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Original Article

Relationships between the changes in sleep patterns and sleep quality among Chinese people during the 2019 coronavirus disease outbreak

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ABSTRACT

Objective: Rapidly increasing numbers of confirmed cases and deaths during the 2019 coronavirus disease outbreak (COVID-19) resulted in widespread psychological problems in the Chinese population. The purpose of this study was to investigate the sleep quality and changes in sleep patterns before and during the outbreak in the general population in China and to determine factors related to sleep quality.
Methods: This cross-sectional study was conducted using an online questionnaire from 20 February to 29 February 2020 in China. Socio-demographic data, self-designed COVID-19-related characteristics, sleep patterns, and Pittsburgh Sleep Quality Index (PSQI) scores were obtained. Single factor analysis and multivariate binary logistic regression analysis were used.
Results: A total of 1897 individuals were included in our study, and 30.0% of participants reported suffering poor sleep quality (PSQI≥8). Logistic regression analysis found that the factors related to sleep quality included poor physical health (OR = 3.382, $p < 0.001$), respiratory disease (OR = 1.629, $p = 0.008$), other diseases (OR = 2.504, $p = 0.012$), suspected case of COVID-19 in the same community (OR = 1.928, $p = 0.002$), confirmed case of COVID-19 in the same community (OR = 2.183, $p = 0.007$), worry about being infected (OR = 2.336, $p < 0.001$), ≥1 h/day spent hearing COVID-19 information (OR = 1.960, $p < 0.001$), time difference in midpoint time in bed (OR = 1.230, $p < 0.001$), and time difference in time in bed (OR = 0.711, $p < 0.001$).
Conclusions: Our study revealed that more than one-fourth of the participants suffered poor sleep quality during the COVID-19 outbreak. In addition to the poor health status and COVID-19-related anxiety, delayed sleep phase and reduced time in bed impacted sleep quality in the general population in China.

1. Introduction

In December 2019, an outbreak of coronavirus disease 2019 (COVID-19), initially reported in Wuhan, Hubei Province, China, rapidly spread throughout China and around the world [1]. As of 9 September 2020, COVID-19 affected more than 27.4 million individuals and led to nearly 895.0 thousand deaths [2]. Previous studies have shown that when an epidemic breaks out, it will cause both physical damage [3,4] and psychological problems in the population [5–8].

The severe acute respiratory syndrome (SARS) in 2003, which had 8422 confirmed cases and resulted in 916 deaths worldwide [9], placed great pressure on individuals resulting in sleep disturbances [10,11]. Currently, the confirmed cases and deaths of COVID-19 which will continue grow are approximately 3300 times and 1000 times higher than those of SARS, respectively. With the high contagiousness of COVID-19 and the shortage of protective equipment resources, the public have been experiencing mental health problems [12]. Considering that the COVID-19 outbreak was stressful [13], the Centers for Disease Control and Prevention predicted that the public may experience changes in sleep patterns and

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difficulty in falling asleep [14]. Moreover, aimed at controlling epidemic spread, the Chinese government encouraged the public to practice social distancing and stay at home as much as possible to prevent droplet transmission [15,16]. One study during the COVID-19 pandemic reported a high mean score on the Pittsburgh Sleep Quality Index (PSQI) in individuals who self-isolated, indicating poor sleep quality [17]. However, only 170 subjects were recruited, and the subjects only isolated for 14 days in that study. In addition, people tend to relax during home quarantine and may have irregular biological rhythms and altered sleep patterns, similar to changes that occur on weekend days and long-term vacation [18–20]. However, most studies about sleep status during the COVID-19 outbreak have focused on healthcare workers [21,22], college students [23], or self-isolated people [17], while few studies have focused on the public. To the best of our knowledge, no study has focused on changes in sleep patterns before and during the COVID-19 outbreak to identify sleep disturbances.

In this account, we aimed to investigate the sleep patterns and their potential changes before and during the COVID-19 outbreak in the general population in China and to determine the relationship of sleep quality with socio-demographics, health conditions, COVID-19-related characteristics, and changes in sleep patterns.

2. Material and methods

2.1. Participants and procedures

This study was completed anonymously by “Toutiao” (ByteDance Ltd, Beijing, China) users. The participants came from 31 provinces, autonomous regions, municipalities and Hong Kong and were more than 18 years old.

2.2. Study design

The cross-sectional study designed by the Chinese Sleep Research Society (CSRS) was conducted with a questionnaire on the online platform “Toutiao” from 20 February to 29 February 2020. The study was approved by the research ethics committee, Nanfang Hospital, Southern Medical University.

2.3. Socio-demographics, health conditions, and COVID-19-related characteristics

Socio-demographics, health conditions, and COVID-19-related characteristics from the participants included age, sex, education level (senior high school or below, college or university, or master or above), employment status (unemployed or employed), per capita household income (>10,000 RMB/month or ≤10,000 RMB/month), living in Hubei Province (no or yes), living arrangements (alone, with family, or with others), self-reported physical health (good or poor), history of illness (no disease, respiratory disease, cardiovascular disease, mental disease, or others), history of personal COVID-19 infection (no or yes), history of COVID-19 infection among friends and relatives (none, suspected case, or confirmed case), history of COVID-19 infection in the same community (none, suspected case, or confirmed case), worry about being infected (no or yes), and time spent hearing COVID-19 information (<1 h/day or ≥1 h/day).

2.4. Sleep patterns

Sleep patterns including bedtime, rise time, time in bed (rise time − bedtime), and midpoint time in bed [(rise time + bedtime)/2] before and during the epidemic (with the line of demarcation on 20 January 2020) were required. The time difference values for bedtime, rise time, time in bed, and midpoint time in bed were obtained by subtracting time before the outbreak from time during the outbreak to determine changes in sleep patterns during the COVID-19 outbreak.

2.5. The Pittsburgh Sleep Quality Index (PSQI)

PSQI [24] was used to assess sleep status not only because of its simplicity, high reliability, and validity but also because of its comprehensive evaluation of sleep status from several dimensions. The scale was comprised of 18 items containing seven dimension that included sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbance, sleep medications, and daytime dysfunction. Each dimension was scored between 0 and 3, with a total score ranging from 0 to 21. A total score ≥8 indicated a poor sleeper, while others were recognized as good sleepers.

2.6. Statistical analysis

Data were reported as the mean ± standard (SD) for continuous variable and as numbers (percentages) for categorical variables. The between-group comparisons of socio-demographics, COVID-19-related characteristics, and sleep patterns were performed using the independent t test for data with normal distribution and Mann–Whitney U test for those without normal distribution. The chi-square (χ^2) test was performed to compare differences in categorical variables, and post hoc analyses on multiple category data were performed with Bonferroni correction. Sex and other variables with $p < 0.05$ were tested as potential related factors of sleep quality by multivariate binary logistic regression using the enter method. A two-sided 5% level of significance was considered significant. All statistical tests were performed with IBM SPSS Statistics for Windows (version 25.0., IBM Corp., Armonk, NY, USA). Figures were generated in GraphPad Prism version 8.0 for Windows (GraphPad Software, San Diego, California, USA).

3. Results

3.1. Sample characteristics

In this study, 1897 (94.7%) valid profiles were collected from a total sample of 2004 individuals surveyed. The research, including 1069 males (56.4%) and 828 (43.6%) females, showed that the mean age of these participants was 36.6 ± 11.5 years old. The sleep quality, measured by the PSQI scale, revealed a sample mean score of 6.09 ± 2.90. A total of 569 (30.0%) participants were considered poor sleepers.

3.2. Socio-demographics, health conditions, and COVID-19-related characteristics of poor sleepers and good sleepers

The socio-demographics, health conditions, and COVID-19-related characteristics between poor and good sleepers are shown in Table 1. Poor sleepers were more likely to be older ($p = 0.011$), have poor physical health ($p < 0.001$), worry about being infected ($p < 0.001$), and spend ≥1 h/day hearing COVID-19 information ($p < 0.001$) compared to good sleepers. Additionally, individuals with poor sleep quality were more likely to have respiratory disease (14.6% vs 7.4%), cardiovascular disease (11.2% vs 6.5%), suspected case of COVID-19 among their friends and relatives (8.8% vs 4.2%), suspected case of COVID-19 in their community (13.5% vs 5.4%), and confirmed case of COVID-19 in their community (5.4% vs 2.6%) than those with good sleep quality (all $p < 0.05$).

Table 1
Demographic and COVID-19-related characteristics of poor sleepers and good sleepers.

	Total (n = 1897)	Poor sleepers (n = 569)	Good sleepers (n = 1328)	*p* value
Demographic data				
Age (years)	36.6 ± 11.5	37.6 ± 11.7	36.1 ± 11.4	0.011
Sex				0.295
Male	1069 (56.4)	331 (58.2)	738 (55.6)	
Female	828 (43.6)	238 (41.8)	590 (44.4)	
Education level				0.577
Senior high school or below	155 (8.2)	52 (9.1)	103 (7.8)	
College or university	1579 (83.2)	467 (82.1)	1112 (83.7)	
Master or above	163 (8.6)	50 (8.8)	113 (8.5)	
Employment status				0.177
Unemployed	143 (7.5)	50 (8.8)	93 (7.0)	
Employed	1754 (92.5)	519 (91.2)	1235 (93.0)	
Per capita household income				0.211
>10,000 RMB/month	875 (46.1)	250 (43.9)	625 (47.1)	
≤10,000 RMB/month	1022 (53.9)	319 (56.1)	703 (52.9)	
Living in Hubei province				0.461
No	1803 (95.0)	544 (95.6)	1259 (94.8)	
Yes	94 (5.0)	25 (4.4)	69 (5.2)	
Living arrangements				0.647
Alone	120 (6.3)	36 (6.3)	84 (6.3)	
With family	1733 (91.4)	517 (90.9)	1216 (91.6)	
With others	44 (2.3)	16 (2.8)	28 (2.1)	
Self-reported physical health				<0.001
Good	1739 (91.7)	476 (83.7)	1263 (95.1)	
Poor	158 (8.3)	93 (16.3)	65 (4.9)	
Illness history				<0.001
No disease	1509 (79.5)	397 (69.8)	1112 (83.7)	
Respiratory disease*	181 (9.5)	83 (14.6)	98 (7.4)	
Cardiovascular disease*	150 (7.9)	64 (11.2)	86 (6.5)	
Mental disease	18 (0.9)	7 (1.2)	11 (0.8)	
Others	39 (2.1)	18 (3.2)	21 (1.6)	
COVID-19-related characteristics				
History of personal COVID-19 infection				0.347
No	1868 (98.5)	558 (98.1)	1310 (98.6)	
Yes	29 (1.5)	11 (1.9)	18 (1.4)	
History of COVID-19 infection among friends and relatives				<0.001
None	1771 (93.4)	509 (89.5)	1262 (95.0)	
Suspected case*	106 (5.6)	50 (8.8)	56 (4.2)	
Confirmed case	20 (1.1)	10 (1.8)	10 (0.8)	
History of COVID-19 infection in the same community				<0.001
None	1683 (88.7)	461 (81.0)	1222 (92.0)	
Suspected case*	149 (7.9)	77 (13.5)	72 (5.4)	
Confirmed case*	65 (3.4)	31 (5.4)	34 (2.6)	
Worry about being infected				<0.001
No	829 (43.7)	153 (26.9)	676 (50.9)	
Yes	1068 (56.3)	416 (73.1)	652 (49.1)	
Time spent hearing COVID-19 information				<0.001
<1 h/day	634 (33.4)	111 (19.5)	523 (39.4)	
≥1 h/day	1263 (66.6)	458 (80.5)	805 (60.6)	

Post hoc analyses on multiple category data were performed by Bonferroni correction. *significant after Bonferroni correction by using the first category as a reference.

3.3. Sleep patterns of poor sleepers and good sleepers

Sleep patterns of participants are presented in Table 2 and Fig. 1. Bedtime, rise time, and midpoint time in bed during the epidemic tended to be late compared to those before the epidemic in both poor sleepers and good sleepers (all $p < 0.001$). The changes in delayed bedtime and delayed midpoint time in bed among poor sleepers were greater than those among good sleepers (both $p < 0.001$). Compared to the time in bed before the epidemic, poor sleepers spent less time in bed during the epidemic, and good sleepers spent more time in bed during the epidemic (both $p < 0.001$). There was a significant difference in the change in time in bed between poor sleepers and good sleepers ($p < 0.001$). Additionally, poor sleepers preferred sleeping late and having less time in bed compared to good sleepers before or during the COVID-19 outbreak (both $p < 0.05$). In terms of rise time, there was no difference in poor sleepers and good sleepers before the epidemic ($p = 0.062$) while poor sleepers got up earlier during the COVID-19 epidemic ($p = 0.049$). Meanwhile, midpoint time in bed before the outbreak was similar between poor sleepers and good sleepers ($p = 0.530$), while the time of poor sleepers was later than that of good sleepers during the outbreak ($p < 0.001$).

3.4. The logistic regression analysis on influence factors of sleep quality

Sex, other socio-demographics, health conditions, and COVID-19-related characteristics with statistical significance in univariate analysis as well as the time difference of midpoint time in bed and the time difference of time in bed were assessed as potential related factors of sleep quality by logistic regression. As shown in Table 3, the factors related to poor sleep quality included poor physical health (OR = 3.382, $p < 0.001$), respiratory disease (OR = 1.629, $p = 0.008$), other diseases (OR = 2.504, $p = 0.012$), suspected case of COVID-19 in the same community (OR = 1.928, $p = 0.002$), confirmed case of COVID-19 in the same community (OR = 2.183, $p = 0.007$), worry

Table 2
Sleep patterns of poor sleepers and good sleepers.

	Total (n = 1897)	Poor sleepers (n = 569)	Good sleepers (n = 1328)	*p* value
PSQI score	6.09 ± 2.90	9.65 ± 1.68	4.57 ± 1.74	<0.001
Sleep patterns				
Bedtime				
Before epidemic (hh:mm)	22:49 ± 01:10	22:56 ± 01:11	22:47 ± 01:09	0.009
During epidemic (hh:mm)	23:31 ± 01:31	00:10 ± 01:38	23:15 ± 01:22	<0.001
Time difference (hh:mm)	+(00:42 ± 01:25)	+(01:14 ± 01:38)	+(00:28 ± 01:15)	<0.001
Rise time				
Before epidemic (hh:mm)	06:58 ± 01:01	06:54 ± 01:00	07:00 ± 01:02	0.062
During epidemic (hh:mm)	07:51 ± 01:25	07:45 ± 01:35	07:54 ± 01:20	0.049
Time difference (hh:mm)	+(00:52 ± 01:18)	+(00:50 ± 01:29)	+(00:53 ± 01:14)	0.901
Midpoint time in bed				
Before epidemic (hh:mm)	02:54 ± 00:55	02:55 ± 00:55	02:53 ± 00:55	0.530
During epidemic (hh:mm)	03:41 ± 01:15	03:57 ± 01:22	03:34 ± 01:11	<0.001
Time difference (hh:mm)	+(00:46 ± 01:08)	+(01:02 ± 01:18)	+(00:40 ± 01:02)	<0.001
Time in bed				
Before epidemic (hh:mm)	08:08 ± 01:11	07:58 ± 01:13	08:13 ± 01:11	<0.001
During epidemic (hh:mm)	08:19 ± 01:31	07:34 ± 01:43	08:39 ± 01:18	<0.001
Time difference (hh:mm)	+(00:10 ± 01:31)	−(00:24 ± 01:43)	+(00:25 ± 01:21)	<0.001

Time difference: time during the outbreak minus time before the outbreak. + means time during the epidemic was delayed or increased compared with that before the epidemic. − means time during the epidemic was advanced or reduced compared with that before the epidemic. PSQI score as well as bedtime, rise time, midpoint time in bed, and time in bed before and during the epidemic were assessed with the independent t test. Time difference in each sleep pattern was assessed with the Mann–Whitney U test.

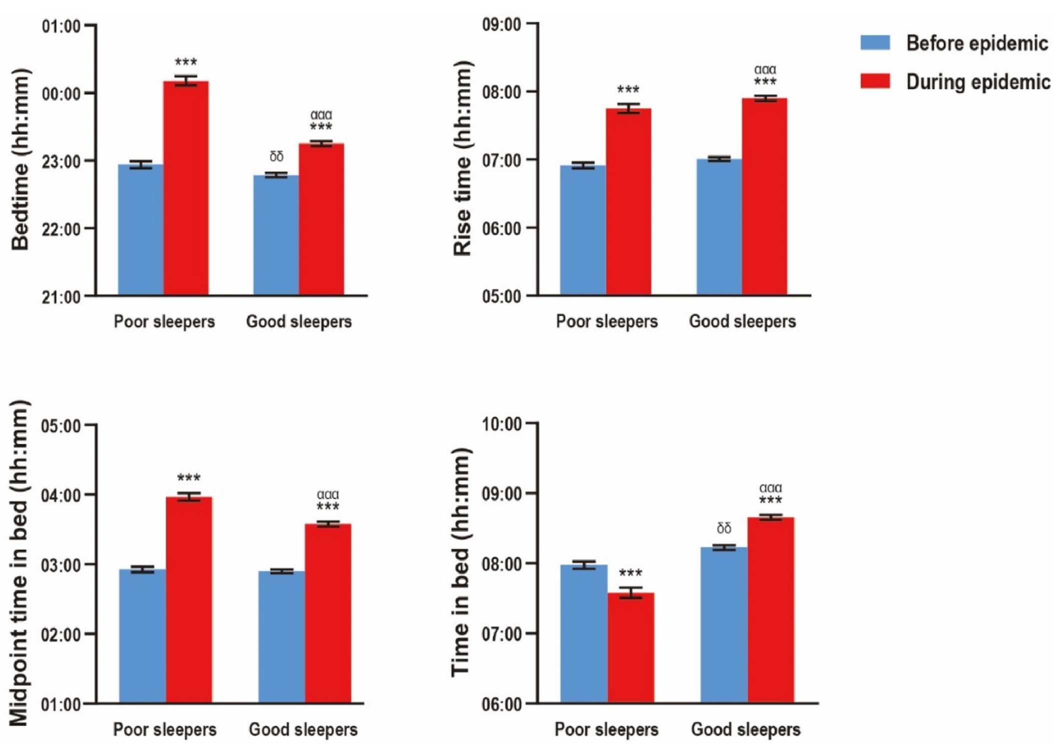

Fig. 1. Sleep patterns of poor sleepers and good sleepers before and during the COVID-19 epidemic. Bars show mean ± standard errors. $^{***}p < 0.001$ indicates differences between the group before the COVID-19 epidemic and the group during the COVID-19 epidemic for poor sleepers or good sleepers; $^{\delta\delta}p < 0.01$ indicates differences between poor sleepers and good sleepers before the epidemic; $^{\alpha\alpha\alpha}p < 0.001$ indicates differences between poor sleepers and good sleepers during epidemic.

about being infected (OR = 2.336, $p < 0.001$), ≥1 h/day spent hearing COVID-19 information (OR = 1.960, $p < 0.001$), time difference in midpoint time in bed (OR = 1.230, p < 0.001), and time difference in time in bed (OR = 0.711, p < 0.001).

4. Discussion

The mean score of PSQI in our study (6.15 ± 2.90) was higher than the national norms in China (3.88 ± 2.52) [25]. During the COVID-19 outbreak, 30.0% of individuals suffered poor sleep quality. In line with our hypothesis, the prevalence of sleep disturbance was higher than that in previous studies on COVID-19 [26], SARS [27], the Wenchuan earthquake [28], and the Ya'an earthquake [29]. These differences in sleep disturbances may be related to the survey time relative to the events, respondents, and the extreme stress that the COVID-19 outbreak exerted on individuals such as uncertainty regarding epidemic control and high contagiousness. Undoubtedly, the public are at high risk for sleep disturbance during

Table 3
The logistic regression analysis on factors influencing sleep quality during the COVID-19 outbreak.

Independent variable	β	SE	OR (95%CI)	*p* value
Age	0.002	0.005	1.002 (0.991–1.012)	0.764
Sex				
Male	0		1	
Female	−0.087	0.115	0.917 (0.732–1.148)	0.450
Self-reported physical health				
Good	0		1	
Poor	1.218	0.193	3.382 (2.319–4.932)	<0.001
Illness history				
No disease	0		1	
Respiratory disease	0.488	0.183	1.629 (1.138–2.330)	0.008
Cardiovascular disease	0.333	0.213	1.395 (0.920–2.116)	0.117
Mental disease	0.438	0.534	1.550 (0.544–4.414)	0.412
Others	0.918	0.364	2.504 (1.227–5.107)	0.012
History of COVID-19 infection among friends and relatives				
None	0		1	
Suspected case	−0.124	0.260	0.884 (0.531–1.472)	0.635
Confirmed case	0.073	0.519	1.075 (0.389–2.974)	0.889
History of COVID-19 infection in the same community				
None	0		1	
Suspected case	0.657	0.212	1.928 (1.272–2.923)	0.002
Confirmed case	0.781	0.289	2.183 (1.240–3.844)	0.007
Worry about being infected				
No	0		1	
Yes	0.849	0.119	2.336 (1.849–2.952)	<0.001
Time spent hearing COVID-19 information				
<1 h/day	0		1	
≥1 h/day	0.673	0.131	1.960 (1.516–2.534)	<0.001
Time difference in midpoint time in bed	0.207	0.050	1.230 (1.116–1.356)	<0.001
Time difference in time in bed	−0.342	0.039	0.711 (0.659–0.767)	<0.001

the COVID-19 outbreak due to stress from COVID-19 [8,21] and poor sleep hygiene caused by home quarantine [30]. In our study, the risk factors for sleep quality included poor physical health, illness history, history of COVID-19 infection in the same community, more time spent hearing COVID-19 information, worry about being infected, delayed midpoint time in bed, and reduced time in bed.

In our study, the risk of poor sleep quality among participants with case of COVID-19 infection in their communities was higher than that of participants without a community case. Transmission of the COVID-19 virus can occur via respiratory droplets and contact routes [31]. Due to the high probability of close contact with individuals infected with COVID-19 in the same community, the public may be worried about infection through droplet transmission. In addition, sharing indoor environments in public places such as elevators and stairways also increases the risk of infection [32]. Additionally, people may not have access to enough face masks, alcohol, and other protective equipment as a result of the initial resource shortage [12]. The dearth of protective equipment makes it easier to become infected. It is believed that high risk of infection makes people anxious about personal and family health, which is highly correlated with poor sleep quality.

Expectedly, we found that worry about being infected was positively associated with poor sleep quality. Up to now, no vaccine for the COVID-19 has been used to prevent infection. People with COVID-19 infection have a risk for developing serious symptoms and even death. Without a curative drug, people will be anxious about their health when infected. Anxiety activates the hypothalamus-pituitary-adrenal (HPA) axis [33] and hypersecretion of stress-related hormones, thereby reducing duration of deep sleep and precipitating sleep disturbances [34]. A study of insomnia of medical staff involved the COVID-19 outbreak found that worry about being infected was related to sleep disorder [21], which was in line with our study.

Individuals who spent more time focusing on COVID-19-related information seemed to have a higher risk for poor sleep quality. Outbreak information, especially information about the individuals' cities, obviously raised awareness of danger to the public. Long-term focus on the epidemic results in repeated and excessive outbreak-related media exposure which possibly increases levels of worry, anxiety, and stress [26,35]. Additionally, some negative feeling, expressed by individuals on social media causes public anxiety because of the nature of emotional contagion [36]. What is more, spending too much time consuming COVID-19 information, especially before bedtime, may deprive sleep time and affect sleep quality [37]. Taken together, time spent hearing about COVID-19 outbreak was relevant to sleep quality.

For self-reported physical health and illness history, it seemed that poorer physical health [20], having respiratory disease [38,39], and having other diseases [40,41] were all risk factors for poor sleep quality. Mental illness was not a statistically significant risk factor for sleep disturbance, probably due to the small number of subjects with mental illness in this study. Patients with underlying health conditions such as chronic lung disease, chronic renal disease, and diabetes mellitus appear to be at higher risk for severe disease or death from COVID-19 [42,43]. High risk for severe COVID-19-associated outcomes, which makes the pandemic a greater stressor for those with underlying health conditions, facilitated poor sleep quality. Thus, patients with underlying health conditions might reduce or not follow up on regular medical care in hospitals due to the risk of infection outdoors. Disruption of maintenance treatment exacerbated negative feelings [5]. Furthermore, the sleep of patients with underlying health conditions may be disrupted by the disease itself, for example, by the emergence of physical symptoms at night or in the early morning [39]. Based on this, patients with respiratory illness may even suffer from abnormal breathing patterns resulting in difficulty initiating or maintaining sleep, increase in light sleep, and reduction of rapid eye movement (REM) sleep and micro-arousal [38,39]. Undoubtedly, individuals with poor physical health, especially those with chronic diseases, are more likely to have poor sleep quality.

The results of this study showed that more delayed midpoint time in bed was positively associated with poor sleep quality. Considering that the sleep-wake cycle is primarily regulated by the circadian rhythm, the larger delay in sleep phase results in a desynchronization with the circadian rhythm, leading to sleep pathology [44,45]. Additionally, as light is a social zeitgebers [44], the individuals with late midpoint time in bed may receive more indoor light before sleep in addition to their disrupted circadian rhythms, including sleep-wake rhythm and melatonin rhythm [46]. Such changes in melatonin rhythm reduce sleepiness and increase arousal at night [47]. On the whole, greater delay of the midpoint time in bed was highly correlated with poor sleep quality.

Furthermore, reduced time in bed was positively associated with poor sleep quality. Short sleep duration commonly prevents people from recovering and facilitates fatigue as well as energy deficiency [20]. Daytime dysfunction is considered part of sleep quality [24]. It should be acknowledged that less time in bed possibly results in sleep insufficiency, and thus it may subsequently impair sleep quality. Sleep insufficiency usually perturbs sleep homeostasis and increases HPA axis activity, leading to a rise in circulating levels of stress hormones, and in turn, sleep fragmentation and reduced slow-wave sleep [34].

Both poor sleepers and good sleepers had delayed midpoint time in bed during the COVID-19 outbreak compared to that before the COVID-19 outbreak. In addition, poor sleepers tended to have reduced time in bed, while good sleepers tended to increase their time in bed during the epidemic. The more delayed sleep phase and reduced time in bed—which disrupt the sleep-wake rhythm, circadian rhythm, and recovery—were highly associated with poor sleep quality. Otherwise, anxiety about COVID-19 including worry about being infected, worry about having high risk for death, and excessive exposure to outbreak-related information was also a risk factor for poor sleep quality. As poor sleep quality was prevalent in the public during the COVID-19 outbreak and it results in numerous adverse outcomes, interventions such as effective anxiety management, adherence to a sleep schedule, and sufficient sleep are important.

5. Strengths and limitations

As far as we know, this was the first study to explore the relationships between poor sleep quality and changes in sleep patterns during the COVID-19 outbreak among the public in China. First, the survey was conducted on “Toutiao”, a widely used application resulting in samples from all over China with better representativeness than other studies. Second, our study launched by CSRS was more accepted the public, indicating that the data are more reliable. Third, the survey covered the period at the beginning of the outbreak through the time of the most severe epidemic situation; thus, this study better explored the impact of the COVID-19 outbreak on sleep status among the Chinese public. Nevertheless, there were several limitations to our study. First, the response rate of the questionnaire could not be obtained because the unfinished questionnaire could not be submitted. Second, due to the time limitation of the outbreak and widespread home quarantine, the survey was only administered via an online platform, and the participants were all “Toutiao” users, which might limit the sample representativeness. Third, considering the sudden outbreak of COVID-19, the study was a cross-sectional survey and was not able to identify causal relationships between risk factors and sleep quality; additionally, the study could not evaluate changes in sleep status over time. Finally, a self-reported questionnaire was used which may have constituted retrospective bias and social desirability bias. Nonetheless, the self-reported questionnaire enabled us to obtain the sleep status in a large sample of the Chinese public during the epidemic in a short time.

6. Conclusions

In summary, poor sleep quality was highly prevalent among the general population in China during the COVID-19 outbreak. Several risk factors associated with poor sleep quality were identified, including greater delay in the midpoint time in bed, reduced time in bed, anxiety about COVID-19 such as worry about being infected and excessive exposure to outbreak-related information, and poor health status. Interventions targeting factors related to poor sleepers are warranted.

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CRediT authorship contribution statement

Yanmei Lin: Writing - original draft, Writing - review & editing, Methodology, Formal analysis, Data curation. **Shuai Liu:** Data curation, Validation, Funding acquisition. **Shuangyan Li:** Data curation. **Heming Zuo:** Resources. **Bin Zhang:** Conceptualization, Supervision, Project administration, Funding acquisition, Resources.

Conflict of interest

None.

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: https://doi.org/10.1016/j.sleep.2021.01.021.

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