https://doi.org/10.5664/jcsm.8930

JCSM | Journal of Clinical Sleep Medicine

REVIEW ARTICLES

Sleep problems during the COVID-19 pandemic by population: a systematic review and meta-analysis

Haitham Jahrami, PhD[1,2]; Ahmed S. BaHammam, MD[3,4]; Nicola Luigi Bragazzi, MD[5]; Zahra Saif, MSc[1]; MoezAlIslam Faris, PhD[6]; Michael V. Vitiello, PhD[7]

[1]Ministry of Health, Manama, Kingdom of Bahrain; [2]College of Medicine and Medical Sciences, Arabian Gulf University, Manama, Kingdom of Bahrain; [3]Department of Medicine, College of Medicine, University Sleep Disorders Center, King Saud University, Riyadh, Saudi Arabia; [4]The Strategic Technologies Program of the National Plan for Sciences and Technology and Innovation in the Kingdom of Saudi Arabia, Riyadh, Saudi Arabia; [5]Laboratory for Industrial and Applied Mathematics, Department of Mathematics and Statistics, York University, Toronto, Canada; [6]Department of Clinical Nutrition and Dietetics, College of Health Sciences/ Research Institute for Medical and Health Sciences, University of Sharjah, Sharjah, United Arab Emirates; [7]Psychiatry & Behavioral Sciences, Gerontology & Geriatric Medicine, and Biobehavioral Nursing, University of Washington, Seattle, Washington

Study Objectives: No systematic review or meta-analysis has yet been conducted to examine the impact of the pandemic on the prevalence of sleep problems among the general population, health care workers, or patients with COVID-19. Therefore, this systematic review was conducted to assess the impact and prevalence of sleep problems among those categories.

Methods: American Psychological Association PsycINFO, Cochrane, Cumulative Index to Nursing and Allied Health Literature (CINAHL), EBSCOhost, EMBASE, Google Scholar, MEDLINE, ProQuest Medical, ScienceDirect, Scopus, and Web of Science from November 1, 2019 to July 5, 2020 were used. Additionally, 5 preprints servers (medRxiv.org; preprints.org; psyarxiv.com; arXiv.org; biorxiv.org) were also searched for papers accepted after peer review but not yet published and indexed. There was no language restriction. The random-effect models meta-analysis model was used with the DerSimonian and Laird methodology.

Results: Forty-four papers, involving a total of 54,231 participants from 13 countries, were judged relevant and contributed to the systematic review and meta-analysis of sleep problems during COVID-19. The global pooled prevalence rate of sleep problems among all populations was 35.7% (95% confidence interval, 29.4–42.4%). Patients with COVID-19 appeared to be the most affected group, with a pooled rate of 74.8% (95% confidence interval, 28.7–95.6%). Health care workers and the general population had comparative rates of sleep problems, with rates of 36.0% (95% confidence interval, 21.1–54.2%) and 32.3% (95% confidence interval, 25.3–40.2%), respectively.

Conclusions: The prevalence of sleep problems during the COVID-19 pandemic is high and affects approximately 40% of people from the general and health care populations. Patients with active COVID-19 appeared to have a higher prevalence rates of sleep problems.

Keywords: sleep disturbance; pandemic; insomnia; sleep hygiene; circadian rhythm.

Citation: 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(2):299–313.

INTRODUCTION

In late December of 2019, a series of cases of a novel virus, eventually named "2019 novel coronavirus (2019-nCoV/SARS-CoV-2)," causing respiratory infections in humans, was observed in the Chinese city of Wuhan.[1] The virus causes the coronavirus disease 2019 (COVID-19) and spread rapidly worldwide. On January 30, 2020, the World Health Organization declared COVID-19 a Public Health Emergency of International Concern, and on March 11, 2020, a pandemic.[2] COVID-19 has infected 14,832,283 patients globally, causing 612,266 deaths as of July 21, 2020.[3]

The COVID-19 pandemic is a considerable challenge to governments, health care systems, educational institutions, and the general public. In the absence of successful treatments or vaccines, measures to manage the spread of the virus were mainly social distancing, wearing masks, frequent hand hygiene and other measures to neutralize the virus if exposure has occurred, and quarantine.[4] Outbreaks of infectious diseases, combined with measures to control the outbreaks, are associated with major psychologic distress and significant symptoms, including poor sleep quality.[5,6] Data from an ongoing longitudinal study of a large representative sample of UK households indicated that 1 month after the World Health Organization's declaration, the percentage of adults categorized as having mental health problems increased from approximately 23% in 2017–2019 to approximately 37% in late April 2020.[7] This increase was particularly striking in young adults and females, an intersection where the risks of anxiety symptoms, depressive symptoms, and sleep problems are high.[7]

When facing the COVID-19 pandemic, sleep becomes essential because of its many benefits for mental and physical health. Lack of sleep can impair psychologic functioning and decision making, jeopardize immune response, increase accidents, lead to mood changes, increase medical expenditures, and render individuals more susceptible to contracting the virus because of poor concentration.[8]

No systematic review or meta-analysis has yet been conducted to examine the impact of the pandemic on the prevalence of sleep problems among the general population, health care

workers, or patients with COVID-19; therefore, the prevalence and severity of sleep problems in different populations remains unknown. To address this knowledge gap, we conducted a comprehensive systematic review and meta-analysis of the prevalence of sleep problems in the face of the pandemic in different populations. These findings may prove helpful in developing effective strategies for screening and providing interventions to lower the negative outcome related to sleep problems.

METHODS

Search strategy

We conducted a scoping review of all available literature on sleep and COVID-19, followed by a systematic review and meta-analysis of original research in compliance with the recommendations and criteria described in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses checklist.[9]

Databases search

Two authors (HJ and ZS) conducted an electronic search in 10 electronic databases and 1 scholarly search engine: American Psychological Association PsycINFO; Cochrane; Cumulative Index to Nursing and Allied Health Literature (CINAHL); EBSCOhost; EMBASE; Google Scholar; MEDLINE; ProQuest Medical; ScienceDirect; Scopus; and Web of Science from November 1, 2019 to July 5, 2020. Additionally, 5 preprints servers (medRxiv.org; Preprints.org; psyarxiv.com; arXiv.org; biorxiv.org) were also searched for papers accepted after peer-review but not yet published and indexed. There was no language restriction.

The search strategy involved the crosschecking of keywords selected based on the Medical Subjects Headings and Boolean logic operators. The following keywords were used in an [All Fields] search:

"COVID-19" OR "2019-nCoV" OR "2019 coronavirus" OR "Wuhan coronavirus" OR "2019 novel coronavirus" OR "SARS-CoV-2" AND "sleep" OR "sleep medicine" OR "sleep disturbances" OR "sleep disorders" OR "sleep problems" OR "polysomnography" OR "sleep quality" OR "PSQI" OR "Pittsburg Sleep Quality Index" OR "insomnia" OR "circadian rhythm" OR "restless leg syndrome" OR "sleep apnea" OR "narcolepsy" OR "daytime dysfunction" OR "daytime sleepiness" OR "ESS" or "Epworth Sleepiness Scale" AND "prevalence" OR "incidence" OR "epidemiology" OR "rate" OR "frequency" OR "risk factors" OR "interventions" OR "treatment" OR "therapy" OR "management".

Reference lists of the obtained studies were searched to find relevant articles and reviews and to make sure that all related publications were included in the current analysis.

The full-text versions of the obtained literature were screened, extracted, and analyzed for methodologic quality by 2 researchers (HJ and ZS). The processes were performed independently, and disagreements between reviewers were resolved by discussion and consensus with a third member of the research team (AB).

Selection criteria and outcomes

The primary outcome of the meta-analysis is the magnitude of sleep problems during the COVID-19 pandemic. Thus, we screened all observational and intervention clinical studies that studied the effect of COVD-19 on the sleep quantity and quality of different populations (eg, patients infected with COVID-19, health care workers, and the general population). Specific inclusion criteria for study selection were as follows: (1) publication date between November 1, 2019 and July 5, 2020; (2) original research articles published in the English, Spanish, German, Portuguese, French, Italian, and Arabic languages; and (3) studies that reported numerical values (eg, arithmetic mean with/without standard deviation or prevalence rate) for sleep problems. The following exclusion criteria were applied to retrieved articles to eliminate factors that may incur potential methodologic and quality issues: abstracts, infographics, letters, editorials, narrative reviews, opinions, and position statements. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram of study selection is presented in **Figure 1**.

Data extraction

Data extraction for complex meta-analysis guidelines[10] were used to plan data extracting for this review. Data extraction involved "study details", "epidemiological findings", and "citation of the article". Study details included: "last author", "time of publication MM/YYYY", "country of origin", "type of study", "objectives of the study", "sample size", "recruitment strategy", "basic sample characteristics including age and % male". Epidemiologic findings included the following: arithmetic mean with/without standard deviation or prevalence rate for "sleep quality" and "other significant findings." The citation included the full citation details of the article, including the digital object identifier. We contacted the corresponding authors when needed for clarifications and to request more information.

Two independent researchers (HJ and ZS) used a Microsoft Excel Spreadsheet to extract the data independently; this was confirmed by a third member (NB).

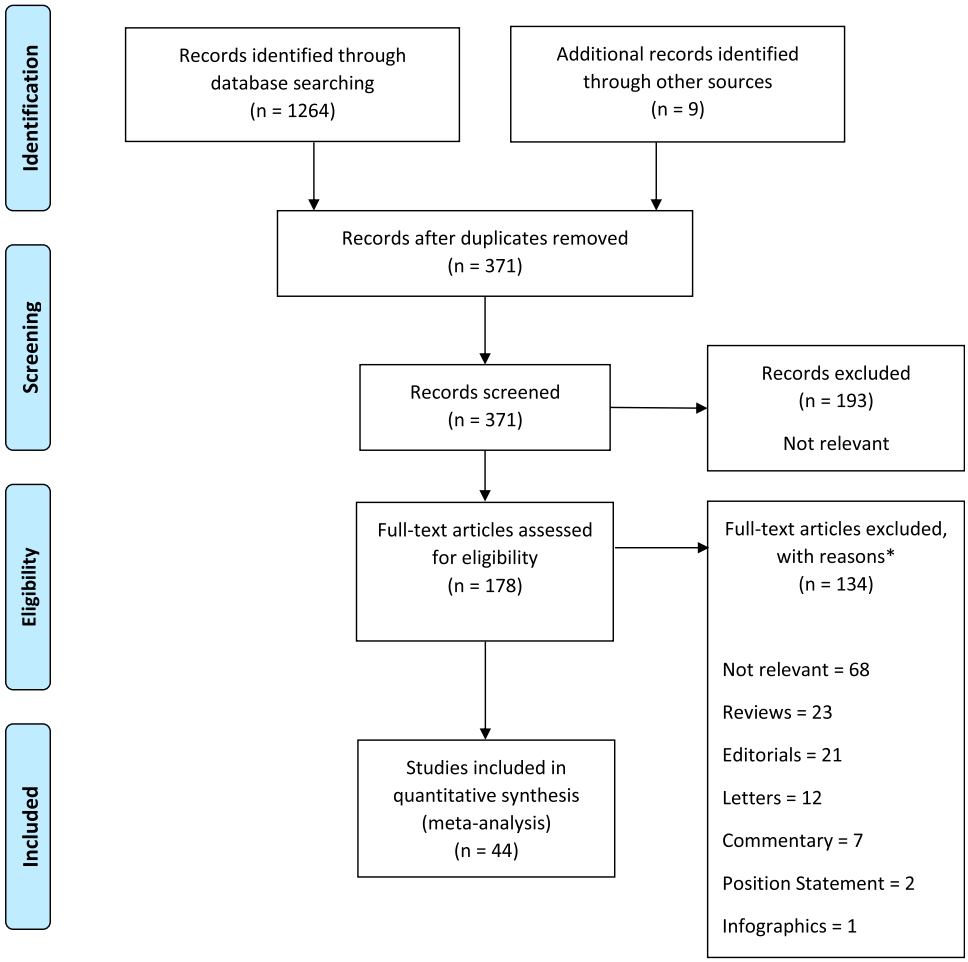
Quality assessment of the studies

We used the Newcastle–Ottawa Scale adapted for cross-sectional studies by Herzog et al[11] to assess the quality of the included studies. The Newcastle–Ottawa Scale for cross-sectional studies checklist contains 7 questions, which we divided into 3 domains: participants selection (questions 1–4), comparability (question 5), and outcome and statistics (questions 6 and 7). Scores range from 0 to 10. Details of the items used in Newcastle–Ottawa Scale and score interpretations are presented in Supplemental Table S1. Quality assessment was also performed in parallel with data extraction by the same researchers (HJ and ZS), and a consensus approach was used to determine the quality score for each study.

Data analysis

Random-effect models meta-analysis model were used with the DerSimonian and Laird methodology,[12] assuming that the effect of interest is not the same in all studies and that the differences observed between them are only caused by sampling errors (variability within the studies). The heterogeneity of the

Figure 1—Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram of study inclusion.



estimates of the sample size effect throughout these studies was quantified by the I^2 statistic. The heterogeneity between the studies was assessed by Cochran's Q test and τ^2 statistics. As the estimates of the prevalence of sleep problems can vary according to the types of populations involved, subgroup meta-analyses were used to assess whether the sleep problems in each of the populations influenced the joint estimate. The results are presented in a forest plot as a point estimate with 95% confidence intervals (95% CIs). A leave-one-out sensitivity analysis was performed by iteratively removing 1 study at a time to confirm that any single study did not drive our findings. Subgroup analysis was performed to examine differences between groups based on categorical variables (eg, research population, research measure). Subgroup analysis was only reported if there were 3 or more studies available for analysis. Meta-regression techniques were applied to analyze for continuous covariates of sleep problems; we used 2 covariates, mean age, and proportion of male sex. Publication bias was assessed using funnel plots to visually assess publication bias. For robust assessment of publication bias, Kendall's tau rank order correlations and Egger's regression were computed.[13] It was planned a priori that when needed, Duval and Tweedie's trim and fill procedure was used to calculate adjusted point estimates to correct for funnel plot asymmetry arising from potential publication bias.[14] Data analyses were performed using Comprehensive Meta-Analysis version 3.0, and visualizations were made using R software for statistical computing version 4.0.2 using the package metafor.

RESULTS

Characteristics of included literature

The initial search was conducted up to June 10, 2020 and was updated to July 5, 2020. A total of 1273 records were identified through database searching and other sources. When duplicates were removed, 371 records remained. A total of 178 potential papers were full text screened. Of these, 134 papers were excluded including narrative and systematic reviews, editorials, commentaries, letters to the editor, position statements irrelevant literature, duplicates, or wrongly classified papers.

Three major themes were identified in the excluded literature; the impact of COVID-19 on the practice of sleep medicine; the importance of prioritization the services for individuals with sleep disorders (especially breathing-related sleep disorders) during the pandemic; and the role of melatonin and other supplements on regulating sleep-wake rhythm.

Table 1—Selected characteristics, methods, and major findings of the included studies in this review about sleep problems during COVID-19.

SN	First Author	Year/Month	Country	Theme	Population	Methods	Measures	Quality*
1	Abdulah	2020/05	Iraq	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 Male: 188 (70.1%)	Cross-sectional, convenience sampling	AIS PSS	8
2	Ahmad	2020/05	India	Examining the correlation between anxiety and socio-demographic factors during Covid19 lockdown among the general Indian population.	398 general population. Age: 30.3 ± 9.28	Cross-sectional, convenience sampling	GAD-7	8
3	Ammar	2020/05	Germany	Creating scientific data to analyzing risk-factors for the psychosocial strain during the COVID-19	1047 general population. Male: 482 (46%)	Cross-sectional, convenience sampling	Researcher developed	7
4	Bai	2020/04	China	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	7
5	Beck	2020/05	France	Examine sleep quality among 1005 general population and COVID-19 patients.	1005 general population.	Cross-sectional, Convenience sampling	Researcher developed	7
6	Bohlken	2020/05	German	Evaluating the effects of the COVID-19 pandemic On German psychiatrist and neurologist.	396 psychiatrists and neurologists.	Cross-sectional, convenience sampling	Researcher developed	7
7	Casagrande	2020/05	Italy	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 Male: 580 (25.3%)	Cross-sectional, convenience sampling	GAD-7 PGWB PSQI PCL-5	8
8	Cellini	2020/05	Italy	Investigating the change in digital media use before going to bed, sleep quality, and their association with depression, anxiety, and stress levels.	1, 310 young adults aged 18 to 35 years Age: 23.91 ± 3.60 years	Cross-sectional, convenience sampling	PSQI DASS-21	8
9	Garcia-Priego	2020/05	Mexico	Estimating the prevalence and distribution of anxiety and depression and assessing the correlation with internet addiction during the COVID-19 outbreak.	561 general population Age: 30.7 ± 10.6 years Male: 163 (29%)	Cross-sectional, convenience sampling	HADS IAT	8
10	Goodman-Casanova	2020/05	Spain	Investigating the impact of confinement on the health status and well-being of community-dwelling and examine the consequence of a television-based	93 general population (older adults). Age: 73.34 ± 6.07 Male: 32 (35%)	Cross-sectional, convenience sampling	Researcher developed	7

(continued on following page)

Table 1—Selected characteristics, methods, and major findings of the included studies in this review about sleep problems during COVID-19. (continued)

SN	First Author	Year/Month	Country	Theme	Population	Methods	Measures	Quality*
				assistive integrated technology during COVID-19.				
11	Hartley	2020/05	France	Analyzing the sleep evolution of during the COVID-19 and identifying associated factors	1, 777 COVID-19 patients in quarantine. Age: 25–54 years Male: 409 (23%)	Cross-sectional, convenience sampling	Researcher developed	7
12	Huang	2020/04	China	Examining the mental health burden of the public during the COVID-19 outbreak and to determining the high-risk group.	7, 236 general population Age: 35.3 ± 5.6 years Male: 3284 (45.4%) were males.	Cross-sectional, convenience sampling	GAD-7 CES-D PSQI	8
13	Innocenti	2020/06	Italy	Examine sleep disorders in Italy amid pandemic COVID-19.	1035 general population. Age: 30–50 years range Male: 177(17.1)%	Cross-sectional, Convenience sampling	PSQI	8
14	Jahrami	2020/07	Bahrain	Assess the prevalence of stress and poor sleep quality and its association with demographic among healthcare workers professionals.	257 healthcare workers (129 frontline healthcare workers and 12 nonfrontline healthcare workers). Age: 40.2 ± 9.7 Male: 77 (30.0%)	Cross-sectional, Simple random sample	PSS PSQI	8
15	Jung	2020/05	Germany	Examining mental health during the lockdown.	3, 545 general population. Age: 40.36 ± 11.70 Male:539 (15.2%)	Cross-sectional, convenience samplin.	PHQ-D/9 PHQ-4 WHO-5	8
16	Kaparounaki	2020/05	Greece	Examining the impact of the lockdown on the mental health behaviors in university students.	1,000 general population (university students). Age: 22.07 ± 3.3 years Male: (30.99%)	Cross-sectional, convenience sampling	STAI CES-D RASS	8
17	Killgore	2020/05	USA	Assessing Anxiety about COVID-19 and it's the association with insomnia severity and suicidal ideation.	1, 013 adult general population. Age: Ranging 18-35 years Male: 446 (44%)	Cross-sectional, convenience sampling	ISI PHQ-9	8
18	Kokou-Kpolou	2020/05	France	Estimating the prevalence of clinical insomnia and its contributing factors during COVID-19.	566 adult general population. Age: 30.06 years Male: 142 (25%).	Cross-sectional, convenience sampling	ISI UCLA	8
19	Li	2020/06	China	Examine potential risk factors associated with sleep Disturbances during pandemic COVID-19.	1970 general population. Age: 37.81 ± 11.00 years. Male: 650(33)%	Cross-sectional, Convenience sampling	SDST	8
20	Liguori	2020/05	Italy	Examining the sNS in patients with COVID-19 infection.	103 patients with COVID-19 infection hospitalized at the University Hospital of Rome. Age: 55 ± 14.65 Male: 94 (91.5%)	Cross-sectional, convenience sampling	sNS	7
21	Lin	2020/06	China	Examine sleep disorders in China amid pandemic COVID-19.	5641 general population. Age: range 18+ years Male: 1685 (29.9%)	Cross-sectional, Convenience sampling	ISI PHQ-9 GAD-7 ASDS	8
22	Liu	2020/05	China	Investigating the prevalence and predictors of posttraumatic stress symptoms (PTSS) and sleep problems during COVID-19.	285 residents in Wuhan and surrounding cities age > 18 years. General population. Age: ≤ 35 = 136	Cross-sectional, convenience sampling	PCL-5; PSQI	8

(continued on following page)

Table 1—Selected characteristics, methods, and major findings of the included studies in this review about sleep problems during COVID-19. (continued)

SN	First Author	Year/Month	Country	Theme	Population	Methods	Measures	Quality*
					(47.7%) > 35 = 149 (52.3%) Male: 118 (45.6%)			
23	Liu	2020/04	China	Identifying the clinical characteristics of suspected COVID-19 schizophrenic hospitalized patients in Hubei Province	21 (infected) hospitalized patients with schizophrenia with suspected COVID-19 in the isolation ward in Wuhan. Age: 43.1 ± 2.6 Male: 9 (42.9%) 30 (not infected) hospitalized patients with schizophrenia (in the general ward in Yichang Age: 45.0 ± 9.2 Male: 15 (50%)	Cross-sectional, convenience sampling	PANSS PSS HAMD HAMA PSQI	6
24	Qi	2020/05	China	Evaluating sleep disturbances of Chinese frontline medical workers (FMW) compared to non-FMW under the outbreak of COVID-19.	1,306 medical workers Age: 33.1 ± 8.4 Male: 256 (19.6%)	Cross-sectional, convenience sampling	PSQI AIS VAS	8
25	Roy	2020/06	India	Study the knowledge, attitude, and anxiety level during the COVID-19 pandemic	662 adult general population. Aged 18 years or more. Age: 29.09 ± 8.83 years Males: 332 (48.6%)	Cross-sectional, observational, snowball sampling technique	Researcher developed	7
26	Sheng	2020/03	China	Examining the psychological status and sleep quality during the outbreak of COVID-19.	95 nursing Interns isolated a general teaching hospital Age: (21.26 ± 1.01) years Male: 6 (6.5%)	Cross-sectional, convenience sampling	SAS SDS PSQI	8
27	Stanton	2020/06	Australia	Changes in physical activity, sleep, tobacco and alcohol use in Australian adults during COVID-19	1491 general adult population. Age: 50.5 ± 14.9 Male: 493 (33%).	Cross-sectional, Convenience snowball sampling	Researcher developed	7
28	Sun	2020/03	China	Estimating the prevalence and exploring risk factors of acute posttraumatic stress symptoms (PTSS) amid the outbreak of COVID-19.	2091 general population Age: 18-60 years Male: 816 (39%)	Cross-sectional, convenience sampling	PCL-5	8
29	Tang	2020/05	China	Estimating the prevalence of PTSD and depression.	2485 home-quarantined college students. Age: 19.81 ± 1.55 Male: 975 (39.2%)	Cross-sectional, convenience sampling	PCL-C t PHQ-9	7
30	Tu	2020/05	China	Examine sleep disorders in China amid pandemic COVID-19.	100 frontline workers. Female nurses. Age: 34.44 ± 5.85 years Male: NA (0%)	Cross-sectional, Convenience sampling	PSQIPHQ-9 GAD-7	7
31	Vitale	2020/05	Italy	Objectively and subjectively assess the consequence of severe symptoms of Covid-19 infection on sleep quality through wrist actigraphy.	4 COVID-19 patients. Age: 54 ± 221 Male: 3(75)%	Case-series	PSQI Wrist actigraphy	6
32	Voitsidis	2020/05	Greece	Examining sleep disturbance during the COVID-19 pandemic.	2, 427 young adults. Age: 18-30 years Male: 578 (23.8%)	Cross-sectional, convenience sampling	AIS IUS JGLS PHQ-2	8
33	Wang	2020/05	China			Cross-sectional, convenience sampling	PSQI SAS SDS	8

(continued on following page)

Table 1—Selected characteristics, methods, and major findings of the included studies in this review about sleep problems during COVID-19. (continued)

SN	First Author	Year/Month	Country	Theme	Population	Methods	Measures	Quality*
				Investigating the influence of the COVID-19 outbreak on sleep quality of healthcare workers.	123 healthcare workers. Age: 33.75 ± 8.41 years Male: 12 (10%)			
34	Wu	2020/ 06 Preprint	Canada	Determinants of self-reported symptoms for COVID-19.	4,240 adult general population. Age: 47.3% were aged 18-45 years Males: 2031 (47.9%)	Representative, stratified randomized	Researcher developed	7
35	Wu	2020/05	China	Describing the differences in psychological factors and sleep status of medical staff in the fight against COVID-19 and giving exercises evidence that plays a role in relieving the stress and improve sleep quality.	120 medical staff Group 1: 60 medical staff worked at the designated hospital (frontline workers), (26.7%) were males Group 2: 60 medical staff worked at the nondesignated hospital (nonfrontline workers) and (25%) were males Age: 33.5 ± 12.4 years, the age range was 25–59 years	Cross-sectional, convenience sampling	SCL-90 SAS SDS PCL-C PSQI	8
36	Xiao	2020/03	China	Examining the effects of social capital on the sleep quality of individuals self-isolated at home for 14 days.	170 general population Age: 37.78 ± 4.12 Male: 101 (59.4%)	Cross-sectional, convenience sampling	PSCI-16 SAS SASR PSQI	8
37	Xiao	2020/03	China	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 28.3% were males	Cross-sectional, convenience sampling	SAS GSES SASR PSQI SSRS	8
38	Yifan	2020/04	China	Assessing the symptoms and causes of SSD among ICU nurses treating COVID-19 pneumonia.	140 nurses working at COVID-19 pneumonia ICU in Wuhan Age: 29.35 ± 4.92 Male: 22 (15.7%)	Cross-sectional, convenience sampling	SSD	6
39	Yin	2020/05	China	Assessing posttraumatic stress symptoms (PTSS) and their sleep quality after one-month of stress.	371 healthcare workers. Age: 35.30 ± 9.48 years Male: 143 (38.5%)	Cross-sectional, snowball sampling	PCL-5 PSQI	7
40	Zhang	2020/05	China	Assessing the adverse impact of the COVID-19 outbreak on the mental health of college students.	66 college students (general population). Age: 20.70 ± 2.11 years Male: 25 (37.8%).	Cross-sectional, snowball sampling. Follow-up (longitudinal element of subsample)	IPAQ-S PSQI DASS-21 BPAQ	6
41	Zhang	2020/03	China	Assessing sleep Disturbances and posttraumatic stress symptoms (PTSS) after the massive outbreak of COVID-19.	2027participants 230 participants exposed in Wuhan 1997 participants non exposed in Wuhan. Age: 35.47 ± 11.32 Male: 788 (38.8%)	Cross-sectional, convenience sampling	PSQI PCL-5	8
42	Zhao	2020/05	China	Examining the impact of perceived stress on the sleep quality of the nondiseased general public during COVID-19.	1,630 general population. Age: 29.17 ± 10.58 years	Cross-sectional, convenience sampling	PSS PSQI SRAS RSE	8
43	Zheng	2020/05	China	Investigating physical activity (PA) levels, sedentary behavior (SB) and sleep among young adults during	Cross-sectional 631 young adults living in Hong Kong. Age: 18-35	Cross-sectional, convenience sampling. The subsample was followed in a longitudinal design	SBQ PSQI	8

(continued on following page)

Table 1—Selected characteristics, methods, and major findings of the included studies in this review about sleep problems during COVID-19. (continued)

SN	First Author	Year/Month	Country	Theme	Population	Methods	Measures	Quality*
				the COVID-19 epidemic, and the change in these behaviors before and during the pandemic.	years. Male: 245 (38.8%) Longitudinal: 70 young adults.			
44	Zhou	2020/06	China	Assess the prevalence of poor sleep quality and its association with demographic among frontline health professionals.	1, 931 frontline health professionals Age:35.08 ± 8.04 Male: 88 males (4.6%)	Cross-sectional, Convenience snowball sampling	PSQI	8

Results of cutoffs included in the analyses are the recommended by each scale (eg, PSQI = 5, ISI = 15). *Quality score measured using the Newcastle-Ottawa Scale customized for cross-sectional analysis. Further details about the domains, items, and score interpretation are available in Supplemental Table S1. AIS = Athens Insomnia Scale, ASDS = Acute Stress, BPAQ = Buss-Perry Aggressive Questionnaire, CES-D = The Center of Epidemiological Studies Depression Scale, DASS-21 = Depression Anxiety Stress Scale, With 21 Self-Reported Items, FMW = Frontline Medical Workers, GAD = General Anxiety Disorder, GAD-7 = Generalized Anxiety Disorder Scale, GAD-7 = Generalized Anxiety Disorder-7, HADS = Hospital Anxiety and Depression Scale, HAMA = Hamilton Anxiety Rating Scale, HAMD = Hamilton Depression Rating Scale, HCWS = Healthcare Workers, IAT = Internet Addiction Test, ICU = Intensive Care Unit, IPAQ-S = Short Version of International Physical Activity Questionnaire, ISI = Insomnia Severity Index, ISI = Insomnia Severity Index, IUS = Intolerance to Uncertainty Scale, JGLS = De Jong Gierveld Loneliness Scale, NSI = Nurse Stress Index, PANSS = Positive and Negative Syndrome Scale, PCL-5 = Posttraumatic Stress Disorder Checklist For DSM-5, PGWB = General Well-Being Questionnaire, PHQ-2 = Patient Health Questionnaire 2 items, PHQ-4 = The Patient Health Questionnaire 4 items, PHQ-9 = The Patient Health Questionnaire 9 items, PSCI-16 = Personal Social, PSQI = Pittsburgh Sleep Quality Index, PSS = Perceived Stress Scale, PTSD = Post-Traumatic Stress Disorder, RASS = Richmond Agitation Sedation Scale, RSE = Rosenberg Self-Esteem Scale, SAS = Self-Rating Anxiety Scale, SASR = Stanford Acute Stress Reaction, SBQ = Sedentary Behavior Questionnaire, SCL-90 = Symptom Checklist 90, SDS = Self-Rating Depression Scale, SDST = Sleep Disturbance and Suicidal Thoughts, SEM = Structural Equation Modeling, sNS = Subjective Neurological Symptoms, SSD = Somatic Symptom Disorder, SSRS = Social Support Rate Scale, STAI = State-Trait Anxiety Inventory, UCLA = Loneliness Scale, VAS = Visual Analog Scale, WHO-5 = World Health Organization–Wellbeing Index.

Forty-four papers,[6,15–57] involving a total of 54,231 participants from 13 countries, were judged relevant and contributed to the systematic review and meta-analysis of sleep problems during COVID-19 (**Table 1**; Supplemental Table S1). Thirty-seven papers (84%)[6,15,17,19–22,24–27,29–40,42–46,48–53,55,57] were published in peer-reviewed journals, and the remaining 7 (16%)[16,18,23,28,41,47,56] were either accepted or provisionally accepted for publication and were available from a preprint server.

Forty studies (91%)[6,15–30,32–35,37–47,51,53–57] reported a prevalence rate defined as the proportion of individuals with sleep problems divided by the total number of people in the sample. Four (9%)[36,49,50,52] studies only reported a mean score and standard deviation of a sleep scale.

All the studies were published after March 2020. Twenty-seven studies (61%)[16,17,19,21–24,27–32,34,35,38,40–42,45,47,49,53–56,58] focused on the general population; thirteen studies (30%).[6,15,18,20,37,39,43,46,48,50–52,57] Only a few studies, 4 (9%),[25,33,36,44] investigated the sleep problems of patients infected with COVID-19. The median number of participants per study was 566 participants. The mean quality score, according to the Newcastle–Ottawa Scale, is 7.5 ± 0.7, ranging from 6 to 8 points (**Table 1**).

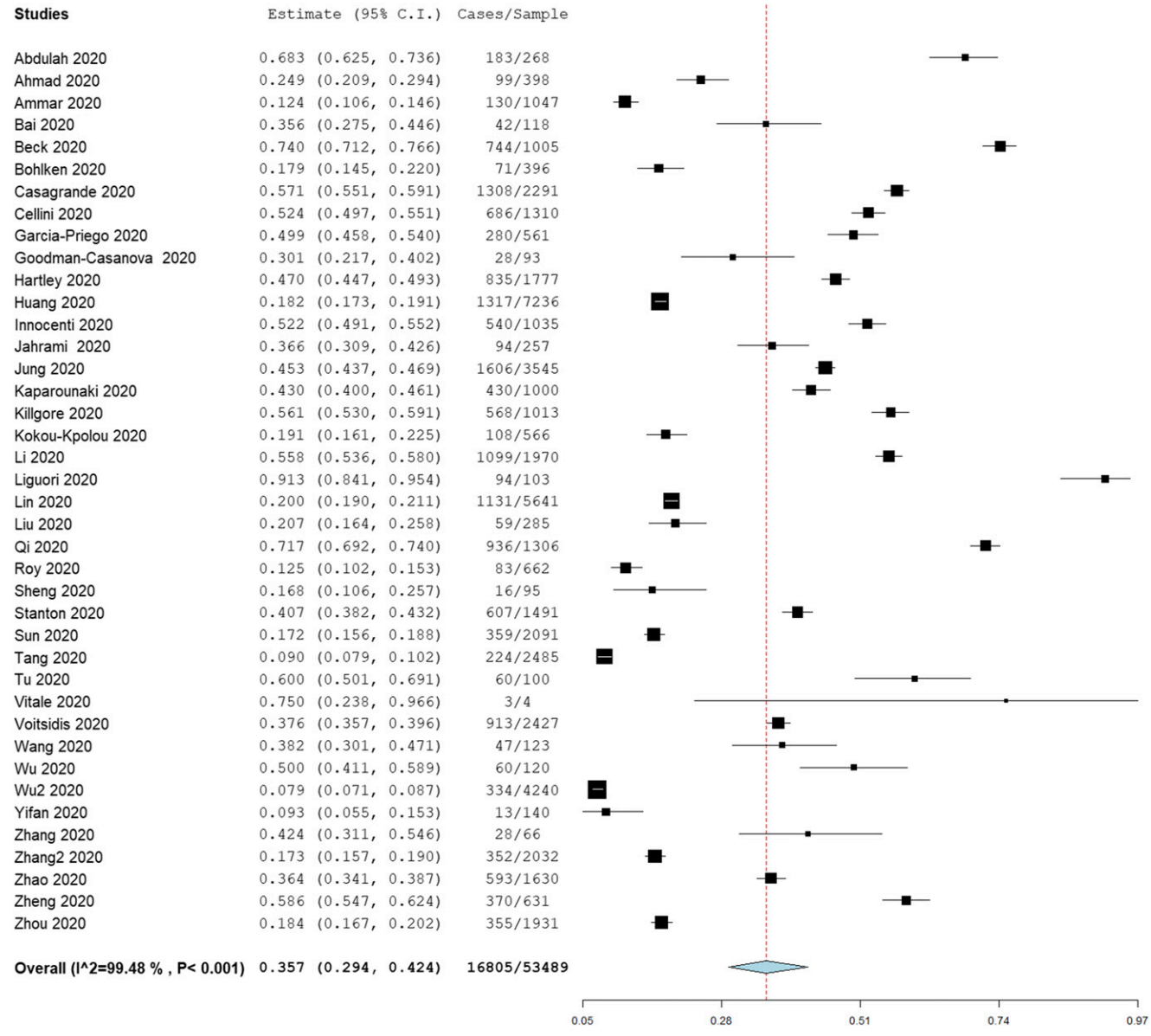
All 44 studies used observational, cross-sectional research design. A range of research measures were used. Thirty-five (80%) of the studies used sleep-specific measures. Altogether, 27 (61%) of the studies used a well-established validated scale: 2 (5%) used the Athens Insomnia Scale[15,45]; 3 (7%) used the Insomnia Severity Index (ISI)[30,31,34]; and 22 (50%) used the Pittsburgh Sleep Quality Index (PSQI).[6,18,21,22,27,35–37,39,43,44,46,48–50,52–56,58] Eight (19%)[17,19,20,24,25,38,40,47] used researcher-developed measures designed specifically to measure sleep problems. The remaining 9 (20%)[16,23,28,29,33,41,42,51,59] used a subsection or cluster of questions to report sleep problems using an established psychologic measure.

Meta-analysis of sleep problems

Meta-analysis of the prevalence of sleep problems in all populations using all available studies (K = 40, n = 53,489) yielded an estimated pooled prevalence rate of 35.7% (95% CI, 29.4–42.4%) with heterogeneity (Q = 7477[39], $\tau^2 = 0.8$, $I^2 = 99.5\%$, $P < .001$). The raw prevalence estimates for sleep problems reported among all populations using any measure ranged from 8% to 91%. **Figure 2** illustrates the forest plot of the meta-analysis of sleep problems in all populations using all measures. Sensitivity analysis revealed that no study affected the prevalence estimate by more than 1%. Results of the sensitivity analysis suggest that the overall pooled prevalence is robust and powered by the methodologic quality of each research study included. Visual inspection to funnel plot (Supplemental Figure S1) indicated no observed publication bias. Kendall's τ without continuity correction was −0.04 ($P = .70$), and Egger's regression was $P = .72$.

Subgroup analysis by country of research origin found that reports from China (K = 18, n = 28,000) yielded an estimated pooled prevalence of sleep problems of 26.5% (95% CI, 26–27.1%) with heterogeneity (Q = 3217, $\tau^2 = 0.8$, $I^2 = 99.5\%$, $P < .001$). Italy and France had higher pooled prevalence rates of

Figure 2—Meta-analysis of the prevalence of sleep problems (all populations, all measures). Cases refer to persons with positive sleep problem.



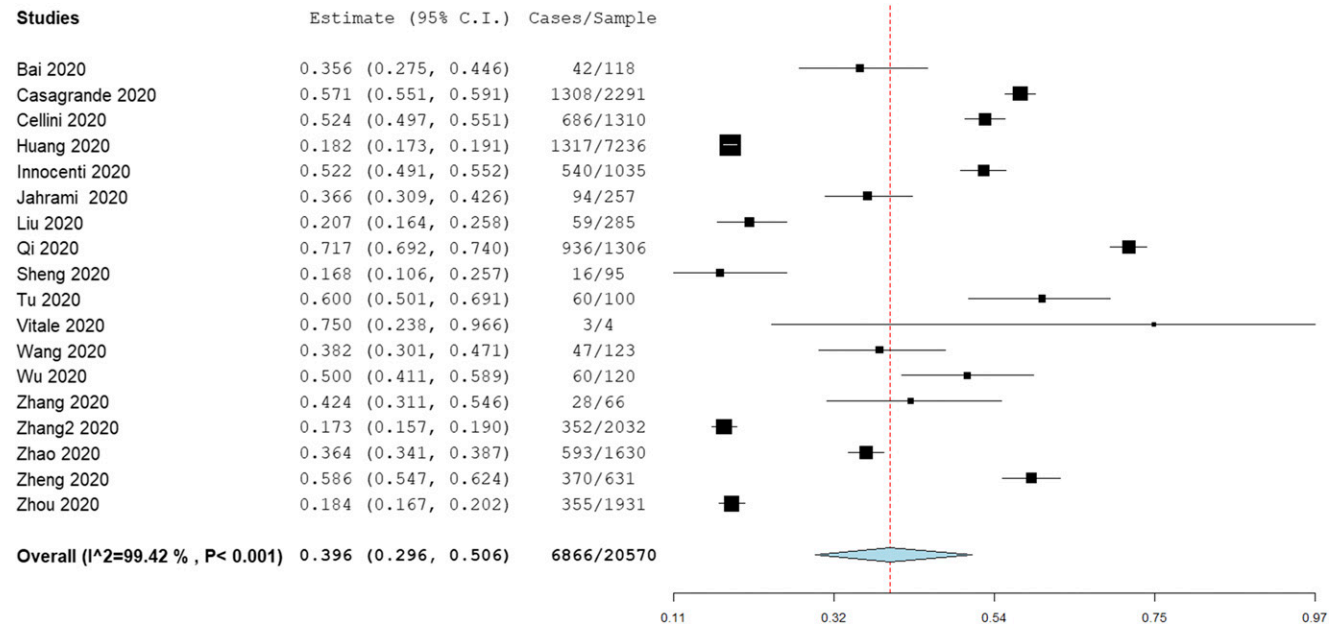
55% (95% CI, 53.6–56.5%) and 50.8% (95% CI, 49–52.6%), respectively. Finally, Germany had a similar prevalence rate to that found overall (38.8%; 95% CI, 37–40.3%).

Subgroup analysis of sleep problems by population showed that most of the studies were conducted on the general population, followed by health care providers, and last on patients infected with SARS-COV-2 and those with symptoms of COVID-19. Meta-analysis of the prevalence of sleep problem in the general population (K = 26, n = 46,751) yielded an estimated pooled prevalence rate of 32.3% (95% CI, 25.3–40.2%) with heterogeneity (Q = 6137[25], $\tau^2 = 0.8$, $I^2 = 99.5\%$, $P < .001$). Health care workers (K = 11, n = 4854) had a slightly higher prevalence of sleep problems (36.0%; 95% CI, 21.1–54.2%) with heterogeneity (Q = 1048[10], $\tau^2 = 1.6$, $I^2 = 99\%$, $P <$ .001). Patients infected with COVID-19 (K = 3, n = 1884) appeared to be the most affected group with a prevalence of sleep problems of 74.8% (95% CI, 28.7–95.6%) with heterogeneity (Q = 50[2], $\tau^2 = 2.7$, $I^2 = 96\%$, $P < .001$). Detailed results are presented in a subgroup analysis forest plot in Supplemental Figure S2.

Moderator analysis revealed that higher age ($\beta = 0.13$, $P =$ .001) and male sex ($\beta = 3.6$, $P = .001$) are associated with higher prevalence of sleep problems in the subgroup of patients with COVID-19.

The PSQI was used in a total of 18 studies (n = 20,570) to estimate sleep problems. Nine of these studies focused on the general population (n = 16,516), 8 studies focused on health care workers (n = 4854), and 1 study focused on patients (n = 4). The

Figure 3—Meta-analysis of the prevalence of sleep problems (all populations, PSQI only). Cases refer to persons with positive sleep problem. PSQI = Pittsburgh Sleep Quality Index.



overall pooled prevalence of sleep problems for all populations using the PSQI was 39.6% (95% CI, 29.6–50.6%) with heterogeneity (Q = 2933[17], τ^2 = 0.8, I^2 = 99.5%, P < .001). **Figure 3** illustrates the forest plot of meta-analysis of sleep problems in all populations using the PSQI. Sensitivity analysis revealed that no study affected the prevalence estimate by more than 1%. The sensitivity analysis results suggest that the overall pooled prevalence is robust and powered by the methodologic quality of each research study. Visual inspection of the funnel plot (Supplemental Figure S3) indicated no observed publication bias. Kendall's τ without continuity correction = −0.04 (P = .80), and Egger's regression was P = .42. One possible explanation for the large heterogeneity is that different sleep measures assess symptoms across somewhat different time frames (eg, PSQI and Athens Insomnia Scale = past month, ISI = past 2 weeks). Thus, given the rapidly evolving nature of the COVID-19 pandemic, this makes it harder to generalize across studies.

Subgroup analysis of sleep problems using the PSQI indicated that the general population and health care workers had comparable sleep problems, with rates of 37.9% (95% CI, 25.2–52.4%) and 39.7% (95% CI, 21.2–61.6%), respectively. Details of the analyses are presented in **Table 2** and illustrated in Supplemental Figure S4.

Moderator analysis revealed that age (β = 0.01, P = .001) was associated with a higher prevalence of sleep problems in the general population subgroup only. Individuals with younger age appeared to have a greater magnitude of sleep problems during the pandemic when measured using PSQI.

Researcher-developed measures and the ISI were commonly used measures among the general population. Meta-analysis of sleep problems measured using researcher-developed measures in the general population (K = 6, n = 8538) yielded an estimated pooled prevalence rate of 25.2% (95% CI, 9.3-52.6%) with heterogeneity (Q = 1774[5], τ^2 = 2.2, I^2 = 99.7%, P < .001). Details of the analyses are presented in **Table 2** and illustrated in Supplemental Figure S5. Three studies (K = 3, n = 7220) reported prevalence of sleep problems using ISI among the general population, and results yielded a prevalence rate of 29.7% (95% CI, 11.9–56.9%) with heterogeneity (Q = 532[2], τ^2 = 1.1, I^2 = 99.6%, P < .001). Details of the analyses are presented in **Table 2** and illustrated in Supplemental Figure S6.

The mean PSQI score was reported for 15 studies (K = 15, n = 9230). The global mean PSQI for all populations was 7.1 (95% CI, 6.3–8.0) with heterogeneity (Q = 1716[14], τ^2 = 2.4, I^2 = 99%, P < .001). Scores for the general population were reported in 6 studies (K = 6, n = 4722), and the mean PSQI was 6.0 (95% CI, 5.3–6.8) with heterogeneity (Q = 182[3], τ^2 = 0.6, I^2 = 98%, P < .001). Health care workers had higher mean score (K = 9, n = 4483), with global PSQI score of 7.7 (95% CI, 6.1–9.2) with heterogeneity (Q = 1358[9], τ^2 = 5.4, I^2 = 99%, P < .001). Details of the analyses are presented in **Table 2** and illustrated in **Figure 4**. Visual inspection to funnel plot (Supplemental Figure S7) indicated no observed publication bias. Subgroup analysis by population of mean PSQI score is available in Supplemental Figure S8.

Six studies reported the individual 7 components of the PSQI. Details of the analyses are presented in **Table 2** The results of this analysis indicated that sleep latency, sleep disturbances, and sleep duration had the highest scores, with 1.5, 1.4, and 1.3, respectively.

DISCUSSION

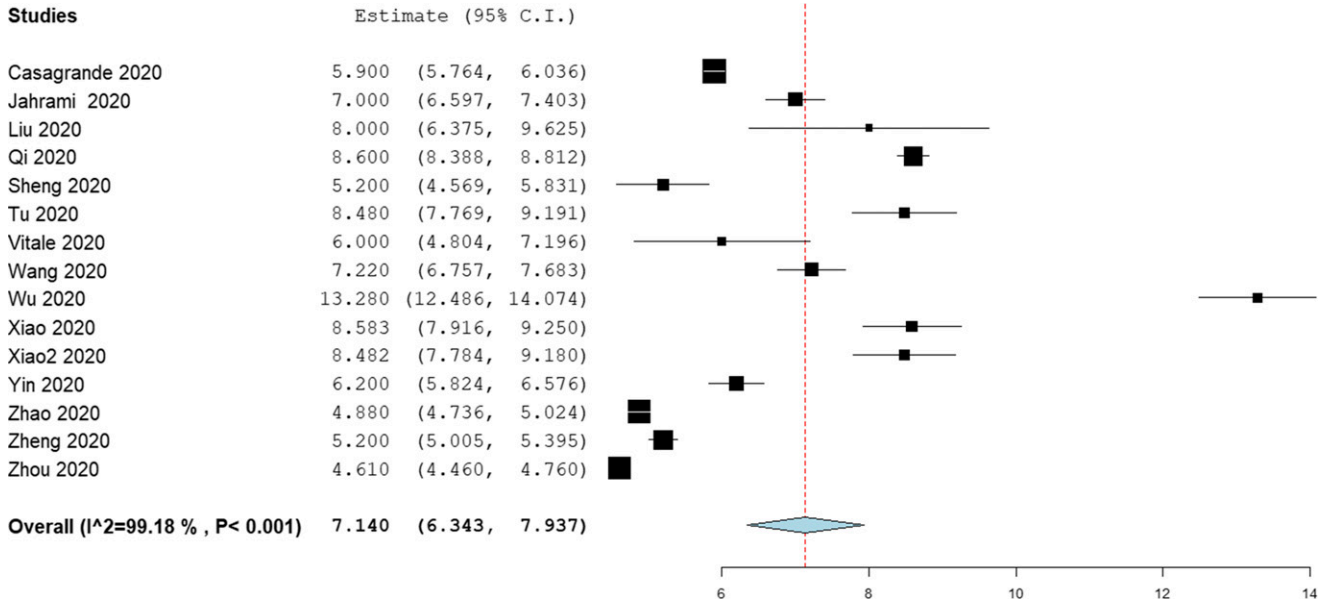
These meta-analyses aimed to comprehensively describe the pooled prevalence of sleep problems in several populations

Table 2—Meta-analysis of sleep problems during COVID-19: by population and by research measure.

Component	K	N	Random-Effects Meta-Analysis Pooled Results [95% CI]	Heterogeneity			Moderators		Publication Bias
				I^2	τ^2	Q	Age	Sex (%Male)	
Sleep problems (all populations, all measures*)	40	53,489	35.7% [29.4%–42.4%]	99.5%	0.8	7477 (39)	NS	NS	Kendall's *P* = .70, Egger's *P* = .72
Sleep problems (general population, all measures)	26	46,751	32.3% [25.3%–40.2%]	99.5%	0.8	6137 (25)	NS	NS	Kendall's *P* = .80; Egger's *P* = .90
Sleep problems (health care workers, all measures)	11	4854	36.0% [21.1%–54.2%]	99%	1.6	1048 (10)	NS	NS	Kendall's *P* = .70; Egger's *P* = .80
Sleep problems (COVID-19 patients, all measures)	3	932	74.8% [28.7%–95.6%]	96%	2.7	50 (2)	*P* = .001	*P* = .001	Kendall's *P* = .60; Egger's *P* = .80
Sleep problems (all populations, PSQI only)	18	20,570	39.6% [29.6%–50.6%]	99.5%	0.8	2933 (17)	NS	NS	Kendall's *P* = .80; Egger's *P* = .42
Sleep problems (general population, PSQI only)	9	16,516	37.9% [25.2%–52.4%]	99.6%	0.8	2018 (8)	*P* = .001	NS	Kendall's *P* = .80; Egger's *P* = .42
Sleep problems (health care workers, PSQI only)	8	4854	39.7% [21.2%–61.6%]	99%	1.6	853 (7)	NS	NS	Kendall's *P* = 1.0; Egger's *P* = .96
Sleep problems (general population, SD)	6	8538	25.2% [9.3%–52.6%]	99.7%	2.2	1774 (5)	NS	NS	Kendall's *P* = .85; Egger's *P* = .96
Sleep problems (general population, ISI)	3	7220	29.7% [11.9%–56.9%]	99.6%	1.1	531 (2)	NS	NS	Kendall's *P* = .60; Egger's *P* = .71
Mean sleep quality (all populations, PSQI)	15	9230	7.1 [6.3–8.0]	99.1%	2.4	1716 (14)	NS	NS	Kendall's *P* = .08; Egger's *P* = .045
Mean sleep quality (general population, PSQI)	4	4722	6.0 [5.3–6.8]	98%	0.6	182 (3)	NS	*P* = .04	Kendall's *P* = 1.0; Egger's *P* = .47
Mean sleep quality (health care workers, PSQI)	9	4483	7.7 [6.1–9.2]	99%	5.4	1358 (9)	NS	NS	Kendall's *P* = .14; Egger's *P* = .13
Mean (C1) self-reported sleep quality (health care workers, PSQI)	6	2897	1.3 [0.3–2.3]	99.8%	1.5	1219 (5)	NS	NS	Kendall's *P* = .34; Egger's *P* = .02
Mean (C2) sleep latency (health care workers, PSQI)			1.5 [0.9–2.2]	99.8%	0.7	2662 (5)	NS	NS	Kendall's *P* = .57; Egger's *P* = .38
Mean (C3) sleep duration (health care workers, PSQI)			0.9 [−0.2 to 2.0]	99.9%	2.0	17713 (5)	NS	NS	Kendall's *P* = .34; Egger's *P* = .34
Mean (C4) habitual sleep efficiency (health care workers, PSQI)			0.9 [−0.1 to 1.9]	99.9%	1.5	13197 (5)	NS	NS	Kendall's *P* = .85; Egger's *P* = .40
Mean (C5) sleep disturbances (health care workers, PSQI)			1.4 [0.4–1.9]	99.9%	1.0	9829 (5)	NS	NS	Kendall's *P* = .60; Egger's *P* = .20
Mean (C6) use of sleep-promoting medications (health care workers, PSQI)			0.7 [−0.1 to 1.6]	99.9%	1.2	14010 (5)	NS	NS	Kendall's *P* = .85; Egger's *P* = .15
Mean (C7) daytime dysfunction (health care workers, PSQI)			1.0 [−0.1 to 2.0]	99.9%	2.0	17641 (5)	NS	NS	Kendall's *P* = .85; Egger's *P* = .72

CI = confidence interval, Cochran's Q = calculated as the weighted sum of squared differences between individual study effects and the pooled effect across studies, with the weights being those used in the pooling method, I^2 = statistic describing the percentage of variation across studies due to heterogeneity rather than chance, K = number of studies, Moderators = a method of moments estimator for random effect multivariate meta-analysis, N = number of participants, NS = not significant, ?-squared = the extent of variation among the effects observed in different studies (between-study variance) in a random-effects meta-analysis, Publication bias was not observed in Funnel plot. *Measures used to estimate sleep problems were as follows: AIS = Athens Insomnia Scale, GAD-7 = General Anxiety Disorder-7, HADS = Hospital Anxiety and Depression Scale, ISI = Insomnia Severity Index, PCL5 = Posttraumatic Stress Disorder Checklist For DSM-5, PHQ-9 = Patient Health Questionnaire-9, PSQ = Psychological Stress Questionnaire, PSQI = Pittsburgh Sleep Quality Index, RASS = Richmond Agitation Sedation Scale, RD = Researcher-developed, SDS = Self-Rating Depression Scale, SNS = Subjective Neurological Symptoms.

Figure 4—Meta-analysis of mean global PSQI (all populations). PSQI = Pittsburgh Sleep Quality Index.



using different measurement measures worldwide during the ongoing COVID-19 pandemic. First, the global pooled prevalence rate of sleep problems among all populations is 35.7% (95% CI, 29.4–42.4%). Second, patients with COVID-19 appeared to be the most affected group, with a pooled rate of 74.8% (95% CI, 28.7–95.6%). Third, health care workers and the general population had comparative rates of sleep problems with rates of 36.0% (95% CI, 21.1–54.2%) and 32.3% (95% CI, 25.3–40.2%), respectively. Similar findings on sleep problems were obtained using the PSQI, suggesting that health care providers and the general population were affected comparatively with rates of 39.7% (95% CI, 21.2–61.6%) and 37.9% (95% CI, 25.2–52.4%), respectively. Fourth, researcher-developed measures appeared to be less sensitive in detecting sleep problems, with prevalence rate of 25.2% (95% CI, 9.3–52.6%), compared with the well-established sleep self-assessment questionnaires such as the PSQI (39.6%; 95% CI, 29.6%–50.6%). Also, The PSQI captures a very broad range of sleep-related issues (eg, nightmares, snoring, sleep medication use), which may explain the higher prevalence rates compared with the Athens Insomnia Scale, ISI, or researcher-developed measures.

In the current meta-analysis, the prevalence of sleep problems among the general population of 32.3% (95% CI, 25.3–40.2%) appeared to be higher than a previous meta-analysis reporting the prevalence of sleep problems in the adult general population in China (15.0%; 95% CI, 12.1–18.5%).[60] Another meta-analysis reported the prevalence of sleep problems among older adults with a pooled prevalence of 35.9% (95% CI, 30.6–41.2%).[61] Interestingly, a recent meta-analysis that summarized the prevalence of stress, anxiety symptoms, and depressive symptoms in the general population during the COVID-19 pandemic reported prevalence rates of 29.6% (95% CI, 24.3–35.4%), 31.9% (95% CI, 27.5–36.7%), and 33.7% (95% CI, 27.5–40.6%],[62] respectively, comparable to our findings of sleep problems. The overlapping prevalence rates between psychologic distress symptoms and our findings of sleep problems point to the potential bidirectional relationships between sleep and psychiatric comorbidities, especially when more comorbidities are present (eg, anxiety and depression), suggesting that sleep specialists should consider psychiatric comorbidities when treating sleep problems and vice versa.

It was expected that patients with COVID-19 would have the highest frequency of disturbed sleep (~75%), because the core symptoms of the disease involve coughing, fever, and difficulty in breathing, all of which have been associated with sleep problems.[63,64] The higher risk of sleep problems among patients with COVID-19 might also be attributable to physical pain and side effects of medications administered for the treatment of the virus.[65] One might argue that the higher prevalence rates of sleep problems among patients with COVID-19 are a byproduct of a smaller study sample size. However, it is important to consider this finding seriously, until larger better-designed studies are available.

Prevalence of sleep problems among health care using all measures (36.0%; 95% CI, 21.1–54.2%) or PSQI only (39.7%; 95% CI, 21.2–61.6%) are similar to the pooled prevalence among Chinese health care professionals before the pandemic (39.2%; 95% CI, 36.0–42.7%).[66] This suggests that reporting sleep problems has not increased among health care working during the COVID-19 pandemic.

Two meta-analyses on nursing staff before the pandemic demonstrated that the pooled prevalence of sleep problems using the PSQI in Iran[67] and China[68]were 64% (55–73%) and 61.0% (55.8–66.1%), respectively. In the current meta-analysis, one of the included studies focused only on female nurses and reported a prevalence rate of 60%.[43] This may imply that the discrepancy is because of heterogeneous health care workers

populations. This may suggest that the stress of nursing and/or being female may be the cause of increased sleep problems.

Thus, future meta-analyses may consider investigating various subgroups of health care workers (eg, nurses vs physicians, frontline vs nonfrontline). Nearly one-third of health care workers were found to have poor sleep quality with greater severity among frontline workers compared with second-line workers.[69] Similarly, when sleep quality was compared among health care workers providing care to COVID-19–positive cases vs those working negative cases, it was found the sleep quality was poorer among those posted in COVID-19–positive hospitals.[48] These studies suggest that poorer sleep quality was associated with exposure to COVIS-19–positive patients. Furthermore, these health care workers had higher scores on somatization, depression, anxiety, and stress scales.[48] Symptoms of depression, anxiety, and stress among frontline medical workers who were treating patients with COVID-19 are related to social support and sleep quality, as reported in a similar study conducted among self-isolated patients.[49,50]

The prevalence of sleep problems observed dropped significantly when a subgroup analysis was performed using researcher-developed assessment measures, but this was not noted in the global analysis and when comparing the PSQI with the other validated measures. A recent meta-analysis of diagnostic accuracy of 3 screening measures (PSQI, ISI, Athens Insomnia Scale) for sleep problems indicated that summary estimates of sensitivity and specificity did not differ significantly among the 3 measures,[70] but this was apparently not the case for researcher-developed assessment instruments.

Because of the rapid publication of COVID-19 research, this meta-analysis serves as a summary of the research literature for only the first 8 months of the pandemic. The major strength of this meta-analysis is the timely, large-pooled analysis stratified by target population and measurement measure. However, 2 limitations should be addressed. First, heterogeneity remained high after subgroup analyses and meta-regression, but heterogeneity cannot be eliminated in large epidemiologic meta-analyses.[61,71] Second, additional investigation of other lifestyle factors such as physical activity, smoking, and substance use need to be considered when adjusting for moderators, with special emphasis on adjusting for stress-related disorders including posttraumatic stress disorder, adjustment disorders, anxiety, and depression. Future original research might also consider the role of social confounding factors (eg, change in marital status or employment) and their impact on sleep.

Cellini et al[22] reported in a sample of 1310 Italians that sleep problems were greater among people with a higher level of depression, anxiety, and symptoms of stress. It has also been shown that social support improves sleep quality among people who were self-isolated at home for 14 days because of COVID-19,[49] because patients with greater support had lower anxiety and stress.

Sleep problems among the general population cannot be ignored because persistent sleep problems may have serious consequences.[72] A recent study demonstrated anxiety about COVID-19 correlated positively with insomnia severity and suicidal ideation.[30]

It is important to assess the impact of COVID-19 on sleep in different ethnicities and strata of society. It is expected that those with limited access to health care services and preventive measures for a contagious disease like COVID-19 will have higher levels of anxiety of catching the infection and hence higher levels of sleep disturbances.[73]

Given the results of this systematic review, there is an urgent need to improve sleep quality in both the general population and health care workers during this pandemic. Currently, available methods that may improve sleep quality include social and administrative support, relaxation techniques, and reasonable working schedules to allow for recovery.

CONCLUSIONS

The prevalence of sleep problems during the COVID-19 pandemic is high and affects approximately 40% of people from general and health care populations. Patients with active COVID-19 appeared to have higher prevalence rates of sleep problems. Further studies, particularly longitudinal studies to determine trajectories of sleep problems over time in these various COVID-19–impacted populations are warranted.

ABBREVIATIONS

CI, confidence interval
ISI, Insomnia Severity Index
PSQI, Pittsburg Sleep Quality Index

REFERENCES

1. Borges do Nascimento IJ, Cacic N, Abdulazeem HM, et al. Novel coronavirus infection (COVID-19) in humans: a scoping review and meta-analysis. *J Clin Med.* 2020;9(4):941.
2. World Health Organization. Coronavirus disease (COVID-19) pandemic. https://www.who.int/emergencies/diseases/novel-coronavirus-2019. Accessed May 2, 2020.
3. Coronavirus Update (Live). COVID-19 virus pandemic: worldometer. https://www.worldometers.info/coronavirus/. Accessed May 2, 2020.
4. Triggle CR, Bansal D, Farag EABA, Ding H, Sultan AA. COVID-19: learning from lessons to guide treatment and prevention interventions. *MSphere*. 2020;5(3): e00317–e00320.
5. 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.
6. Jahrami H, BaHammam AS, AlGahtani H, et al. The examination of sleep quality for frontline healthcare workers during the outbreak of COVID-19 [published online ahead of print June 26, 2020]. *Sleep Breath.*, doi:10.1007/s11325-020-02135-9.
7. Daly M, Sutin A, Robinson E. Longitudinal changes in mental health and the COVID-19 pandemic: evidence from the UK Household Longitudinal Study. PsyArXiv. Preprint posted online June 3, 2020. doi:1031234/osfio/qd5z7.
8. Medic G, Wille M, Hemels ME. Short- and long-term health consequences of sleep disruption. *Nat Sci Sleep*. 2017;9:151–161.
9. Liberati A, Altman DG, Tetzlaff J, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. *PLoS Med.* 2009;6(7): e1000100.

10. Pedder H, Sarri G, Keeney E, Nunes V, Dias S. Data extraction for complex meta-analysis (DECiMAL) guide. *Syst Rev.* 2016;5(1):212.
11. Herzog R, Álvarez-Pasquin MJ, Díaz C, Del Barrio JL, Estrada JM, Gil Á. Are healthcare workers' intentions to vaccinate related to their knowledge, beliefs and attitudes? A systematic review. *BMC Public Health*. 2013;13(1):154.
12. Deeks JJ, Higgins JP, Altman DG, Group CSM. Analysing data and undertaking meta-analyses. *Cochrane Handbook Syst. Rev. Interventions*. 2019:2019; 241–284.
13. van Aert RCM, Wicherts JM, van Assen MALM. Publication bias examined in meta-analyses from psychology and medicine: a meta-meta-analysis. *PLoS One*. 2019;14(4):e0215052.
14. Shi L, Lin L. The trim-and-fill method for publication bias: practical guidelines and recommendations based on a large database of meta-analyses. *Medicine (Baltimore)*. 2019;98(23):e15987.
15. Abdulah DM, Musa DH. Insomnia and stress of physicians during COVID-19 outbreak. *Sleep Med.* 2020;2:100017.
16. Ahmad A, Rahman I, Agarwal M. Factors influencing mental health during covid-19 outbreak. medRxiv. Preprint posted online May 6, 2020. doi:10.1101/2020.05.03.20081380.
17. Ammar A, Trabelsi K, Brach M, et al. Effects of home confinement on mental health and lifestyle behaviours during the COVID-19 outbreak: Insight from the "ECLB-COVID19" multi countries survey. medRxiv. Preprint posted online May 8, 2020. doi:10.1101/2020.05.04.20091017.
18. Bai Y, Wang X, Huang Q, et al. SARS-CoV-2 infection in health care workers: a retrospective analysis and a model study. medRxiv. Preprint posted online April 1, 2020. doi:10.1101/2020.03.29.20047159.
19. 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 [publihsed online ahead of print June 28, 2020]. *J Sleep Res.*, doi:10.1111/jsr.13119.
20. Bohlken J, Schömig F, Seehagen T, et al. Experience of practice-based psychiatrists and neurologists during the COVID-19 pandemic. *Psychiatr Prax.* 2020;47(4):214–217.
21. 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.
22. 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: e13074.
23. Garcia-Priego BA, Triana-Romero A, Pinto-Galvez SM, et al. Anxiety, depression, attitudes, and internet addiction during the initial phase of the 2019 coronavirus disease (COVID-19) epidemic: a cross-sectional study in Mexico. medRxiv. Preprint posted online May 15, 2020. doi:10.1101/2020.05.10.20095844.
24. Goodman-Casanova JM, Dura-Perez E, Guzman-Parra J, Cuesta-Vargas A, Mayoral-Cleries F. Telehealth home support during COVID-19 confinement for community-dwelling older adults with mild cognitive impairment or mild dementia: survey study. *J Med Internet Res.* 2020;22(5):e19434.
25. Hartley S, Colas des Francs C, Aussert F, et al. The effects of quarantine for SARS-CoV-2 on sleep: an online survey. *Encephale*. 202046, 3S, 3s:S53–S59.
26. Huang Y, Zhao N. Mental health burden for the public affected by the COVID-19 outbreak in China: who will be the high-risk group? *Psychol Health Med.* 2020: 1–12.
27. 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(8):2021–2022.
28. Jung S, Kneer J, Krueger T. The German COVID-19 survey on mental health: primary results. medRxiv. Preprint posted online May 12, 2020. doi:10.1101/2020.05.06.20090340.
29. 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.
30. Killgore WDS, Cloonan SA, Taylor EC, Fernandez F, Grandner MA, Dailey NS. Suicidal ideation during the COVID-19 pandemic: the role of insomnia. *Psychiatry Res.* 2020;290:113134.
31. Kokou-Kpolou CK, Megalakaki O, Laimou D, Kousouri M. Insomnia during COVID-19 pandemic and lockdown: prevalence, severity, and associated risk factors in French population. *Psychiatry Res.* 2020;290:113128.
32. Li D-J, Ko N-Y, Chen Y-L, Wang PW, Chang YP, Yen CF, Lu WH. COVID-19-related factors associated with sleep disturbance and suicidal thoughts among the Taiwanese public: a Facebook survey. *Int J Environ Res Public Health*. 2020; 17(12):4479.
33. Liguori C, Pierantozzi M, Spanetta M, et al. Subjective neurological symptoms frequently occur in patients with SARS-CoV2 infection. *Brain Behav Immun.* 2020; 88:11–16.
34. Lin LY, Wang J, Ou-Yang XY, et al. The immediate impact of the 2019 novel coronavirus (COVID-19) outbreak on subjective sleep status [published online ahead of print June 1, 2020]. *Sleep Med.*, doi:10.1016/j.sleep.2020.05.018.
35. Liu N, Zhang F, Wei C, et al. Prevalence and predictors of PTSS during COVID-19 outbreak in China hardest-hit areas: gender differences matter. *Psychiatry Res.* 2020;287:112921.
36. Liu X, Lin H, Jiang H, et al. Clinical characteristics of hospitalised patients with schizophrenia who were suspected to have coronavirus disease (COVID-19) in Hubei Province, China. *Gen Psychiatr.* 2020;33(2):e100222.
37. Qi J, Xu J, Li BZ, et al. The evaluation of sleep disturbances for Chinese frontline medical workers under the outbreak of COVID-19. *Sleep Med.* 2020;72:1–4.
38. Roy D, Tripathy S, Kar SK, Sharma N, Verma SK, Kaushal V. Study of knowledge, attitude, anxiety & perceived mental healthcare need in Indian population during COVID-19 pandemic. *Asian J Psychiatr.* 2020;51: 102083.
39. Sheng X, Liu F, Zhou J, Liao R. Psychological status and sleep quality of nursing interns during the outbreak of COVID-19. *Nan Fang Yi Ke Da Xue Xue Bao*. 2020; 40(3):346–350.
40. Stanton R, To QG, Khalesi S, et al. Depression, anxiety and stress during COVID-19: associations with changes in physical activity, sleep, tobacco and alcohol use in Australian adults. *Int J Environ Res Public Health*. 2020;17(11): E4065.
41. Sun L, Sun Z, Wu L, et al. Prevalence and risk factors of acute posttraumatic stress symptoms during the COVID-19 outbreak in Wuhan, China. medRxiv. Preprint posted online May 10, 2020. doi:10.1101/2020.03.06.20032425.
42. Tang W, Hu T, Hu B, et al. Prevalence and correlates of PTSD and depressive symptoms one month after the outbreak of the COVID-19 epidemic in a sample of home-quarantined Chinese university students. *J Affect. Disord*. 2020;274:1–7.
43. Tu ZH, He JW, Zhou N. Sleep quality and mood symptoms in conscripted frontline nurse in Wuhan, China during COVID-19 outbreak: a cross-sectional study. *Medicine (Baltimore)*. 2020;99(26):e20769.
44. Vitale JA, Perazzo P, Silingardi M, Biffi M, Banfi G, Negrini F. Is disruption of sleep quality a consequence of severe Covid-19 infection? A case-series examination. *Chronobiol Int.* 2020;37(7):1110–1114.
45. Voitsidis P, Gliatas I, Bairachtari V, et al. Insomnia during the COVID-19 pandemic in a Greek population. *Psychiatry Res.* 2020;289:113076.
46. Wang S, Xie L, Xu Y, Yu S, Yao B, Xiang D. Sleep disturbances among medical workers during the outbreak of COVID. *Occup Med (Lond.)*. 2020;70(5):364–369.
47. Wu DC, Jha P, Lam T, et al. Determinants of self-reported symptoms and testing for COVID-19 in Canada using a nationally representative survey. medRxiv. Preprint posted online June 2, 2020. doi:10.1101/2020.05.29.20109090.
48. 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.
49. 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.
50. 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.

51. Yifan T, Ying L, Chunhong G, et al. Symptom cluster of ICU nurses treating COVID-19 pneumonia patients in Wuhan, China. *J Pain Symptom Manage.* 2020; 60(1):e48–e53.
52. Yin Q, Sun Z, Liu T, et al. Posttraumatic stress symptoms of health care workers during the corona virus disease 2019. *Clin Psychol Psychother.* 2020;27(3): 384–395.
53. Zhang Y, Zhang H, Ma X, Di Q. Mental health problems during the COVID-19 pandemics and the mitigation effects of exercise: a longitudinal study of college students in China. *Int J Environ Res Public Health*. 2020;17(10):E3722.
54. Zhang F, Shang Z, Ma H, et al. High risk of infection caused posttraumatic stress symptoms in individuals with poor sleep quality: A study on influence of coronavirus disease (COVID-19) in China. medRxiv. Preprint posted online March 24, 2020. doi:10.1101/2020.03.22.20034504.
55. Zhao X, Lan M, Li H, Yang J. Perceived stress and sleep quality among the non-diseased general public in China during the 2019 coronavirus disease: a moderated mediation model. *Sleep Med.* 2020:S1389-9457(20) 30224-0.
56. Zheng C, Huang WY, Sheridan S, Sit CH-P, Chen X-K, Wong SH-S. COVID-19 pandemic brings a sedentary lifestyle: a cross-sectional and longitudinal study. medRxiv. Preprint posted online May 24, 2020. doi:10.1101/ 2020.05.22.20110825.
57. Zhou Y, Yang Y, Shi T, et al. Prevalence and demographic correlates of poor sleep quality among frontline health professionals in Liaoning Province, China during the COVID-19 outbreak. *Front Psychiatry.* 2020;11:520.
58. Huang Y, Zhao N. Generalized anxiety disorder, depressive symptoms and sleep quality during COVID-19 outbreak in China: a web-based cross-sectional survey. *Psychiatry Res.* 2020;288:112954.
59. Li DJ, Ko NY, Chen YL, et al. COVID-19-related factors associated with sleep disturbance and suicidal thoughts among the Taiwanese public: a Facebook survey. *Int J Environ Res Public Health*. 2020;17(12):E4479.
60. Cao X-L, Wang S-B, Zhong B-L, et al. The prevalence of insomnia in the general population in China: a meta-analysis. *PLoS One*. 2017;12(2):e0170772.
61. Lu L, Wang S-B, Rao W, et al. The prevalence of sleep disturbances and sleep quality in older Chinese adults: a comprehensive meta-analysis. *Behav Sleep Med.* 2019;17(6):683–697.
62. Salari N, Hosseinian-Far A, Jalali R, et al. Prevalence of stress, anxiety, depression among the general population during the COVID-19 pandemic: a systematic review and meta-analysis. *Global Health*. 2020;16(1):57.
63. Ferrando M, Bagnasco D, Roustan V, Canonica GW, Braido F, Baiardini I. Sleep complaints and sleep breathing disorders in upper and lower obstructive lung diseases. *J Thorac Dis.* 2016;8(8):E716–E725.
64. Singh DP, Jamil RT, Mahajan K. Nocturnal cough. In: Cascella M, Rajnik M, Cuomo A, Dulebohn SC, Di Napoli RS, eds. *StatPearls*. Treasure Island, FL: StatPearls Publishing; 2020.
65. Shi L, Lu ZA, Que JY, et al. Prevalence of and risk factors associated with mental health symptoms among the general population in China during the coronavirus disease 2019 pandemic. *JAMA Netw Open*. 2020;3(7):e2014053.
66. Qiu D, Yu Y, Li R-Q, Li Y-L, Xiao S-Y. Prevalence of sleep disturbances in Chinese healthcare professionals: a systematic review and meta-analysis. *Sleep Med.* 2020;67:258–266.
67. Sayehmiri K, Mohammadi E. Sleep disturbances among nurses in Iran: a meta-analysis. *Iran Red Crescent Med J.* 2018;20(11):e62089.
68. Zeng LN, Yang Y, Wang C, et al. Prevalence of poor sleep quality in nursing staff: a meta-analysis of observational studies. *Behav Sleep Med.* 2020;18(6):746–759.
69. Lai J, Ma S, Wang Y, et al. Factors associated with mental health outcomes among health care workers exposed to coronavirus disease 2019. *JAMA Netw Open*. 2020;3(3):e203976.
70. Chiu H-Y, Chang L-Y, Hsieh Y-J, Tsai P-S. A meta-analysis of diagnostic accuracy of three screening tools for insomnia. *J Psychosom Res.* 2016;87:85–92.
71. Li Y, Cao XL, Zhong BL, et al. Smoking in male patients with schizophrenia in China: a meta-analysis. *Drug Alcohol Depend.* 2016;162:146–153.
72. Sher L. COVID-19, anxiety, sleep disturbances and suicide. *Sleep Med.* 2020; 70:124.
73. 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(8):1401–1402.

SUBMISSION & CORRESPONDENCE INFORMATION

Submitted for publication July 23, 2020
Submitted in final revised form October 11, 2020
Accepted for publication October 13, 2020
Address correspondence to: Haitham Jahrami, PhD, College of Medicine and Medical Sciences, Arabian Gulf University, PO Box: 26671, Manama, Kingdom of Bahrain; Email: HJahrami@health.gov.bh

DISCLOSURE STATEMENT

All authors have seen and approved the manuscript. This article does not contain any studies with human participants performed by any of the authors. For this type of study (meta-analysis), formal consent is not required. The authors report no conflict of interest.