



Impacts of Coronavirus Disease 2019 Pandemic on Sleep Pattern

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The ongoing coronavirus disease 2019 (COVID-19) pandemic is the third global crisis after two epidemics of severe acute respiratory syndromes. It has affected general public besides health care systems and governments. Confinements and lock downs have changed waking up time and going to bed time, ultimately affecting circadian clocks that can disturb sleep quality which can lead to anxiety, stress, and depression. This puts the most susceptible group -young adults and females- at risk of psychological disorders and even inflammatory events. Several kinds of sleep disorders due to COVID-19 including insomnia, sleep apnea, sleepiness during daytime, post-traumatic-like sleep dysfunction, abnormal dreams, and restless legs syndrome have been reported. As sleep deprivation can alter circadian clock and weaken immunity which makes human more susceptible to pulmonary inflammatory process of COVID-19 and even enhance its manifestations, it should be considered as an urgent complication that needs to be treated. Furthermore, longstanding effects of sleep disturbances during COVID-19 pandemic need to be elucidated.

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Keywords COVID-19; Sleeping habits; Sleep quality; Insomnia; Circadian clock.

INTRODUCTION

The COVID-19 pandemic is one of the biggest health challenges worldwide. It is the third global crisis after epidemics of severe acute respiratory syndrome-related coronavirus (SARS) and Middle East respiratory syndrome-related coronavirus (MERS) [1,2]. COVID-19 pandemic not only affects health care systems, but also affects government, educational systems, and the general public [3].

Isolation and social distancing as main strategies to control COVID-19 transmission have dramatic effects not only on social interactions, but also on waking up time, going to bed time, ultimately affecting circadian clocks that can disrupt a high quality sleep [4]. Recent studies in the United States and UK have shown that COVID-19 is accompanied by poor sleep quality, anxiety, stress, and depression, with a 37% increase in 2020 for mental health problems, shortly after World Health Organization's declaration about COVID-19 [5,6].

Similar results have been reported for Chinese psychological and emotional status at the beginning of the pandemic [7]. When an infectious virus attacks, any action taken to control them seems to be associated with major psychological problems and symptoms, including poor sleep quality [8,9].

According to previous data, infectious diseases in survivors and even in non-infected people can cause complaints such as anxiety, depression, post-traumatic stress disorders, and sleep deprivation which can negatively change daily behavior and mental health in general

[2,10-12]. In fact, onset of insomnia is one of the main results of intensified depression and anxiety with concern about the nonstop pandemic and its various side effects. Impaired mental health arising from sleep deprivation is an additional issue that needs to be dealt with [13]. Young adults and females are the most vulnerable population in this regard. They are mostly at risk of psychological disorders [6]. Because of this kind of social restrictions of COVID-19 pandemic, decreased quality of sleep is inevitable. However, estimation of insomnia rate is not easily accessible. It has been foresighted that a large proportion of people have experienced it [2].

Sleep disorders such as insomnia can cause mental and even inflammatory events [14]. As mentioned earlier, people who face sudden events experience an adverse effect on mental health which can lead to post-traumatic stress disorders symptomatology [15]. Events such as COVID-19 outbreak can lead to psychological symptoms and consequently deteriorate sleep quality [16].

Despite the large number of published papers on sleep disorders in the context of COVID-19 pandemic [17], longstanding effects remain to be cleared given that this health crisis remains ongoing. This study was designed to estimate sleep quality and related factors during the COVID-19 period.

SLEEP DISORDERS DURING COVID-19 PANDEMIC

Research on sleep has attracted a lot of attention when the world faces the COVID-19 pandemic because sleep has many benefits for physical and especially mental health. Increasing prevalence of insomnia during the COVID-19 outbreak has been reported previously [18]. In some cases, new onset of insomnia was detected. It was found that when insomnia defined as time in bed and total sleep time were increased, sleep efficiency was decreased significantly [18]. Supplementary Table 1 (in the online-only Data Supplement) shows some findings about sleep disorders during COVID-19 pandemic.

Delay in going to bed to sleep and wake up in the morning due to lockdown shows that people align their sleep timing with their internal time [19]. Altena et al. [20] in a work of the European Cognitive-Behavioral Treatment (CBT)-I Academy have shown that during social isolation, sleep patterns have changed due to social restrictions and adjustment of social rhythms, such as working and regular activities [21,22].

Sleep deprivation have different side effects. For instance, it could impair decision making or cause mood changes. It can increase accidents rates. It can also damage immune response and increase medical expenditures, making individuals more vulnerable to contracting the virus [23].

There are various type of sleep disorders including acute/persistent insomnia, sleep apnea due to COVID-19, sleepiness during daytime, post-traumatic-like sleep dysfunction, abnormal

dreams, and restless legs syndrome because of insomnia [24].

WHO ARE MORE VULNERABLE TO SLEEP DIFFICULTIES DURING COVID-19 PERIOD?

It seems that sleep disturbance due to COVID-19 has different manifestation among different ethnicities and societies. For example, societies with lower access to medical services for infectious diseases might show higher rate of being infected by COVID-19 and then experience sleep disorders [25]. Sleep quality is improved among self-isolated people at home for 2 weeks who could benefit from social support because it reduces anxiety and stress level [26].

Health care workers who are treating patients with COVID-19 are prone to depression, anxiety, and stress as well as sleep disorders [8,17,26,27]. Several risk factors for depression, anxiety, and stress have been introduced by Chinese studies which ultimately affect sleep quality [7,26-28]. These risk factors include the following: being woman, student, poor quality of life, and showing evocative COVID-19 symptoms. The strongest risk factors are having an underlying disease, being a healthcare staff, living in rural areas, and having contact with COVID-19 infected patients [29]. Having a primary disease make non-medical healthcare staff more disposed to insomnia and mental health problems [30]. A recent meta-analysis on sleep problems during the COVID-19 pandemic has shown that the overall prevalence rate of sleep problem is 35.7%, with those infected with COVID-19 having the highest prevalence (74.8%), followed by healthcare workers and general population (insomnia rates: 36.0 and 32.3%, respectively) [17]. The result was repeated for COVID-19 infected in another cohort. Sleep problems, depression, and anxiety last for more than six months in patients with COVID-19 [31]. These effects of COVID-19 on sleep quality and psychiatric symptoms have been reported in another systematic review [32].

COVID-19, IMMUNE SYSTEM, AND SLEEP PATTERN

Not only sleep plays a vital role in proper immune system function, but also its circumstance which determines sleep quality can affect responsiveness to vaccines [33]. Thus, it is logical that changes in routine caused by the COVID-19 pandemic due to psychosocial impact can change sleep, consequently alter immunity [34].

In a social environment with a high level of anxiety and stress because of COVID-19, sleep might be disrupted, which can deregulate inflammatory and antiviral responses. As a result, inappropriate sleep impairs immune response that can lead to infec-

tion by COVID-19 with mental health side effects [2].

Immunity includes innate immunity and adaptive immunity. Their key elements are cytokines [34]. Immune function variation in relation to sleep is more evident when there is an increase in the activity of cytokines such as interferon (IFN), tumor necrosis factor-alpha (TNF α), interleukin-1-beta (IL1 β), and C-reactive protein (CRP) in sleep deprivation [35-37]. IL-6 and TNF α are two cytokines with close relation to sleep [2]. IL-6 is a pro-inflammatory cytokine that can regulate anabolic and catabolic pathways in such way that can increase energy expenditure and finally decrease weight gain [38]. TNF α on the other hand can induce lipid breakdown, immunomodulation, apoptosis, proliferation, and pathological responses [38,39]. Nunes et al. [40] have studied effects of sleep deprivation in allergic mice. They took dexamethasone as anti-allergic medicine. However, due to sleep problems, inflammatory effects of corticosteroids were masked and IL-17 and TNF α levels were lower than those in the control group [40].

Different studies have shown that sleep duration for less than 5 hours per day can lead to more rhinopharyngitis and acute bronchitis when compared with 7–8 hours of sleep a day [41]. Even in chronic fatigue syndrome, quality of sleep determines the severity of symptoms and levels of pro-inflammatory cytokines [42]. In addition, reduction of T lymphocytes and activity of natural killer cells (NK), shorter telomere length of T-cells, and higher level of inflammatory markers (CRP and IL-6) have been reported in those with less than 6 hours of sleep a day [43].

Feelings of loneliness and defenselessness arising from social distancing might cause disappointing and depressed mood which in turn can disrupt sleep quality and some physiological dysregulation such as decreased melatonin synthesis, which can change biological rhythms [44].

Hypothalamic–pituitary–adrenal axis is another candidate for connecting deprived sleep and feelings of loneliness and fear [5,45]. When relationships of immunity, sleep, and depression are analyzed, patients who naturally experience great psychological stress have higher levels of pro-inflammatory markers, mostly CRP and IL-6. On the other hand, inflammation can potentially exaggerate depressive symptoms [14].

Sleep is not only a regulator for mood, concentration, memory, and body temperature, but also a vital element in immune system function [2]. Thus, sleep deprivation that weakens immunity can make people more susceptible to different diseases such as pulmonary inflammatory process of COVID-19. It can even enhance manifestations of COVID-19 [46].

IMPACTS OF COVID-19 ON INDIVIDUALS' CHRONOTYPES

Circadian clock is planned by different regulators such as environmental timekeepers (for example, light cycle) and endoge-

nous timekeepers (for example, supra-chiasmatic nucleus) [47]. Social pressure due to work shifts and school schedule is one the strongest factors affecting circadian timing [48]. This can lead to sleep deprivation in evening-oriented types during the week and then longer time in bed at the weekend [47].

In response to adaptation to all these environmental causes, some sleep disturbances and changes in life style may occur. When someone wakes up early in the morning, he/she is more likely to watch a movie at home instead of doing a physical activity due to social restrictions. By working at home and teleworking that has become common during the pandemic, people do not need to sleep early at night to wake up early in the morning. Since daily routine has changed, sleep pattern has also changed [49].

A recent review by Cellini et al. [21] has focused on changes in sleep quality, insomnia, sense of time, and use of electronic devices among workers and university students during COVID-19 restrictions and reported a growth in digital media's usage before bedtime [20]. This was accompanied by later falling asleep and waking up later next morning which leads to a lower quality of sleep [21]. However, information about home confinement effects due to COVID-19 pandemic on chronotype is limited. Marelli et al. [50] have reported some changes in chronotypes between pre- and during-COVID-19 isolation. Such changes were more evident among “evening types” who go to bed and wake up late, following their circadian rhythm due to their not so rigorous program. These effects were less for “intermediate types” and “morning types” as their biological time was more compliant to social routine [50].

Even with delay of bed time and waking up hours, more than 50% of young students sampled suffer from late fall asleep [50]. This outcome among high school students has been reported by Genta and colleagues who have proven effects of COVID-19 pandemic on sleep pattern, decrease in social jet lag, and a shift of chronotype toward evening type [51]. However, bed time delay between workers and students was not different meaningfully (about 40 min in both). WU delay was higher among workers in comparison with students (60 and 13 min, respectively) [21].

Fluctuations in temperature, hormones, and sleep-wakefulness can regulate some cycles in the body. They can keep the body's physiological systems during everybody life. Any imbalanced conditions can harm being status [52]. In new circumstances such as COVID-19 pandemic and restrictions, routine is not synchronized with the circadian clock, which can lead to such disorders.

In this regard, younger students experienced much more effects of lockdown on sleep and chronotype. Subjects with changes in their working conditions showed larger variances in sleep and chronotype. However, participants who did not work outside during restrictions experienced better sleep. Their chronotype became more delayed. It can be explained by the association between routine and weaker social cue such as absence of work or school schedules and limited sun light exposure as signs of dif-

ferent life routines [19].

The nonoccurrence that happens between environment cycle and endogenous circadian clock is usual among workers in irregular shifts. This group that experiences such recurrent changes in routines shows increased risk for cardiovascular and inflammatory diseases and higher blood pressure and inflammatory markers [53]. High quality night sleep with enough duration and right time has a positive effect on flexibility. It can help people cope with different aspects of disease [47,54].

STRATEGIES TO TREAT SLEEP DISTURBANCES DURING COVID-19 PANDEMIC

Taking a specific action to treat sleep disorders arising from COVID-19 pandemic remains to be clear. In cases of primary insomnia or insomnia triggered by stressors such as COVID-19, cognitive behavioral therapy (CBT) can be adopted. However, whether it works in long-term intervention has not been studied enough in recent situation [55]. Thus, it seems that use of short-term prescription such as sleep aids will work. However, choosing the best strategy needs more time. Prescribing drugs might be effective in treating acute COVID-19 related sleep disorders. For chronic insomnia, CBT is a more appropriate option. Despite the lack of sufficient data, it seems that using some sleep aids such as temazepam or quazepam could be safely considered as the first line treatment of COVID-19 related insomnia. However, they should have no interactive effects with COVID-19 medications or negative effect on respiratory system. In addition, they should not be metabolized by the liver [56].

Like most mental health disorders, sleep problems could be relieved by family and social support. With the pandemic receding and its restrictions by widespread vaccination, many stressors can be certainly removed and sleep quality will improve.

General actions specific to COVID-19 include preventative actions (vaccinations, masking and gloving, social distancing, etc.), handling of co-morbidities (medical, psychiatric and neurological), supportive actions for patients with respiratory distress (oxygen, ventilator support), disease-specific treatments (e.g., remdesivir, monoclonal antibodies [e.g., tocilizumab], corticosteroids, etc.) (although efficacy has not been proven), specific measures to battle sleep disorder, short-term sleep aids for acute insomnia, cognitive-behavioral therapy for chronic insomnia, melatonin for ICU-related fever and sleep dysfunction, and positive airway pressure treatment for obstructive sleep apnea (using special precautions to prevent aerosolization) [24].

CONCLUSION

Taking together, adopting an urgent strategy to help sleep qual-

ity in general population and health care staffs during COVID-19 pandemic is essential. At present, social and administrative support, relaxation practices, and practical working plans might be helpful for improving sleep quality.

Supplementary Materials

The online-only Data Supplement is available with this article at <https://doi.org/10.17241/smr.2022.01557>.

Availability of Data and Material

Data sharing not applicable to this article as no datasets were generated or analyzed during the study.

Author Contributions

Conceptualization: Samira Rabiei. Data curation: Maryam Nazari. Resources: Samira Rabiei, Maryam Nazari. Writing—original draft: Samira Rabiei. Writing—review & editing: Maryam Nazari.

Conflicts of Interest

The authors have no potential conflicts of interest to disclose.

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REFERENCES

- Li Q, Guan X, Wu P, Wang X, Zhou L, Tong Y, et al. Early transmission dynamics in Wuhan, China, of novel coronavirus-infected pneumonia. *N Engl J Med* 2020;382:1199-207.
- Silva ESME, Ono BHVS, Souza JC. Sleep and immunity in times of COVID-19. *Rev Assoc Med Bras (1992)* 2020;66(Suppl 2):143-7.
- Triggle CR, Bansal D, Farag EABA, Ding H, Sultan AA. COVID-19: learning from lessons to guide treatment and prevention interventions. *mSphere* 2020;5:e00317-20.
- Guichard K, Geoffroy P, Taillard J, Micoulaud-Franchi JA, Royant-Parola S, Poirot I, et al. [Strategies for managing the impact of confinement on sleep: a summary of experts]. *Med du Sommeil* 2020;17:108-12. French
- Voitsidis P, Gliatas I, Bairachtari V, Papadopoulou K, Papageorgiou G, Parlapani E, et al. Insomnia during the COVID-19 pandemic in a Greek population. *Psychiatry Res* 2020;289:113076.
- Daly M, Sutin A, Robinson E. Longitudinal changes in mental health and the COVID-19 pandemic: evidence from the UK household longitudinal study. *Psychol Med* 2022;52:2549-58.
- 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;17:1729.
- Wu K, Wei X. Analysis of psychological and sleep status and exercise rehabilitation of front-line clinical staff in the fight against COVID-19 in China. *Med Sci Monit Basic Res* 2020;26:e924085.
- Jahrami H, BaHammam AS, AlGahtani H, Ebrahim A, Faris M, AlEid K, et al. The examination of sleep quality for frontline healthcare workers during the outbreak of COVID-19. *Sleep Breath* 2021;25:503-11.
- Hull HF. SARS control and psychological effects of quarantine, Toronto, Canada. *Emerg Infect Dis* 2005;11:354-5.
- Wu KK, Chan SK, Ma TM. Posttraumatic stress, anxiety, and depression in survivors of severe acute respiratory syndrome (SARS). *J Trauma Stress* 2005;18:39-42.
- Wu KK, Chan SK, Ma TM. Posttraumatic stress after SARS. *Emerg Infect Dis* 2005;11:1297-300.
- Tempesta D, Succi V, De Gennaro L, Ferrara M. Sleep and emotional processing. *Sleep Med Rev* 2018;40:183-95.

14. Irwin MR, Opp MR. Sleep health: reciprocal regulation of sleep and innate immunity. *Neuropsychopharmacology* 2017;42:129-55.
15. Mak IW, Chu CM, Pan PC, Yiu MG, Ho SC, Chan VL. Risk factors for chronic post-traumatic stress disorder (PTSD) in SARS survivors. *Gen Hosp Psychiatry* 2010;32:590-8.
16. Brooks SK, Webster RK, Smith LE, Woodland L, Wessely S, Greenberg N, et al. The psychological impact of quarantine and how to reduce it: rapid review of the evidence. *Lancet* 2020;395:912-20.
17. Jahrami H, BaHammam AS, Bragazzi NL, Saif Z, Faris M, Vitiello MV. Sleep problems during the COVID-19 pandemic by population: a systematic review and meta-analysis. *J Clin Sleep Med* 2021;17:299-313.
18. Li Y, Qin Q, Sun Q, Sanford LD, Vgontzas AN, Tang X. Insomnia and psychological reactions during the COVID-19 outbreak in China. *J Clin Sleep Med* 2020;16:1417-8.
19. Leone MJ, Sigman M, Golombek DA. Effects of lockdown on human sleep and chronotype during the COVID-19 pandemic. *Curr Biol* 2020;30:PR930-1.
20. Altena E, Baglioni C, Espie CA, Ellis J, Gavriloff D, Holzinger B, et al. Dealing with sleep problems during home confinement due to the COVID-19 outbreak: practical recommendations from a task force of the European CBT-I Academy. *J Sleep Res* 2020;29:e13052.
21. Cellini N, Canale N, Mioni G, Costa S. Changes in sleep pattern, sense of time and digital media use during COVID-19 lockdown in Italy. *J Sleep Res* 2020;29:e13074.
22. Losada-Baltar A, Jiménez-Gonzalo L, Gallego-Alberto L, Pedroso-Chaparro MDS, Fernandes-Pires J, Márquez-González M. "We are staying at home." Association of self-perceptions of aging, personal and family resources, and loneliness with psychological distress during the lock-down period of COVID-19. *J Gerontol B Psychol Sci Soc Sci* 2021;76:e10-6.
23. Medic G, Wille M, Hemels ME. Short- and long-term health consequences of sleep disruption. *Nat Sci Sleep* 2017;9:151-61.
24. Bhat S, Chokroverty S. Sleep disorders and COVID-19. *Sleep Med* 2022;91:253-61.
25. Jackson CL, Johnson DA. Sleep disparities in the era of the COVID-19 pandemic highlight the urgent need to address social determinants of health like the virus of racism. *J Clin Sleep Med* 2020;16:1401-2.
26. Xiao H, Zhang Y, Kong D, Li S, Yang N. Social capital and sleep quality in individuals who self-isolated for 14 days during the coronavirus disease 2019 (COVID-19) outbreak in January 2020 in China. *Med Sci Monit* 2020;26:e923921.
27. 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.
28. Li Z, Ge J, Yang M, Feng J, Qiao M, Jiang R, et al. Vicarious traumatization in the general public, members, and non-members of medical teams aiding in COVID-19 control. *Brain Behav Immun* 2020;88:916-9.
29. Alimoradi Z, Broström A, Tsang HWH, Griffiths MD, Haghayegh S, Ohayon MM, et al. Sleep problems during COVID-19 pandemic and its' association to psychological distress: a systematic review and meta-analysis. *EclinicalMedicine* 2021;36:100916.
30. Zhang WR, Wang K, Yin L, Zhao WF, Xue Q, Peng M, et al. Mental health and psychosocial problems of medical health workers during the COVID-19 epidemic in China. *Psychother Psychosom* 2020;89:242-50.
31. Huang C, Huang L, Wang Y, Li X, Ren L, Gu X, et al. 6-month consequences of COVID-19 in patients discharged from hospital: a cohort study. *Lancet* 2021;397:220-32.
32. Vindegaard N, Benros ME. COVID-19 pandemic and mental health consequences: systematic review of the current evidence. *Brain Behav Immun* 2020;89:531-42.
33. Irwin MR. Why sleep is important for health: a psychoneuroimmunology perspective. *Annu Rev Psychol* 2015;66:143-72.
34. Abbas AK, Lichtman AH, Pillai S. *Cellular and molecular immunology*. Philadelphia: Elsevier 2017;51-2.
35. Ruiz F, Tufik S. Sleep and sleep medicine. In: Paiva T, Andersen ML, Tufik S. *Immunological aspects of sleep*. Barueri: Manole 2014;124-31.
36. Laan M, Cui ZH, Hoshino H, Lötvall J, Sjöstrand M, Gruenert DC, et al. Neutrophil recruitment by human IL-17 via C-X-C chemokine release in the airways. *J Immunol* 1999;162:2347-52.
37. Miyamoto M, Prause O, Sjöstrand M, Laan M, Lötvall J, Lindén A. Endogenous IL-17 as a mediator of neutrophil recruitment caused by endotoxin exposure in mouse airways. *J Immunol* 2003;170:4665-72.
38. Veronesi R, Focaccia R. [Textbook of infectology]. 5th ed. São Paulo: Atheneu 2015;334-5.
39. Holbrook J, Lara-Reyna S, Jarosz-Griffiths H, McDermott M. Tumour necrosis factor signalling in health and disease. *F1000Res* 2019;8(F1000 Faculty Rev):111.
40. Nunes JOF, Apostolico JS, Andrade DAG, Ruiz FS, Fernandes ER, Andersen ML, et al. Sleep deprivation predisposes allergic mice to neutrophilic lung inflammation. *J Allergy Clin Immunol* 2018;141:1018-27.e4.
41. Prather AA, Leung CW. Association of insufficient sleep with respiratory infection among adults in the United States. *JAMA Intern Med* 2016;176:850-2.
42. Milrad SF, Hall DL, Jutagir DR, Lattie EG, Ironson GH, Wohlgemuth W, et al. Poor sleep quality is associated with greater circulating pro-inflammatory cytokines and severity and frequency of chronic fatigue syndrome/myalgic encephalomyelitis (CFS/ME) symptoms in women. *J Neuroimmunol* 2017;303:43-50.
43. Besedovsky L, Lange T, Haack M. The sleep-immune crosstalk in health and disease. *Physiol Rev* 2019;99:1325-80.
44. van Santen A, Vreeburg SA, Van der Does AJ, Spinhoven P, Zitman FG, Penninx BW. Psychological traits and the cortisol awakening response: results from the Netherlands study of depression and anxiety. *Psychoneuroendocrinology* 2011;36:240-8.
45. Griffin SC, Williams AB, Mladen SN, Perrin PB, Dzierzewski JM, Rybarczyk BD. Reciprocal effects between loneliness and sleep disturbance in older Americans. *J Aging Health* 2020;32:1156-64.
46. Salles C, Mascarenhas Barbosa H. COVID-19 and obstructive sleep apnea. *J Clin Sleep Med* 2020;16:1647.
47. Staller N, Randler C. Changes in sleep schedule and chronotype due to COVID-19 restrictions and home office. *Somnologie (Berl)* 2021;25:131-7.
48. Roenneberg T, Allebrandt KV, Meroo M, Vetter C. Social jetlag and obesity. *Curr Biol* 2012;22:939-43.
49. Tosini G, Ferguson I, Tsubota K. Effects of blue light on the circadian system and eye physiology. *Mol Vis* 2016;22:61-72.
50. Marelli S, Castelnuovo A, Somma A, Castronovo V, Mombelli S, Bottoni D, et al. Impact of COVID-19 lockdown on sleep quality in university students and administration staff. *J Neurol* 2021;268:8-15.
51. Genta FD, Rodrigues Neto GB, Sunfeld JPV, Porto JF, Xavier AD, Moreno CRC, et al. COVID-19 pandemic impact on sleep habits, chronotype, and health-related quality of life among high school students: a longitudinal study. *J Clin Sleep Med* 2021;17:1371-7.
52. Farhud D, Aryan Z. Circadian rhythm, lifestyle and health: a narrative review. *Iran J Public Health* 2018;47:1068-76.
53. Morris CJ, Purvis TE, Hu K, Scheer FA. Circadian misalignment increases cardiovascular disease risk factors in humans. *Proc Natl Acad Sci U S A* 2016;113:E1402-11.
54. Morin CM, Carrier J, Bastien C, Godbout R; Canadian Sleep and Circadian Network. Sleep and circadian rhythm in response to the COVID-19 pandemic. *Can J Public Health* 2020;111:654-7.
55. Edinger JD, Wohlgemuth WK, Radtke RA, Marsh GR, Quillian RE. Cognitive behavioral therapy for treatment of chronic primary insomnia: a randomized controlled trial. *JAMA* 2001;285:1856-64.
56. Rismanbaf A. Insomnia drug therapy in COVID-19 patients; a letter to editor. *Caspian J Intern Med* 2020;11(Suppl 1):583-4.

Supplementary Table 1. Sleep disorders during COVID-19 pandemic

Author/ Country/Year	Theme	Population	Methods/Measures	Findings
Abdulah/ Iraq/2020 [1]	Quantifying the severity of sleep difficulty and its association with duration of dealing with suspected/confirmed cases of COVID-19 in physicians	268 physicians Age: 35.06 ± 7.61 years Male: 188 (70.1%)	Cross-sectional, convenience sampling/ AIS	Working with COVID-19 patients has a negative effect on the sleep of physicians.
Wang/ China/2020 [2]	Evaluating sleep quality and working pressure in HCWs	118 healthcare workers 12 HCWs (Acquired COVID-19) 106 Healthcare workers (Healthy) Age: 30.5 ± 5.3 years	Cross-sectional, convenience sampling/ PSQI, NSI	Poor sleep quality and high working pressure were positively related with high risks of COVID-19.
Beck/ France/2021 [3]	Examine sleep quality among 1005 general population and COVID-19 patients	1005 general population	Cross-sectional, convenience sampling/ Researcher developed	COVID pandemic is associated with severe sleep disorders among the French, especially young people.
Casagrande/ Italy/2020 [4]	Assessing psychological effects of the COVID-19 outbreak on aspects of sleep quality, general anxiety symptomatology, and psychological distress	2291 general population Age: 18.89 ± 11.5 years Male: 580 (25.3%)	Cross-sectional, convenience sampling/ GAD-7, PGWB, PSQI, PCL-5	COVID-19 crisis appears to be a risk factor for sleep disorders and psychological diseases in the Italian population.
Cellini/ Italy/2020 [5]	Investigating the change in digital media use before going to bed, sleep quality, and their association with depression, anxiety, and stress levels	1310 young adults aged 18 to 35 years Age: 23.91 ± 3.60 years	Cross-sectional, convenience sampling/ PSQI, DASS-21	The increase in sleep disorders was stronger for people with a higher level of depression, anxiety and stress, and related with the feeling of elongation of time.
Innocenti/ Italy/2020 [6]	Examine sleep disorders in Italy amid pandemic COVID-19	1035 general population Age: 30–50 years Male: 177 (17.1%)	Cross-sectional, convenience sampling/ PSQI	Disqualified sleep during COVID-19, might represent a risk factor for the development of chronic insomnia or other sleep disorders.
Kaparounaki/ Greece/2020 [7]	Examining the impact of the lockdown on the mental health behaviors in university students	1000 general population (university students) Age: 22.07 ± 3.3 years Male: 309 (30.99%)	Cross-sectional, convenience sampling/ STAI, CES-D, RASS	There was a 25-fold increase in possible clinical cases of depression and an almost 8-fold increase in suicidal thoughts.
Sheng/ China/2020 [8]	Examining the psychological status and sleep quality during the outbreak of COVID-19	95 nursing interns who isolated a general teaching hospital Age: 21.26 ± 1.01 years Male: 6 (6.5%)	Cross-sectional, convenience sampling/ SAS, SDS, PSQI	Results showed relatively high levels of anxiety and depression during the collective isolation that affected sleep quality.
Xiao/ China/2020 [9]	Identifying the social support influence on sleep quality and function of medical staff who treated patients with COVID-19 using SEM	180 medical staff who treated patients with COVID-19 infection Male: 51 (28.3%)	Cross-sectional, convenience sampling/ SAS, GSES, SASR, PSQI, SSRS	Health workers in China who were treating patients with COVID-19 infection during January and February 2020 showed levels of anxiety, stress, and self-efficacy that were associated with sleep quality and social support.

COVID-19, coronavirus disease 2019; AIS, Athens Insomnia Scale; CES-D, Center of Epidemiological Studies Depression Scale; GAD-7, Generalized Anxiety Disorder Scale; IAT, Internet Addiction Test; NSI, Nurse Stress Index; PCL-5, Posttraumatic Stress Disorder Checklist for DSM-5; PGWB, General Well-Being Questionnaire; PSQI, Pittsburgh Sleep Quality Index; RASS, Richmond Agitation Sedation Scale; SAS, Self-Rating Anxiety Scale; SASR, Stanford Acute Stress Reaction; SDS, Self-Rating Depression Scale; SSRS, Social Support Rate Scale; HCW, health care workers; SEM, structural equation modeling; DASS-21, Depression Anxiety Stress Scales 21; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; HADS, Hospital Anxiety and Depression Scale; STAI, State Trait Anxiety Inventory; GSES, General Self-Efficacy Scale.

REFERENCES

- Abdulah DM, Musa DH. Insomnia and stress of physicians during COVID-19 outbreak. *Sleep Med X* 2020;2:100017.
- Wang X, Jiang X, Huang Q, Wang H, Gurarie D, Ndeffo-Mbah M, et al. Risk factors of SARS-CoV-2 infection in healthcare workers: a retrospective study of a nosocomial outbreak. *Sleep Med X* 2020;2:100028.
- Beck F, Léger D, Fressard L, Peretti-Watel P, Verger P, Coconel Group. Covid-19 health crisis and lockdown associated with high level of sleep complaints and hypnotic uptake at the population level. *J Sleep Res* 2021;30:e13119.
- Casagrande M, Favieri F, Tambelli R, Forte G. The enemy who sealed the world: effects quarantine due to the COVID-19 on sleep quality, anxiety, and psychological distress in the Italian population. *Sleep Med* 2020;75:12-20.
- Cellini N, Canale N, Mioni G, Costa S. Changes in sleep pattern, sense of time and digital media use during COVID-19 lockdown in Italy. *J Sleep Res* 2020;29:e13074.
- Innocenti P, Puzella A, Mogavero MP, Bruni O, Ferri R. Letter to editor: CoVID-19 pandemic and sleep disorders-a web survey in Italy. *Neurol Sci* 2020; 41:2021-2.
- Kaparounaki CK, Patsali ME, Mousa DV, Papadopoulou EVK, Papadopoulou KKK, Fountoulakis KN. University students' mental health amidst the COVID-19 quarantine in Greece. *Psychiatry Res* 2020;290:113111.
- Sheng X, Liu F, Zhou J, Liao R. [Psychological status and sleep quality of nursing interns during the outbreak of COVID-19]. *J South Med Univ* 2020;40: 346-50. Chinese
- 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.