677 (80.5)	890 (19.5)	
51–100	1732 (16.4)	1405 (81.1)	327 (18.9)	
>100	2441 (23.1)	1969 (80.7)	472 (19.3)	
Do not know the number of patients	1180 (11.2)	986 (83.6)	194 (16.4)	
Family member or friend infected/ suspected[b] infected				<0.001
None	8797 (83.2)	7280 (82.8)	1517 (17.2)	
Confirmed	1178 (11.1)	889 (75.5)	289 (24.5)	
Suspected	594 (5.6)	434 (73.1)	160 (26.9)	
Time spent using electronics (h/d)				<0.001
<1	637 (6.0)	589 (92.5)	48 (7.5)	
1–4	4212 (39.9)	3622 (86.0)	590 (14.0)	
5–8	3518 (33.3)	2850 (81.0)	668 (19.0)	
9–12	1578 (14.9)	1127 (71.4)	451 (28.6)	
>12	624 (5.9)	415 (66.5)	209 (33.5)	
Time spent on COVID-19 information (h/day)				0.004
<0.5	5032 (47.6)	4030 (80.1)	1002 (19.9)	
0.5–1	4653 (44.0)	3849 (82.7)	804 (17.3)	

(continued)

TABLE 1. (continued)

Variables	Total	Good sleep quality	Poor sleep quality $n = 1966$	p value
	$(n = 10\,569)$	$n = 8603\ (81.4\%)$	(18.6%)	
>1	884 (8.4)	724 (81.9)	160 (18.1)	
Number of meals every day				<0.001
Decreasing	956 (9.0)	642 (67.2)	314 (32.8)	
Unchanged	9405 (89.0)	7826 (83.2)	1579 (16.8)	
Increasing	208 (2.0)	135 (64.9)	73 (35.1)	
Eating quality				<0.001
Decreasing	1185 (11.2)	750 (63.3)	435 (36.7)	
Unchanged	8762 (82.9)	7354 (83.9)	1408 (16.1)	
Increasing	622 (5.9)	499 (80.2)	123 (19.8)	
Exercise time every day				<0.001
Decreasing	5830 (55.2)	4522 (77.6)	1308 (22.4)	
Unchanged	3934 (37.2)	3382 (86.0)	552 (14.0)	
Increasing	805 (7.6)	699 (86.8)	106 (13.2)	
Anxiety				<0.001
No	9855 (93.2)	8367 (84.9)	1488 (15.1)	
Yes	714 (6.8)	236 (33.1)	478 (66.9)	
FNE				<0.001
No	2960 (28.0)	2704 (91.4)	256 (8.6)	
Yes	7609 (72.0)	5899 (77.5)	1710 (22.5)	

[a]Adolescents in junior and senior high school were forced to be quarantined at home to prevent further spread of COVID-19.
[b]The suspected cases need to meet at least one of the epidemiological history features and two clinical manifestations or three clinical manifestations items if without a clear epidemiological history. The confirmed cases were defined as suspected case with pathogenic or serological evidence.
p value < 0.05 was statistically significant and calculated by the χ^2 test and T-test.

TABLE 2. Pearson correlation analysis according to sleep quality

|	Mean	1	2	3	4	5	6	7	8	9	10
Subjective sleep quality	0.59	1									
Sleep latency	0.83	0.50**	1								
Sleep duration	0.20	0.20**	0.11**	1							
Sleep efficiency	0.45	0.12**	0.15**	0.29**	1						
Sleep disturbance	0.64	0.41**	0.34**	0.11**	0.08**	1					
Use of sleeping medication	0.02	0.15**	0.10**	0.06**	0.04**	0.14**	1				
Daytime dysfunction	0.66	0.48**	0.32**	0.23**	0.03**	0.40**	0.13**	1			
FNE	36.19	0.30**	0.22**	0.12**	0.02*	0.27**	0.07**	0.37**	1		
Anxiety	37.30	0.41**	0.31**	0.17**	0.15**	0.34**	0.17**	0.41**	0.30**	1	
PSQI	3.39	0.74**	0.70**	0.44**	0.45**	0.61**	0.25**	0.69**	0.36**	0.50**	1

*$p < 0.05$.
**$p < 0.01$.
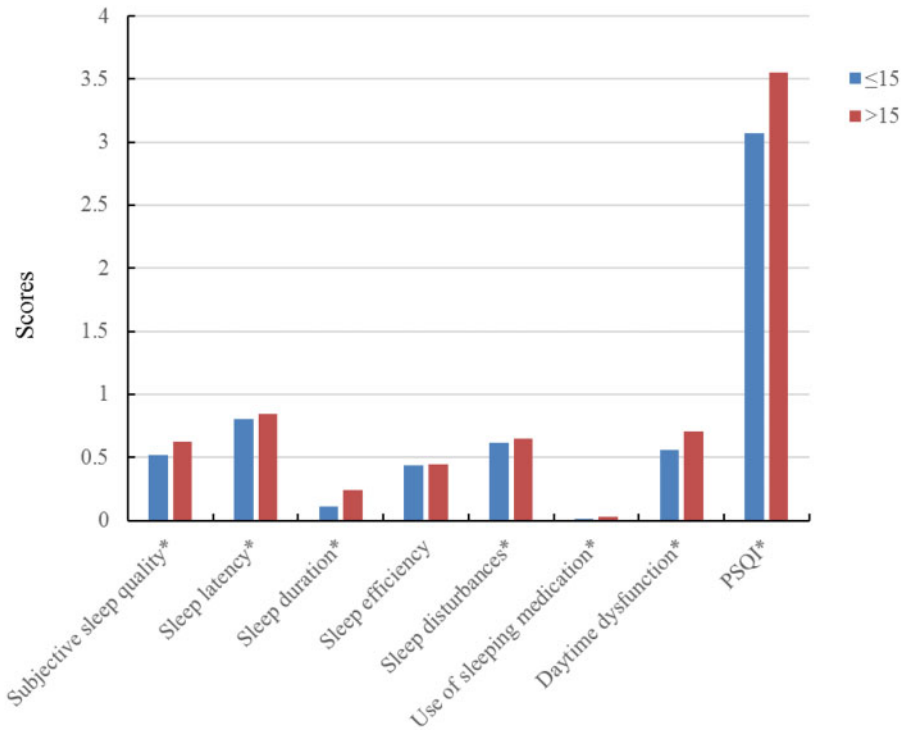
FIG. 2. The domain score of sleep quality by age. *Significant difference over different age groups (*p* value < 0.05).
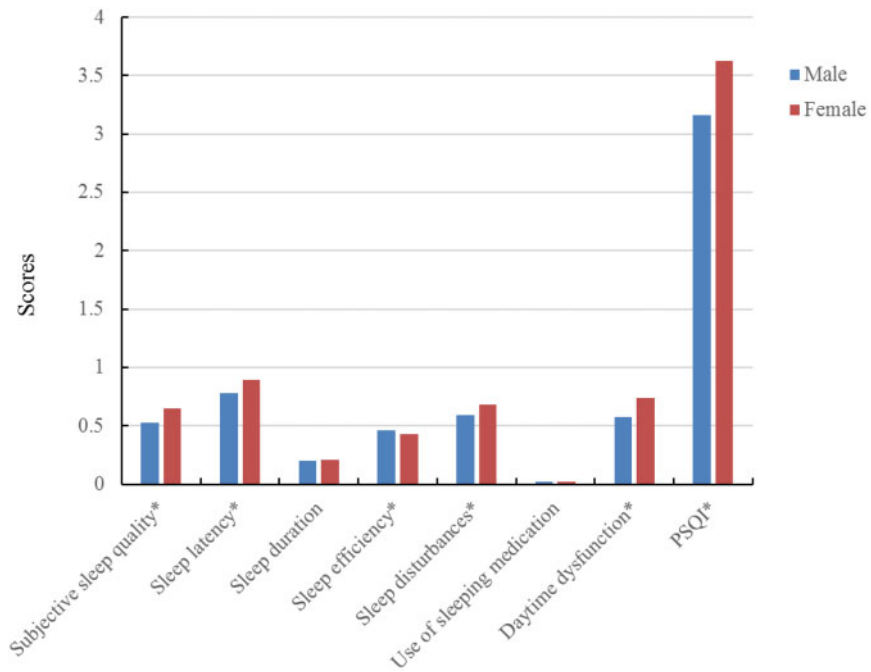

FIG. 3. The domain score of sleep quality by gender. *Significant difference over different gender groups (*p* value < 0.05).

sleep latency, sleep disturbance, daytime dysfunction and total PSQI scores than males.

Related factors of poor sleep quality

The independent factors of poor sleep quality are shown in Table 3. During the COVID-19 pandemic, the univariate analyses showed that being a single child and being forced to homestay during the COVID-19 pandemic were not associated with the sleep quality. Whereas, older adolescents' age, female gender, senior high education, increasing number of COVID-19 cases in the city, having a suspected or infected family member of COVID-19, the increasing daily hours spent using electronics, having anxiety and FNE were positively associated with poor sleep quality. On the other hand, living in Hubei province, the increasing daily hours spent following or searching for COVID-19 information, unchanged number of daily meals, unchanged or increased eating quality and unchanged or increased daily exercise time were inversely associated with poor sleep quality. In the multivariable-adjusted models, being a female, as well as a senior school student, were both associated with higher risk of poor sleep quality (OR : 1.228, 95% CI: 1.153–1.435 and OR : 1.533, 95% CI: 1.237–1.902). Living in Hubei Province was negatively correlated with poor sleep quality (OR: 0.826, 95% CI: 0.723–0.944). Adolescents with family member or friend infected or suspected to be infected with the new virus were more likely to have poor sleep quality (OR: 1.327, 95% CI: 1.124–1.566 for confirmed infection and 1.454; 95% CI: 1.176–1.796 for suspected infection). The OR of having poor sleep quality increased with time spent on electronics in a dose–response pattern reaching an (OR: 3.08, 95% CI: 2.492–5.223 for >12 vs. <1 h/d). Time spent on COVID-19 information per day was inversely associated with the poor sleep quality (OR: 0.774, 95% CI: 0.627–0.957 for >1 h/d vs. <0.5 h/d). In reference to adolescents with decreased diet quality, those who kept their diet quality unchanged and those who increased it, during the pandemic, had ORs (95% CIs) for poor sleep quality = 0.541 (0.463–0.632) and 0.523 (0.401–0.682), respectively. In addition, the higher category of the dichotomized anxiety score (OR: 8.269, 95% CI: 6.883–9.935) and the FNE (OR: 2.834, 95% CI: 2.341–

3.430) were significantly associated with the odds of having poor sleep quality.

Related factors of sleep quality stratified by education

Factors which associated with poor sleep quality among Chinese adolescents varied by the education level as shown in Table 4. Among senior high school students, all the studied factors, except for the number of COVID-19 cases in the city were associated with poor sleep quality. While among Junior high school students, the number of COVID-19 cases in the city besides female gender, suspected COVID-19 in family members or friends and diet-related factors were associated with poor sleep quality. Anxiety and FNE were associated with poor sleep quality in both levels of education.

DISCUSSIONS

The prevalence of poor sleep quality among Chinese adolescents in junior and senior high schools during the COVID-19 pandemic period was 18.6%, and the overall average score of PSQI was 3.39. Factors that were positively associated with poor sleep quality included older age, female gender, senior high education, having an infected/suspected family member or a friend, time spent using electronics every day, anxiety and FNE; while living in Hubei province, time spent on COVID-19 information, improving diet and increasing daily exercise time were inversely associated with poor sleep quality. Our findings provided a data support for an accurate understanding about the Chinese adolescents' sleep quality during COVID-19 outbreak.

Factors associated with poor sleep quality

Females were more likely to have poor sleep quality than males during the COVID-19 outbreak, which was consistent with findings of an earlier study [6]. Anxiety and FNE scores were strongly correlated with scores of the seven dimensions of PSQI in our study (subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication and daytime dysfunction) indicating an association between sleep quality and mental health issues [2, 22]. Recent studies have suggested that the public level of anxiety-related

TABLE 3. Univariate and adjusted logistic regression analysis of factors influencing the poor sleep quality

Variables	Univariate OR (95% CI)	*p* value	Adjusted OR[a] (95% CI)	*p* value
Age (years)				
<16	1.00		1.00	
≥16	1.415 (1.269–1.579)	<0.001	1.002 (0.861–1.165)	0.983
Gender				
Male	1.00		1.00	
Female	1.387 (1.257–1.531)	<0.001	1.286 (1.153–1.435)	<0.001
Education				
Junior high school	1.00		1.00	
Senior high school	1.944 (1.685–2.244)	<0.001	1.533 (1.237–1.902)	<0.001
Single child				
No	1		1.00	
Yes	0.910 (0.825–1.004)	0.060	0.912 (0.814–1.022)	0.114
Living in Hubei Province				
No	1.00		1.00	
Yes	0.762 (0.689–0.843)	<0.001	0.826 (0.723–0.944)	0.005
Quarantine				
No	1.00			
Yes	1.074 (0.973–1.184)	0.155	0.981 (0.881–1.094)	0.734
Number of COVID-19 cases in your city				
None	1.00		1.00	
≤50	1.651 (1.296–2.102)	<0.001	1.226 (0.944–1.591)	0.126
51–100	1.587 (1.224–2.058)	<0.001	1.205 (0.909–1.596)	0.195
>100	1.635 (1.271–2.102)	<0.001	1.284 (0.971–1.698)	0.080
Family member or friend infected/suspected				
None	1.00		1.00	
Confirmed	1.560 (1.351–1.801)	<0.001	1.327 (1.124–1.566)	0.001
Suspected	1.769 (1.464–2.138)	<0.001	1.454 (1.176–1.796)	0.001
Time spent using electronics (h/d)				
<1	1.00		1.00	
1–4	1.999 (1.471–2.717)	<0.001	1.899 (1.367–2.639)	<0.001
5–8	2.876 (2.118–3.906)	<0.001	2.417 (1.738–3.361)	<0.001
9–12	4.911 (3.588–6.721)	<0.001	3.490 (2.484–4.903)	<0.001
>12	6.180 (4.408–8.664)	<0.001	3.608 (2.492–5.223)	<0.001
Time spent on COVID-19 information (h/d)				
<0.5	1.00		1.00	
0.5–1	0.840 (0.758–0.931)	0.001	0.887 (0.792–0.994)	0.039
>1	0.889 (0.739–1.069)	0.211	0.774 (0.627–0.957)	0.018

(continued)

TABLE 3. (continued)

Variables	Univariate OR (95% CI)	p value	Adjusted OR[a] (95% CI)	p value
Number of meals every day				
Decreasing	1.00		1.00	
Unchanged	0.413 (0.357–0.477)	<0.001	0.653 (0.549–0.776)	<0.001
Increasing	1.106 (0.807–1.515)	0.532	1.308 (0.904–1.893)	0.155
Eating quality				
Decreasing	1.00		1.00	
Unchanged	0.330 (0.290–0.376)	<0.001	0.541 (0.463–0.632)	<0.001
Increasing	0.250 (0.338–0.536)	<0.001	0.523 (0.401–0.682)	<0.001
Exercise time every day				
Decreasing	1.00		1.00	
Unchanged	0.564 (0.506–0.629)	<0.001	0.773 (0.685–0.873)	<0.001
Increasing	0.524 (0.424–0.490)	<0.001	0.792 (0.626–1.002)	0.052
Anxiety				
No	1.00		1.00	
Yes	11.389 (9.653–13.437)	<0.001	8.269 (6.883–9.935)	<0.001
FNE				
No	1.00		1.00	
Yes	3.062 (2.664–3.518)	<0.001	2.834 (2.341–3.430)	<0.001

OR, Odds ratio; CI, confidence interval.
[a]Adjusted ORs were derived from a logistic regression model included the significant factors in univariate analyses where p values <0.05 indicated statistical significance.

symptoms increased when a major infectious disease occurred such as in SARS [23] and COVID-19 [24]. As sleep quality is sensitive to psychological status, and with the prevalent symptoms of anxiety and depression during the COVID-19 pandemic [25], many people had suffered from poor sleep quality [6, 7, 24]. The current study showed that adolescents in junior and senior high schools with anxiety and FNE had approximately eight and three times, respectively, poor sleep quality rate compared with those without anxiety and FNE ($p < 0.05$).

In addition, adolescents with a family member or a friend infected or suspected to be infected with COVID-19 were more likely to develop poor sleep quality. The presence of nearby infected relatives or friends could have led to experience more anxiety and negative emotions, which can affect the sleep quality of the young individuals of the family [24, 26]. The COVID-19 has disrupted the normal learning and living conditions of the adolescent students and affected their sleep quality. Due to the outbreak of COVID-19, a large number of students had to apply social distancing or forced to isolate at home. This has led to more spare time to use various electronic devices and to stay awake later than usual. Staying awake for late or midnight time could change the circadian rhythm and slow the homeostatic sleep drive accumulation, which may lead to the decline of sleep quality in those adolescents [27].

Factors associated with good sleep quality

The average time spent focusing on the COVID-19 outbreak news was found inversely associated with poor sleep quality. This result may be explained by the fact that the time of monitoring COVID-19 news could have provided the adolescents by the necessary information; such as facts, inflection data and government measures which could have reduced their fears and anxiety and led to the better quality of sleep [28]. It is somewhat surprising that adolescents living in Hubei province, where the first COVID-19 case was detected, showed a better sleep

TABLE 4. Stratified analyses of factors influencing the poor sleep quality by education level

Variables	Junior high school		Senior high school	
	Univariate OR (95% CI)	*p* value	Adjusted OR[a] (95% CI)	*p* value
Gender				
Male	1.00		1.00	
Female	1.501 (1.110–2.031)	<0.001	1.225 (1.087–1.381)	0.001
Single child				
No	1.00		1.00	
Yes	1.058 (0.774–1.446)	0.724	0.889 (0.785–1.007)	0.065
Living in Hubei Province				
No	1.00		1.00	
Yes	1.037 (0.665–1.618)	0.871	0.851 (0.737–0.982)	0.027
Quarantine				
No	1.00		1.00	
Yes	0.946 (0.702–1.274)	0.713	0.975 (0.866–1.097)	0.674
Number of COVID-19 cases in your city				
None	1.00		1.00	
≤50	3.515 (1.144–10.796)	0.028	1.064 (0.793–1.427)	0.679
51–100	4.322 (1.304–14.327)	0.017	1.153 (0.854–1.556)	0.353
>100	2.941 (0.974–8.879)	0.056	1.071 (0.781,1.467)	0.671
Family member or friend infected/suspected				
None	1.00		1.00	
Confirmed	1.301 (0.879–1.926)	0.188	1.295 (1.073–1.564)	0.007
Suspected	1.675 (1.007–2.787)	0.047	1.374 (1.084–1.741)	0.009
Time spent using electronics (h/d)				
<1	1.00		1.00	
1–4	1.506 (0.823–2.755)	0.184	2.092 (1.400–3.128)	<0.001
5–8	1.533 (0.816–2.879)	0.184	2.656 (1.778–3.966)	<0.001
9–12	1.767 (0.854–3.659)	0.125	3.782 (2.512–5.695)	<0.001
>12	1.071 (0.393–2.920)	0.893	3.623 (2.339–5.610)	<0.001
Time spent on COVID-19 information (h/d)				
<0.5	1.00		1.00	
0.5–1	0.929 (0.672–1.284)	0.655	0.905 (0.800–1.024)	0.113
>1	1.157 (0.721–1.856)	0.546	0.747 (0.586–0.952)	0.018
Number of meals every day				
Decreasing	1.00		1.00	
Unchanged	0.441 (0.293–0.665)	<0.001	0.740 (0.609–0.900)	0.000
Increasing	1.407 (0.583–3.393)	0.447	1.314 (0.868–1.988)	0.193

(**continued**)

TABLE 4. (continued)

Variables	Junior high school		Senior high school	
	Univariate OR (95% CI)	p value	Adjusted OR[a] (95% CI)	p value
Diet quality				
Decreasing	1.00		1.00	
Unchanged	0.653 (0.424–1.004)	0.052	0.541 (0.456–0.641)	<0.001
Increasing	0.932 (0.473–1.835)	0.838	0.482 (0.359–0.648)	<0.001
Exercise time every day				
Decreasing	1.00		1.00	
Unchanged	0.901 (0.644–1.262)	0.545	0.773 (0.678–0.881)	<0.001
Increasing	0.723 (0.449–1.163)	0.181	0.790 (0.598–1.044)	0.098
Anxiety				
No	1.00		1.00	
Yes	8.373 (5.082–13.796)	<0.001	6.854 (5.598–8.390)	<0.001
FNE				
No	1.00		1.00	
Yes	1.075 (1.054–1095)	<0.001	1.064 (1.056–1.072)	<0.001

OR, Odds ratio; CI, confidence interval.
[a]Adjusted ORs were derived from a logistic regression model included the significant factors in univariate analyses where *p* values <0.05 indicated statistical significance.

quality than adolescents in other provinces. This could be attributed to the adequate medical resources and online psychological counselling services provided by the Chinese government to the Hubei residents [29, 30]. The results of study showed an interesting phenomenon that adolescents were more likely to get a good sleep when their physical activity levels improved or did change during the pandemic. Therefore, we recommend governments to encourage young individuals to practice more indoor exercise during epidemics. In our study, more than 80% of adolescents have not changed the number of daily meals or their diet quality. Adolescents who did not change their frequency of eating or decreased the quality of their diet were more likely to get a good sleep. A growing body of evidence also supports the idea that properly controlled diets can have an impact on circadian rhythms and sleep [31, 32].

Stratified analysis by the education level
Age was positively associated with poor sleep quality in our sample of Chinese adolescents, which could be reflecting the effect of the stage of education. Of note, 20.3% of senior high school students,

compared with 11.6% junior high school students, had a poor sleep quality during the COVID-19 pandemic. All the studied factors showed strong associations with poor sleep quality among senior rather than junior high school students. Senior high school students have heavier academic burdens, and being not able to attend school regularly with the potentiality to face the university entrance exam during the COVID-19 outbreak may have resulted in more anxiety and worries about their chances of getting into college, which could be triggers for decreased sleep quality [6, 7, 9, 11].

Strengths and limitations
This cross-sectional study has provided a comprehensive insight into factors associated with sleep quality of junior and senior high school adolescents during the COVID-19 pandemic in China. We used validated scales to assess the dependent and independent variables under the study. Moreover, we provided stratified analyses by the education level to assess the potential impact of the stage of education on the adolescents' sleep pattern response to varied factors during the COVID-19 pandemic.

The study limitations include the difficulty to deduce causal associations between the outcome and exposure variables because of the cross-sectional nature of this study. However, some factors such as anxiety, FNE and increasing time spent using electronics showed consistent strong associations in the adjusted and stratified models which suggest a potential cause–effect association. To further explore the temporal relationship between the outcome and exposure variables, we are considering to conduct a case–control study whenever the data are available. Second, the prevalence of poor sleep quality may be over-or under-estimated, and the indicated levels of sleep quality may not always be consistent with the evaluations of mental health professionals, since the study was conducted by self-reports from only one source. Third, due to the impact of COVID-19 pandemic, we conducted the survey of this study by online questionnaire rather than face-to-face investigation, which may bear certain deviation in the response population, especially with the use of convenience sampling. This was obvious for the differences in the age strata proportions; adolescents aged ≥16 accounted for a relatively large proportion, and age matching should be carried out in future studies. Therefore, the findings of the study should be cautiously applied to sleep problems among national adolescents.

CONCLUSIONS

During the COVID-19 pandemic, poor sleep quality was prevalent in junior and senior high school adolescents in China. A variety of demographic and geopolitical factors detected to influence the adolescents' sleep quality. Sleep support is important for managing the COVID-19 emergency and improving sleep quality, and even is helpful to protect the adolescents' physical health. Therefore, more attention should be paid to sleep quality among adolescents and be ensured that they get enough rest and sleep time. Also, in order to protect the adolescents' mental and physical health, more interventions in reducing COVID-19-caused anxiety and promoting healthy sleep habits are recommended.

DATA AVAILABILITY

The data that support the findings of this study are available upon request, Prof. Bing Xiang (397126318@qq.com).

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